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# PRELIMS SAMPOORNA

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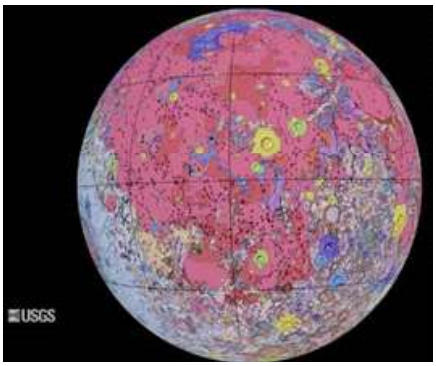
# 1 PHYSICS

## 1. Unified Geologic Map of the Moon

**Context:** The first-ever digital, unified, global, geological map of the moon was released virtually by the **United States Geological Survey (USGS), NASA** and the **Lunar Planetary Institute.**

### About the Map




- The map is a 'seamless, globally consistent, 1:5,000,000-scale geologic map'.
- The new map identifies over 12,000 distinct outcrops.
- At a scale of 1:5,000,000, the smallest feature discernible on it is a crater rim roughly 3 kilometers across, about the width of **Manhattan**.
- This geologic map combines six lunar geologic maps (**near, central far, east, west, north, and south sides**).
- The mapped surface features of the moon included **crater rim crests, buried crater rim crests, fissures, grabens, scarps, mare wrinkle ridges, faults, troughs, rilles, and lineaments.**
- **Significance:** The unified geological map (UGM) will serve as a blueprint for future human missions and a source of research and analysis for the educators and the general public interested in lunar geology.

### Why the focus is on moon's 'South Pole'?

- The moon's South Pole's elemental and positional advantages make it a suitable pit stop for future space exploration.
- The moon's South Pole is especially interesting because the area is much larger than the North Pole and there could be a possibility of the presence of water in these permanently shadowed areas.

### Interesting facts about Moon's South Pole

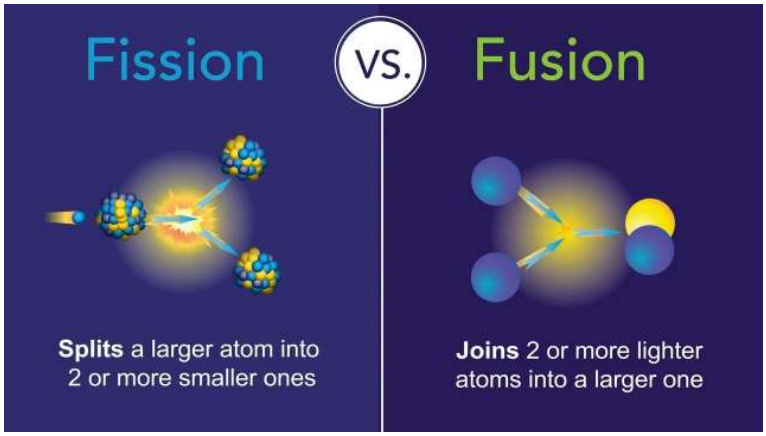
- Its craters have been untouched by sunlight for billions of years — offering an undisturbed record of the solar system's origins.
- Its permanently shadowed craters are estimated to hold nearly 100 million tons of water.
- Its regolith has traces of **hydrogen, ammonia, methane, sodium, mercury, and silver** — making it an untapped source of essential resources.

# 2. Scientists set new record in creating energy from nuclear fusion

**Context:** The **Joint European Torus (JET) nuclear-fusion experiment** based in **Oxfordshire, UK**, has more than doubled the amount of fusion energy produced in a **single "shot".**

## What is Nuclear energy?

- Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons.
- This source of energy can be produced in two ways:
  - **fission** – when nuclei of atoms split into several parts
  - **fusion** – when nuclei fuse together




- The nuclear energy harnessed around the world today to produce electricity is through nuclear fission.
- Nuclear fusion is the process whereby nuclei join together into one nucleus. The fusion of two atomic nuclei into one nucleus is not possible under standard temperature and pressure.

## Results of the recent research

- During an experiment in late 2021, JET achieved 59 **megajoules (MJ)** of fusion energy, beating the previous record of 22 MJ in 1997.
- The record and scientific data from these crucial experiments are a major boost for ITER, the larger and more advanced version of the JET.

### Joint European Torus (JET)

- JET, which was built in 1983, is operated by the **Culham Centre for Fusion Energy (CCFE) – the UK's national fusion research laboratory.**
- It is a fusion reactor that uses magnetic confinement to hold a hot plasma reaching temperatures of 150 million kelvin, 10 times hotter than the centre of the Sun.
- JET is the only device currently operating that can use the deuterium–tritium fuel mix, of the kind that will be used for commercial fusion power.
- It is the world's most powerful tokamak (a doughnut shaped apparatus) and is the focal point of the European fusion research program.

### About ITER

- ITER is the next-generation power-plant-scale (target: 500 MW fusion power) tokamak currently under construction at **Caderache, France.**
- It is intended to be capable of long (100s of seconds) pulses and generate significant fusion power in a range of experimental scenarios to prove the controlled plasma physics required for commercial fusion power.
- It is an international collaboration between the **EU, China, India, Japan, Korea, Russia, and the United States**, covering nearly half the world's population.

## 3. Solar flare causes radio blackout over Indian Ocean

**Context:** In a recent event, a powerful M5.5-class solar flare has ejected due to the eruption of sunspot AR2929, causing a shortwave radio blackout around the Indian Ocean and Atlantic Ocean.

### What is Solar flare?

- A flare is defined as a sudden, rapid, and intense variation in brightness.
- A solar flare occurs when magnetic energy that has built up in the solar atmosphere is suddenly released.
- **Radiation** is emitted across virtually the entire electromagnetic spectrum, from radio waves at the long wavelength end, through optical emission to x-rays and gamma rays at the short wavelength end.

- The amount of energy released is the equivalent of millions of 100-megaton hydrogen bombs exploding at the same time.

### Classification of solar flare

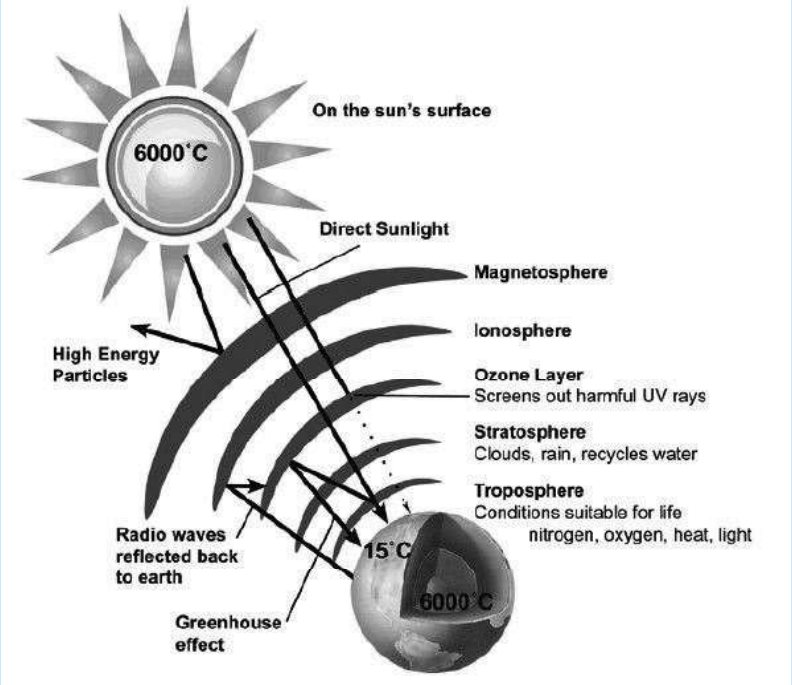
- Solar flares are classified into three categories according to their brightness in the x-ray wavelengths.
  - **X-class flares** are big; they are major events that can trigger radio blackouts around the whole world and long-lasting radiation storms in the upper atmosphere.
  - **M-class flares** are medium-sized; they generally cause brief radio blackouts that affect Earth's Polar Regions. Minor radiation storms sometimes follow an M-class flare.
  - **C-class flares** are smaller events as compared to X- and M-class events with few noticeable consequences here on Earth.

### Impacts

When radiation, energetic particles and solar plasma material released during a solar flare interact with the **Earth's magnetosphere and ionosphere**, it creates **strong geomagnetic storms.**

- **Impact on routes:** This induces **strong currents** at ground levels which can trip electric power grids in countries situated at high latitudes, **impacting air traffic on polar routes, etc.**
- **Disturb ionosphere:** These storms can disturb the ionosphere region of the Earth that plays an important role in radio communications, used by defense agencies, airline operators, and emergency services.
- **Dysfunctional satellites:** Satellites can be tumbled out of control and sensitive electronics can become dysfunctional.

**Earth's magnetosphere and ionosphere** are the regions of Earth's atmosphere in which the number of electrically charged particles—ions and electrons—are large enough to affect the propagation of radio waves.




## Flares and Sunspot

- The frequency of flares coincides with the **Sun's eleven year cycle.**
- When the solar cycle is at a minimum, active regions are small and rare and few solar flares are detected. These increase in number as the Sun approaches the maximum part of its cycle.
- The Sun will reach its next maximum in the year 2033.

### Other important solar storms

- **Coronal Mass Ejection**: A coronal mass ejection (CME) is a significant release of plasma and accompanying magnetic field from the solar corona.
  - They often follow solar flares and are normally present during a solar prominence eruption.
- **Geomagnetic Storm:** A geomagnetic storm is a major and temporary disturbance of Earth's magnetosphere.

- They occur when a surge of solar wind (charged particles from the sun) interacts with Earth's magnetic field and generates charged particles and currents in Earth's upper atmosphere.
- Geomagnetic storms interfere with high-frequency radio communications and GPS navigation systems. Aircraft flights, power grids, and space exploration programmes are vulnerable.

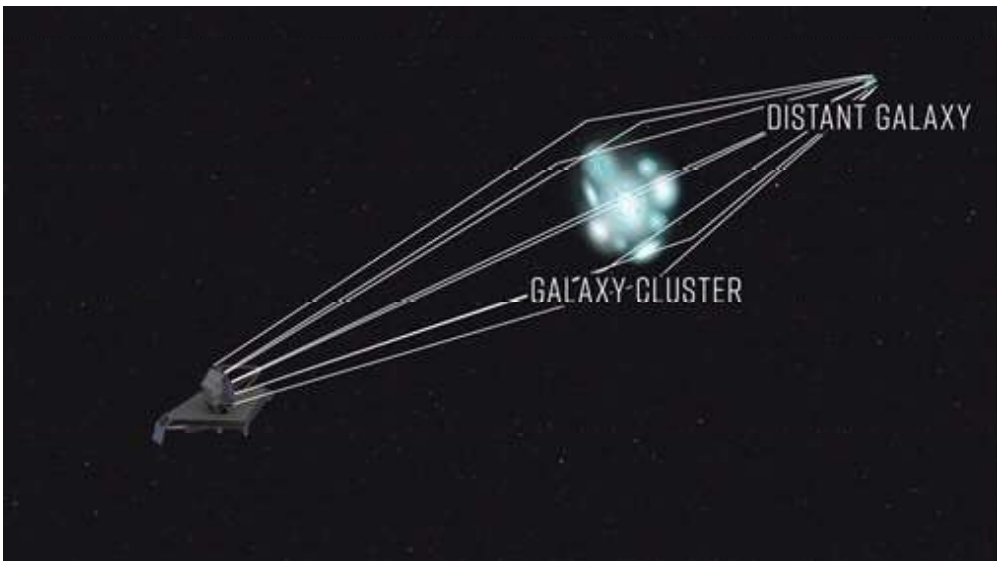
- **Solar Particle Events:** A solar particle event or solar proton event (SPE), occurs when particles (mostly protons) emitted by the Sun become accelerated either close to the Sun during a flare or in interplanetary space by coronal mass ejection shocks.

## 4. Time machine in space

**Context:** NASA has planned to use the concept of gravitational lensing to study how star formation is distributed across the galaxies through the programme called **Targeting Extremely Magnified Panchromatic Lensed Arcs and Their Extended Star Formation (TEMPLATES)**

### TEMPLATES

- Using **NASA's James Webb Space Telescope** as a sort of time machine, and taking advantage of natural, cosmic telescopes called gravitational lenses, this NASA's initiative will investigate how stars like our Sun formed in the universe.
- The TEMPLATES team has four main goals:
  - Measure how many new stars are forming, to determine how rapidly galaxies form stars
  - Map the star-formation rate in these galaxies
  - Compare the young and old stellar populations
  - Measure the conditions of the gas within these galaxies




**Use of Gravitational Lensing to study much farther stars/galaxies; PC: NASA**

### Need of the Programme

- Today, the rate and number of star formation is much less than billions of years ago.
- For e.g., our Milky Way continues to form the equivalent of one Sun every year. But in the past, that rate was up to 100 times greater.
- So if we really want to understand how stars like our Sun formed in the universe, we need to look billions of years into the past.
- Now, a team of researchers with the help of James Webb Space Telescope intends to just that.

### James Webb Space Telescope as a time machine

- Powerful space telescopes, like JWST or the Hubble, are often called time-machines because of their ability to view very faraway objects.
- The light coming from those objects, captured by these telescopes, began its journey millions of years earlier. So, what these telescopes see are images of these stars or galaxies as they were millions of years ago.
- The more distant the planet or star, the farther back in time are the telescopes able to see.

### James Webb Space Telescope

- JWST is a **general-purpose observatory** with a large aperture telescope optimised for infrared observations and a suite of state-of-the-art astronomical instruments capable of addressing many outstanding issues in astronomy.
- It was named after **former administrator of NASA James E. Webb**.
- It was launched as an **international collaboration between NASA, ESA (European Space Agency) and the Canadian Space Agency**.
- Key features of JWST are-
  - JWST will operate in an orbit around the Earth-Sun **L2 Langrage point**, ~ 1.5 million kilometres away from Earth. This makes its operation, pointing and stability requirements much simpler in comparison with HST
  - It orbits around the Earth at an altitude of ~570 km above it.
  - The telescope and the instruments will operate at the extremely low temperature of -233°C, which prevents the instrument's own infrared emission from overwhelming the signals from the astronomical targets.

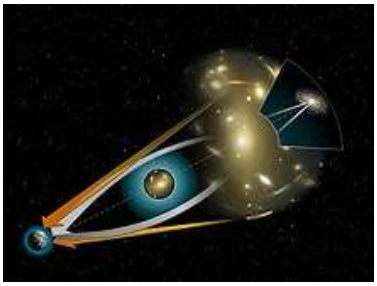
#### Langrage point

- Lagrange Points are areas where **gravity from the Sun and Earth balance the orbital motion of a satellite.**
- Putting a spacecraft at any of these points allows it to stay in a fixed position relative to the Earth and Sun with a minimum amount of energy needed for course correction.
- There are five "Lagrange Points" in space.
  - **L2** is short-hand for the second Lagrange Point.

### What is the phenomenon of Gravitational Lensing?

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

- The effect allows researchers to study the details of early galaxies too far away to be seen otherwise with even the most powerful space telescopes.
- Due to this, galaxies that appear much, much brighter than they actually are, because they've been highly magnified.



## 5. Developing Next-Generation Optoelectronic Devices Based on 2D Materials

**Context:** As per recent report, the **Global Optoelectronics Market** is projected to grow at a CAGR of 12.80% reaching USD 9,915.91 million by 2026.

### What is Optoelectronics?

- It is the study of optical power from light-detecting devices, which functions as an electrical-to-optical or optical-to-electrical transducer.
- Optoelectronics use the **quantum mechanical effect of light** on materials used in electronic devices such as semiconductors. These effects are:
  - Photovoltaic or photoelectric
  - Photoconductivity
  - Stimulated emission
  - Radiative recombination

#### Quantum theory of light

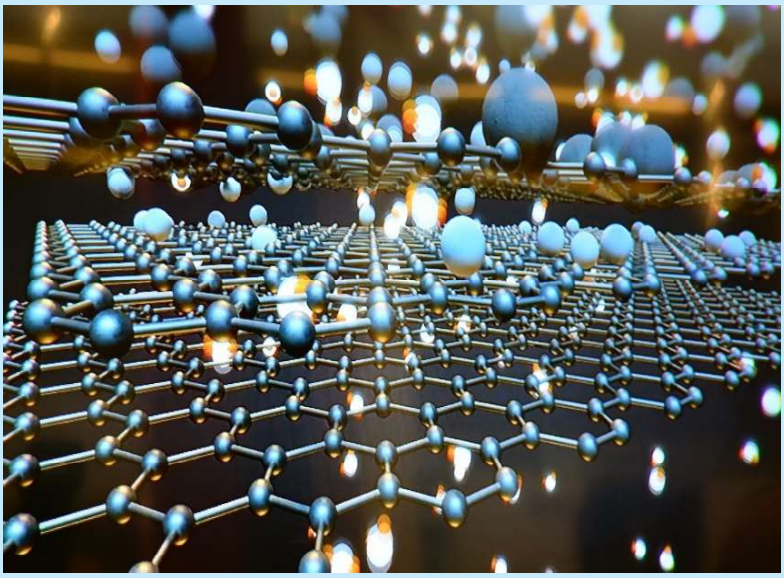
- Quantum theory tells us that both light and matter consists of tiny particles which have wavelike properties associated with them.
- Light is composed of particles called **photons**, and matter is composed of particles called **electrons, protons, neutrons.**

### The challenges

- Despite its growing market size, the challenges in light-matter interactions and optical integration for large-scale production are still there.
- It is believed that the **next-generation 2D materials** can address these challenges.

#### 2D materials

- In materials science, the term single-layer materials or **2D materials** refers to **crystalline solids** consisting of a **single layer of atoms.**
- These materials are promising for some applications but remain the focus of research.



## Next-Generation 2D Materials

- Through their **van der Waals forces**, 2D materials can directly combine with other structures.
- Their excellent tunable band structure, ultra-fast carrier mobility, and ultra-high nonlinear co-efficiency can be utilized in various applications in optoelectronic devices.
- They are being used in optical fibers, photovoltaic cells, sensing, quantum computing, etc.
- 2D materials, such as **graphene, black phosphorous (BP)**, and transition metal dichalcogenides (TMDs), are being tested in optical communication, biosensing, biomedical, laser sources, and photodetectors, etc.
- Materials such as **tungsten diselenide (WSe2) and molybdenum diselenide** are being studied for their opto-electronic properties.

## Graphene

- Graphene is a **one-atom-thick layer** of **carbon atoms** arranged in a **hexagonal lattice.**
- It is the **building-block of Graphite** (which is used, among others things, in pencil tips).
- Graphene is the **thinnest material known** to man at one atom thick, and also incredibly strong - about 200 times stronger than steel.
- On top of that, graphene is an **excellent conductor of heat and electricity** and has **interesting light absorption abilities.**
- It is truly a material that could change the world, with unlimited potential for integration in almost any industry.

**Note**: Optoelectronics should not be confused with electro-optics, as this field is a wider branch of physics that deals with the interaction of electric fields and light, without concern if an electronic device is involved or not.

# 6. Abundance of Lithium in stars

**Context:** Scientists have found a clue to the mystery behind the high abundance of **Lithium**— a trace element.

### About Lithium

- It is a chemical element with the symbol **Li and Atomic number 3.**
- It is a soft, silvery-white metal.
- Under standard conditions, it is the lightest metal and the lightest solid element.
- It is highly reactive and flammable, and must be stored in mineral oil.
- Lithium has become the new 'white gold' as the demand for high performing rechargeable batteries is rising.
- Rising global lithium demand and surging prices have drawn increased interest in the so-called **'lithium triangle'** that spans parts of **Argentina, Bolivia and Chile.**


### Lithium reserve in India

- Researchers at the Atomic Minerals Directorate have estimated lithium reserves of 14,100 tonnes in a small patch of land surveyed in Southern Karnataka's Mandya district recently.
- This is also to be India's first ever Lithium deposit site found.

# 7. Ploonets

**Context:** Astronomers have defined a new class of celestial objects called **"ploonets,"** which are orphaned moons that have escaped the bonds of their planetary parents.

### About Ploonets

- Ploonets are referred to as orphaned moons that have escaped the bonds of their planetary parents.
- The scientists think these objects should exist in solitary orbits around their host stars.

### What Makes moon as a Ploonet?

- It has been observed that a large number of giant exoplanets classified as 'hot Jupiters' being located very close to their host stars.
- When a planet gets too close to the host star, the gravity of host star could push some of the moons into a new orbit, changing their status to ploonets.

- If these ploonets manage to collect some material as they travel, they may evolve into fully-fledged small planets.
- If the ploonet, when it was a moon, had an icy surface or an atmosphere and then escaped its planet and moved closer to its star, the star's heat would evaporate the ice.
- If the ploonet starts to evaporate, it could grow a long, light-blocking tail.

**Note**: The migration of the Moon away from the Earth is mainly due to the action of the Earth's tides.

## 8. Intermediate-Mass Black Hole

**Context:** Scientists from the **Chennai Mathematical Institute and Ors analyzed data from LIGO-VIRGO** viewing centers and rated the fraction of Black Hole binary integration found so far demonstrating the potential for Intermediate-Mass Black Holes.

### What are Black Hole?

- A black hole is a place in space where gravity pulls so much that even light cannot get out.
- The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- Because no light can get out, people can't see black holes.
- They are invisible. Space telescopes with special tools can help find black holes.
- The special tools can see how stars that are very close to black holes act differently than other stars.

### Types of Black Holes

- Astronomers have long thought that black holes come in just two kinds, the "stellar" and the "supermassive", depending on the mass of the black hole.
- Now, as per the new findings, it looks like there is a third kind. Because it has a mass somewhere between these two types, it is called an "intermediate mass black hole."

### Stellar Black holes

- A stellar black hole forms when a massive star undergoes an explosive death called a supernova.
- This explosion, which can outshine an entire galaxy of stars for about a week, leaves behind the small, heavy core of a star.
- If this core is massive enough, it will collapse on itself and form a black hole.
- A typical stellar-class of black hole has a mass between about 3 and 10 solar masses.

### Supermassive black holes

- Supermassive black holes exist in the center of most galaxies, including our own Milky Way Galaxy.
- They are astonishingly heavy, with masses ranging from millions to billions of solar masses.
- There are so many stars and so much gas and dust that the black hole can grow large very quickly.
- And since many galaxies collide repeatedly during their long lifetimes, supermassive black holes have a ready-made way to collide and coalesce into even heavier supermassive black holes.

### Intermediate-mass black hole

- The intermediate mass black hole is estimated to have a mass between 100 and 1000 solar masses.
- It is formed by merging two or more stellar black holes.
- One of the theories of intermediate mass black hole formation has to do with 'hierarchical growth'.
- That is, if the black holes exist among a dense cluster of stars, the remnant (black hole) of a merger can pair up with another black hole close by to form a binary. This can eventually merge to form a second remnant which is more massive. This process, happening in a hierarchical manner, can explain intermediate mass black hole formation.

> No single star could ever form such a heavy black hole. The only way astronomers think such black holes could form is for a single black hole to devour lots and lots of material to get up to the required heft, or for individual black holes to merge together.

### About Black Hole Merger

- The combination of two or more black holes results in different types of black holes. For eg, **Intermediate-Mass Black Holes and Binary Black Holes.**
- The Intermediate-Mass black hole (IMBH) is a section of black hole weighing in the range 102-105 of the solar masses: much larger than the black holes but under the higher black holes.
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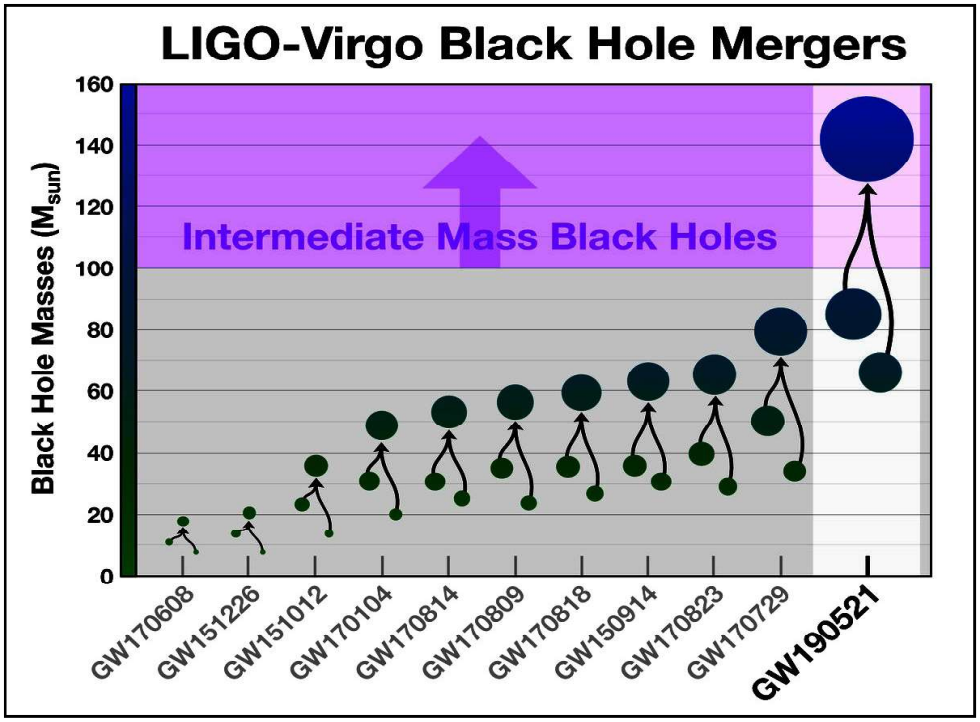


### Kick at the merger

- "Kick" is the opposite pressure received by a black hole left during a merger.
- It is a response to Gravitational Waves that removes equal energy and momentum during the merger.
- These kicks can be quite large, giving it speeds of up to 1000 kilometres per second.
- If this kick velocity is above the escape velocity of the star cluster in which the black hole is formed, it escapes from the environment and moves out. This hinders further hierarchical mergers.
- The extent of kicks received by the remnant can be calculated from the masses of black joint holes and their rotation.
- The kick estimates help understand which mergers have the possibility of forming Intermediate-Mass black holes.

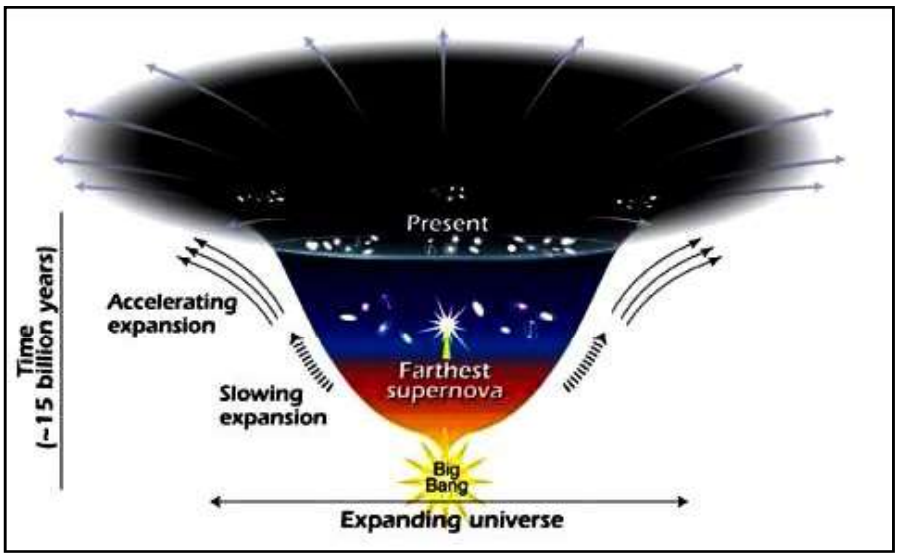
**Note**: Gravitational Waves (GW) are created when two black holes rotate and merge.

## 9. Dark Energy

**Context:** Recently, an international team of researchers made the first putative direct detection of **dark energy.**

### What is Dark Energy?

- Dark energy is the name given to the **mysterious force** that's causing the rate of expansion of our universe to accelerate over time, rather than to slow down.
- That's contrary to what one might expect from a universe that began in a **Big Bang.**
- It turns out that roughly 68% of the universe is dark energy. Dark matter makes up about 27%. The rest, all normal matter, adds up to less than 5% of the universe.




### Explanatory theories for dark energy

- **Property of space:** One explanation for dark energy is that it is a property of space.
- **Empty space:** Albert Einstein was the first person to realize that empty space is not nothing. Then one version of Einstein's gravity theory, the version that contains a cosmological constant, makes a second prediction: "empty space" can possess its own energy.

- **Quantum theory of matter:** Another explanation for how space acquires energy comes from the quantum theory of matter.
  - In this theory, "empty space" is actually full of temporary ("virtual") particles that continually form and then disappear. But when physicists tried to calculate the energy, the number came out 10120 times too big.
- **Dynamical energy fluid or field:** Another explanation for dark energy is that it is a new kind of dynamical energy fluid or field, something that fills all of space but something whose effect on the expansion of the universe is the opposite of that of matter and normal energy.

## 10. Swallowing up of neutron start by black holes

**Context:** A team of international scientists, including those from India, confirms detecting collisions between **black holes and neutron stars** by analyzing **gravitational waves** created in January 2020.

### Key findings

- Scientists detected the gravitational waves, earlier in 2020, as a result of the two mergers of celestial bodies.
- Now, it is found that these waves were generated by the process of swallowing neutron stars by the black hole.
- The first merger involved a black hole about nine times the mass of our sun and a neutron star about 1.9 times the mass of our sun.

### Neutron Stars

- Neutron stars are formed when a massive star runs out of fuel and collapses.
- The very central region of the star, the core, collapses, crushing together every proton and electron into a neutron.
- If the core of the collapsing star is between about 1 and 3 solar masses, these newly-created neutrons can stop the collapse, leaving behind a neutron star.
- Stars with higher masses will continue to collapse into stellar-mass black holes.
- Many neutron stars are likely undetectable because they simply do not emit enough radiation.

### Gravitational waves

- Gravitational waves are **ripples in the space-time fabric.**
- These are created by **extreme events,** such as the collision of two blackholes or two neutron stars.
- They were first discovered in 2015 and since then observed in the **collision between similar cosmic bodies.**

### Laser Interferometer Gravitational-wave Observatory (LIGO)

- It is the **world's largest gravitational wave observatory** and a marvel of precision engineering.

- Comprising two enormous laser interferometers located 3000 kilometers apart, it exploits the physical properties of light and of space itself to detect and understand the origins of **gravitational waves (GW).**
- Unlike optical or radio telescopes, LIGO does not see electromagnetic radiation (e.g., visible light, radio waves, and microwaves).
- It doesn't have to because gravitational waves are not part of the electromagnetic spectrum.
- A single LIGO detector could not initially confirm gravitational waves on its own.

## 11. Neutrino Oscillations induced by Space-time

**Context:** A study conducted by the **National Centre for Basic Sciences (SNBNCBS)** shown that the geometry of space-time can cause neutrinos to oscillate.

### Neutrinos and their oscillation

- A neutrino is a **subatomic particle** that is very similar to an electron, but has no electrical charge and a very small mass, which might even be zero.
- Neutrinos are one of the **most abundant particles in the universe.**
- Because they have very little interaction with matter, however, they are **incredibly difficult to detect.**
- Nuclear force treats electrons and neutrinos identically; neither participate in the strong nuclear force, but both participate equally in the weak nuclear force. Particles with this property are termed leptons.
- They oscillate and different types of neutrinos change into one another.
- The phenomenon of neutrino oscillations requires neutrinos to have tiny masses.
- Probing oscillations of neutrinos and their relations with mass are crucial in studying the origin of the universe.

### Findings of the study

- The geometry of space-time can cause neutrino oscillations through quantum effects even if neutrinos are massless.
- Einstein's theory of general relativity says that gravitation is the manifestation of space-time curvature.
- The neutrinos, electrons, protons, and other particles which are in the category of fermions show a certain peculiarity when they move in presence of gravity.
- Space-time induces a quantum force in addition to gravity between every two fermions.
- This force can depend on the spin of the particles and causes massless neutrinos to appear massive when they pass through matter, like the Sun's corona or the Earth's atmosphere.
- Something similar happens for electroweak interactions, and together with the geometrically induced mass, it is enough to cause oscillation of neutrinos.

### Sources of Neutrinos

- Natural sources of neutrinos include the radioactive decay of primordial elements within the earth, which generate a large flux of low-energy electron-anti-neutrinos.
- Calculations show that about 2 percent of the sun's energy is carried away by neutrinos produced in fusion reactions there.
- Supernovae too are predominantly a neutrino phenomenon, because neutrinos are the only particles that can penetrate the very dense material produced in a collapsing star; only a small fraction of the available energy is converted to light.
- It is possible that a large fraction of the dark matter of the universe consists of primordial, Big Bang neutrinos.

**Note**: Space-time is a mathematical model which fuses the three dimensions of space and the one dimension of time into a single four-dimensional manifold.

## 12. Three-dimensional distribution of molecular & atomic hydrogen in galaxies

**Context:** A researcher, at **Raman Research Institute (RRI), Bengaluru**, has estimated the **three-dimensional distribution of molecular and atomic hydrogen** in a nearby galaxy which can help lead to clues to the star formation processes and the evolution of the galaxy.

### Key Features of the Study

- The estimates are based on the phenomenon of the galaxies like, the **Milky Way**, which consists of **discs containing stars, molecular and atomic hydrogen, and helium.**
- The spectral lines of **carbon monoxide (CO)** were studied to accurately trace molecular hydrogen, whose spectral lines are more difficult to observe.

### What are Spectral lines?

- These are narrow emission or absorption features in the **spectra of gaseous and ionized sources.**
- Spectral lines are powerful diagnostics of physical and chemical conditions in astronomical objects.
- Their rest frequencies identify the specific atoms and molecules involved, and their **Doppler shifts measure radial velocities.**
- These velocities yield **the redshifts and Hubble distances of extragalactic sources**, plus rotation curves and radial mass distributions for resolved galaxies.
- Spectral lines of the **CO molecule** are used to infer the three-dimensional distribution of both the narrow disc component and the diffuse component of molecular hydrogen.

### Role of Molecular Hydrogen gas in star formation

- The molecular hydrogen gas converts to individual stars under the pull of gravity, thus holding clues to the star formation processes and the evolution of the galaxy.
- The atomic hydrogen extends both above and below the discs.
- It has also been estimated that molecular hydrogen extends farther from the disc in both directions, up to about 3000 light-years.

- This gaseous component is warmer than the one straddling the disc and has comparatively lesser densities. This is known as the 'diffuse' component of the molecular disc.

### Outcomes of the study

- The research says that the extension of gas may explain the occurrence of stars at a few thousand light-years perpendicular to the galactic disc.
- Research found that the diffuse component makes up about 70 percent of the molecular hydrogen, and this fraction remains roughly constant along the radius of the disc.

## 13. Hidden 'Goldilocks' black hole exposed by early universe explosion

**Context:** Analysis of light of a **gamma-ray burst**, which dates back three billion years ago, has revealed the presence of a previously undetected black hole.

### Findings

- The discovered black hole is **Intermediate-mass black holes** which is an elusive category of black holes that were considered non-existing until a few years ago.
- The gravitational lensing technique was used to detect the black hole. It is then used to identify the **intermediate-mass black hole (IMBH)** which lensed the gamma-ray burst.

### Gamma-ray burst

- The gamma-ray burst that is known as **GRB 950830** was detected in 1995.
- GRBs are the most energetic form of electromagnetic events in the universe having short bursts of gamma rays that ejected at the speed of light.
- Gamma-ray bursts are formed when a high-mass star collapses and creates a neutron star or black hole.

## 14. Nobel Prize in Physics, 2021

**Context:** The Nobel Prize in Physics 2021 was awarded "for groundbreaking contributions to our understanding of complex systems" with-

- One half jointly to **Syukuro Manabe and Klaus Hasselmann** "for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming".
- The other half to **Giorgio Parisi** "for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales."

### Nobel Prize in Physics

- Physics was the prize area which **Alfred Nobel** mentioned first in his will from 1895.
- At the end of the nineteenth century, many people considered physics as the foremost of the sciences, and perhaps Nobel saw it this way as well.
- His own research was also closely tied to physics.
- The Nobel Prize in Physics is awarded by **the Royal Swedish Academy of Sciences, Stockholm, Sweden.**

## 15. China's 'artificial sun' experimental fusion reactor set a new record

**Context:** China's 'artificial sun' EAST achieved a peak temperature of 288 million degrees Fahrenheit, which is over ten times hotter than the sun, for 20 second.

### About China's 'artificial sun' EAST

- The **Experimental Advanced Superconducting Tokamak (EAST)** reactor is an advanced nuclear fusion experimental research device located at the **Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP)** in Hefei, China.
- The purpose of the artificial sun is to replicate the process of nuclear fusion, which is the same reaction that powers the sun.
- The EAST is one of three major domestic tokamaks that are presently being operated across the country.
- It first became operational in 2006.
- EAST has set several records for the duration of confinement of exceedingly hot plasma.
- The EAST project is part of the **International Thermonuclear Experimental Reactor (ITER) facility,** which will become the world's largest nuclear fusion reactor when it becomes operational in 2035.
- The project includes the contributions of several countries, including **India, South Korea, Japan, Russia and the United States.**

### Working of EAST

- The EAST Tokamak device is designed to replicate the nuclear fusion process carried out by the sun and stars.
  - Nuclear fusion is a process through which high levels of energy are produced without generating large quantities of waste.
  - For nuclear fusion to occur, tremendous heat and pressure are applied on hydrogen atoms so that they fuse together.
  - The nuclei of deuterium and tritium — both found in hydrogen — are made to fuse together to create a helium nucleus, a neutron along with a whole lot of energy.
- Fuel is heated to temperatures of over 150 million degrees C so that it forms a hot plasma "soup" of subatomic particles. With the help of a strong magnetic field, the plasma is kept away from the walls of the reactor to ensure it does not cool down and lose its potential to generate large amounts of energy.
- The plasma is confined for long durations for fusion to take place.

## 16. 'The Unicorn', closest known black hole to Earth

**Context:** Scientists named a newly discovered and the closest to our solar system black hole, in the Milky Way galaxy, as **Unicorn**. It may be the **smallest known black hole.**

### About Unicorn

- It is roughly three times the mass of our sun, located about 1,500 light-years away from Earth.
- A luminous star known as a red giant, orbits with the black hole in a binary star system, named **V723 Mon.**

- It is nicknamed as the Unicorn' partly because V723 Mon is in the Monoceros constellation that translates to unicorn and partly because it is a unique system.
- It is said to be the **smallest known black hole.**
- It is thought to be formed by the gravitational collapse of a single star.
- 'The Unicorn' falls into a "mass gap", that is between, the largest-known neutron at around 2.2 times the mass of our sun and the smallest black holes at around five times the sun's mass.
- Its strong gravity causes the tidal distortion which alters the shape of its companion star.
- It makes the star elongated rather than spherical and causes its light to change as it moves along its orbital path.

### Some of the discovered black holes

- The closest black hole to Earth is a part of the system **HR 6819** and is active just 1,000 light-years from earth.
- The smallest known black hole is **GRO J0422+32**. It was discovered in 1992 at around 7,800 light-years from us.
- A supermassive black hole called **Sgr A*** and is 26,000 light-years from Earth. It holds a mass of at least 40 lakh times the Sun's.
- The first-ever black hole detected was **Cygnus X-1** in 1964.

## 17. Muon g–2: challenge to particle physics

**Context:** The newly published results of an international experiment show the possibility of **new physics which would govern the laws of nature.**

### Key-highlights of the Study

- A subatomic particle called the **muon** were studied and do not match the predictions of the **Standard Model.**

### Standard Model

- The Standard Model is a theory to predict the behaviour of the **building blocks of the universe.**
- It forms the rules for six types of quarks, six leptons, the Higgs boson, three fundamental forces, and how the subatomic particles behave under the influence of electromagnetic forces.
- The g-factor can be calculated precisely using the **Standard Model.**

- The experiment which is called **Muon g–2 (g minus two)** was conducted at the **US Department of Energy's Fermi National Accelerator Laboratory (Fermilab).**
- The rate at which the muon wobbles is described by the **g-factor,** the quantity that was measured.
- This value is known to be close to 2, so scientists measure the deviation from 2. Hence the name g–2.

### Muon

- The muon is one of the **leptons.**
- A muon is about **200 times as massive as its cousin, the electron.**
- They occur naturally when cosmic rays strike Earth's atmosphere, and particle accelerators at **Fermilab** can produce them in large numbers.
- Like electrons, muons act as if they have a tiny internal magnet.
- In a strong magnetic field, the direction of the muon's magnet precesses, or wobbles, much like the axis of a spinning top or gyroscope.
- The strength of the internal magnet determines the rate that the muon precesses in an external magnetic field and is described by a number that physicists call the g-factor. This number can be calculated with ultra-high precision.
- As the muons circulate in the **Muon g-2** magnet, they also interact with a quantum foam of subatomic particles popping in and out of existence.
- Interactions with these short-lived particles affect the value of the g-factor, causing the muons' precession to speed up or slow down very slightly.
- The Standard Model predicts this so-called anomalous magnetic moment extremely precisely. But if the quantum foam contains additional forces or particles not accounted for by the Standard Model, that would tweak the muon g-factor further.
- This quantity reflects the interactions of the muon with everything else in the universe.

## 18. Discovery of 12 rare 'quadruple quasars' can better tell the rate of universe expansion

**Context:** The international astronomers from the **Gaia Gravitational Lenses Working Group (GraL)** have discovered **12 rare quasars.**

### About the rare quadruple quasars

- Quasars are distant galaxies with **extremely luminous nuclei.**
- They consist of **black holes.**
- They measure many million times larger than our Sun.
- They are surrounded by thick gaseous matter.
- The first quadruple quasar image was captured in 1985.
- The latest finding has now increased the total confirmed Einstein's crosses by 25 percent.

### Significance

- Quasar observations are mainly used-
  - to study dark matter in determining the evolution of galaxies
  - to understand the rate of expansion of the universe., which is measured by using the Hubble-Lemaítre constant

### Hubble-Lemaítre constant

- It is expressed by the equation v = H0D, with H0 the constant of proportionality.
- Hubble constant is most frequently quoted in (km/s)/Mpc.
- Its value is about 70 (km/s)/Mpc.

- The SI unit of H0 is simply s−1, and the SI unit for the reciprocal of H0 is simply the second.
- The reciprocal of H0 is known as the Hubble time.
- The Hubble constant can also be interpreted as the relative rate of expansion.

### How the study is conducted for quasars?

- Each of the discovered quasars offers four distinct quadruple images, which is commonly called Einstein's cross.
- Gravity causes massive objects like galaxies and emissions from them to bend over time and space. Emissions from a quadruple quasar are said to bend over time and space causing 'natural' lenses.
- Some deflection is resultant of the presence of numerous galaxies which act as barriers located between a source and Earth, ultimately split it into four images.
- Big Data and Augmented Intelligence were applied to confirm this rare discovery.

## 19. CERN Collider discovered the existence of New Force of Nature

**Context:** The scientists working at **CERN Collider** have seen evidence of the existence of a new force of nature.

### The Standard Model of fundamental particles

- The universe is found to be constituted of a few basic building blocks, known as fundamental particles. These particles are governed by four fundamental forces.
- The interaction between the particles and three of the forces was studied through a model of particle physics developed in the 1970s.
- The standard model says that nature is studied at a fundamental scale through particles known as lepton and quarks and the forces which exist between them.
- The beauty quarks (one of the subtypes of quark) decay into leptons known as **'muons'.**

### New finding

- A difference in the decay rate of muons and electrons was observed.
- It is expected that a new unseen particle or force is behind this differential rate of decay.
- Two particles Z prime and lepto-quark are considered to be the expected particles as a part of the experiment to support the finding.
- It could help in finding the new fundamental particles which will the physical phenomenon further.
- It could help in studying the invisible dark matter or nature of Higgs boson.

### Large Hadron Collider (LHC)

- It is the world's most powerful and largest particle accelerator.
- The accelerator is in a tunnel on the Franco-Swiss border near Geneva, Switzerland, underground at **CERN, the European Organization for Nuclear Research.**

## CERN

- Founded in 1954, the **CERN laboratory** sits astride the **Franco-Swiss border** near Geneva.
- It is a European research organization that operates the largest particle physics laboratory in the world.

- The collider was started in 2008.
- It consists of a 27-kilometer ring of superconducting magnets along accelerating structures to boost the energy of the particles through their way.
- The two high-energy particle beams travel closer to the speed of light before they meet to Collide.
- The beams travel in opposite directions in separate beam pipes – two tubes kept at ultrahigh vacuum. They are guided by a strong magnetic field maintained through the superconducting electromagnets.
- It made a breakthrough discovery of **Higgs Boson in 2012.**

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# 2 CHEMISTRY

## 1. India's First Indigenous Fuel Cell System

**Context:** India's first indigenous **High Temperature Fuel Cell System** has been developed by **Council of Scientific and Industrial Research (CSIR)** in partnership with Indian industries under the program named **"New Millennium Indian Technology Leadership Initiative (NMITLI)".**

### About HT-PEMFCs

- The Fuel Cells developed are based on **High Temperature Proton Exchange Membrane (HTPEM) Technology.**
- High temperature proton exchange membrane fuel cells are one type of promising energy device with the advantages of fast reaction kinetics (high energy efficiency), high tolerance to fuel/air impurities, simple plate design, and better heat and water management.
- They have been expected to be the next generation of PEMFCs specifically for application in hydrogen-fueled automobile vehicles and **combined heat and power (CHP) systems.**
- It is **5.0 kW fuel cell system,** which generates power in a green manner using methanol / bio-methane, with heat and water as bi-products for further use.
- It amounts to efficiency greater than 70%, which otherwise may not be possible by other energy sources.
- The fuel cell system will meet the requirement of efficient, clean and reliable backup power generator for telecom towers, remote locations and strategic applications as well.
- However, their high-cost and low durability interposed by the insufficient performance of key materials such as **electrocatalysts** and membranes at high temperature operation are still the challenges hindering the technology's practical applications.

## 2. Discovery of new enzyme for cell stability

**Context:** The **Centre for Cellular and Molecular Biology (CCMB)** scientists have discovered an enzyme that helps maintain the stability and integrity of cell walls in bacteria such as *Escherichia coli*.

### The newly discovered enzyme

- The enzyme named as **'LdtF'**, plays a vital role in the formation of covalent linkages between the bacterial outer membrane and an inner polymer layer that protects bacteria from environmental stress.

- Absence of this LdtF enhances growth defects and increases the **peptidoglycan-lipoprotein linkages** in the bacteria.
- The presence of this enzyme, however, decreases the levels of **peptidoglycan-bound lipoprotein,** suggesting its role in modulating the peptidoglycan-lipoprotein linkages.
- Such LdtF-mediated modulation of the cell wall gives bacteria flexibility and a survival advantage in fluctuating environmental conditions.
- This study will help understand the fundamental bacterial cell wall biology and identify alternate drug targets for the development of new antimicrobials.

## 3. Transparent wood

**Context:** As per a new study, researchers have found a way to make **wood transparent** without using huge amounts of energy in the process.

### Wood's opaqueness

- Wood's lack of transparency comes from the combination of its two main components-
  - Cellulose
  - Lignin
- The fibres in the wood, which mainly comprise cellulose, are hollow tube-like structures. The air in these hollow tubes scatter light, further reducing the material's transparency.
- The lignin absorbs light, and the presence of chromophores – light activated compounds – in the material makes the **wood look brown.**

### The new method

- The new study demonstrates how to make wood transparent using a simple chemical – **hydrogen peroxide** – commonly used to bleach hair.
- This chemical modifies the chromophores, changing their structure so they no longer act to absorb light and colour the wood.
- The chemical can be brushed onto the wood, and then activated using light to produce a brilliant white material.

### Usage of transparent wood

- Transparent wood would be much more resistant to accidental breakage.
- It could become an alternative to glass in energy efficient buildings, or perhaps coverings for solar panels in harsh environments.

## 4. Nobel Prize in Chemistry, 2021

### Context:

- The Royal Swedish Academy of Sciences decided to award the Nobel Prize in Chemistry 2021 to
  - **Benjamin List, Max-Planck-Institut für Kohlenforschung, Mülheim an der Ruhr, Germany**
  - And **David W.C. MacMillan, Princeton University, USA** "for the development of **asymmetric organocatalysis**"

### Organocatalysis

- Many research areas and industries are dependent on chemists' ability to construct molecules that can form elastic and durable materials, store energy in batteries or inhibit the progression of diseases.
- This work requires **catalysts,** which are substances that control and accelerate chemical reactions, without becoming part of the final product.
  - Catalysts are thus fundamental tools for chemists, but researchers long believed that there were, in principle, just two types of catalysts available:
    - metals
    - enzymes
- **Organocatalysis (enzymes)** does the same thing in a biochemical reaction.
- They bind to the reacting molecules to form short-lived intermediates that are more reactive than the substrate molecules on their own.

### Asymmetric organocatalysis

- **Benjamin List** and **David MacMillan** were awarded the Prize because in 2000 they, independent of each other, developed a third type of catalysis.
- It is called **asymmetric organocatalysis** and builds upon small organic molecules.
- The rapid expansion in the use of **organic catalysts** is primarily due to their ability to drive asymmetric catalysis.
- When molecules are being built, situations often occur where two different molecules can form, which – just like our hands – are each other's mirror image.
- Chemists will often only want one of these, particularly when producing pharmaceuticals.
- Being chiral (a type of molecule that has all its attached groups distinct, and has non-superimposable mirror image), the catalyst transfers its handedness to the substrate, controlling which side of the intermediate can react further.
- Using these organocatalyzed reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells.
- In this way, organocatalysts are bringing the greatest benefit to humankind.

## 5. Recyclable Battery made From Amino Acids

**Context:** Researchers at **Texas A&M** developed a battery that would be lightweight and powerful, like **lithium-ion batteries** and more easily recyclable.

### About the amino acid batteries

- **Basic material:** Polypeptides (polymers of amino acids)
- **Conduction:** Although polypeptides are not inherently conductive, the researchers modified them by attaching structural units that can transfer electrons back and forth.
- **Electrodes:** Mixture of polypeptides and carbon black (a conductive material)
- **Reusability:** 250 times in a one go; then, the researchers disassembled the batteries and broke the electrodes down into amino acids and other small molecule building blocks to be reused to re-build battery electrodes again.

**Note**: Amino acids are organic compounds that contain **amino (–NH2) and carboxyl (–COOH)** functional groups and are the structural units (monomers) that make up proteins, the building blocks of organism.

## 6. Oxygen movement in ferroelectricity materials

**Context:** Using state-of-the-art **atomic resolution microscopy**, scientists have shown experimentally, for the first time, how an unusual form of **ferroelectricity** arises in certain **nano-sized materials.**

Nanomaterials are materials with at least one external dimension that measures 100 nanometers (nm) or less or with internal structures measuring 100 nm or less.

### Findings of the Study

- When an electric field is applied, ferroelectricity arises in materials called **hafnia-based oxides**, due to the displacement and reversible movement of negatively charged oxygen atoms.
- These findings were also confirmed by **X-ray diffraction** studies carried out in Sweden.
- The insights offered by the study open up new avenues for designing oxygen-conducting ferroelectric materials that could be used for miniature memory and logic devices.

### Hafnia-based oxides

- It is a chemical element with symbol **Hf** and **Atomic Number 72.**
- It is a **lustrous, silvery gray, tetravalent transition metal.**
- Hafnium chemically resembles zirconium and is found in many zirconium minerals.
- Ferroelectric material are generally unsuitable for miniaturisation as they lose their ferroelectric properties when the crystal is made smaller than a particular size.
- Hafnia-based oxides provide an alternative for this as they could exhibit ferroelectricity even when they are nano-sized.
- Their ferroelectricity even grows stronger as the material size gets smaller that opens up numerous opportunities for microelectronics.

### Ferroelectric materials and Semiconductor industry

- They are like magnets in which they show spontaneous polarization (the separation of positive and negative charges) which can be reversed or switched using an electric field.
- Because ferroelectrics have two stable polarization states, they can be used to store information in computer memory.
- If a thin ferroelectric material is sandwiched between two metals, it acts as a barrier to the flow of current.
- Another important development is a **negative capacitance field effect transistor (nc-FET)** for use in computer processors.
- In this type of device, a ferroelectric and traditional dielectric are connected in series under the gate of a transistor.

# 7. Producing low-cost and energy-efficient hydrogen fuel with the help of magnets

**Context:** **Indian researchers (at IIT Bombay)** have come up with an **innovative hydrogen manufacture route** which increases its production three times and lowers the energy required that could pave the path towards environment-friendly **hydrogen fuel** at a lower cost.

## About the study

- To extract hydrogen from water, researchers insert two electrodes across water and pass current.
- The study has used a compound consisting of cobalt and oxygen in lieu of metals like **Platinum, Rhodium, and Iridium** to speed up electrolysis at a much lower cost because transition metals have more **'valency'** –– the ability to exchange electrons with other.
- To further increase the speed of electrolysis, the researchers used magnetic fields, by introducing a small fridge magnet near their setup, and the reaction speed increased about three times.
- They found that the electrolysis consumed 19% less energy in a stipulated time.

- Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water.
- Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind.

## Significance

- As a fuel, hydrogen has a critical role to play in driving the **paradigm shift** towards a **green and sustainable economy.**
- In addition to having about 3-fold higher calorific value compared to non-renewable energy sources such as coal and gasoline, product is non-polluting.
- Due to the extremely low abundance of molecular hydrogen in the **earth's atmosphere (350 ppbv)**, electric-field driven breakdown of water is an attractive route for production of hydrogen.
- However, such electrolysis requires high energy input and is associated with slow rate of hydrogen production.
- The use of expensive platinum- and iridium-based catalysts also discourages it for wide-spread commercialization.
- Therefore, the transition to **'green-hydrogen-economy'** demands approaches that lower the energy cost and material cost and simultaneously improve the hydrogen production rate.

## Notes

- In their study, the researchers showed that the cobalt oxide was affected by the magnetic fields.
- Even after the researchers removed the external magnet, the reaction still took place about three times faster than in the absence of the magnetic field because the catalyst, cobalt oxide, can sustain the magnetization for prolonged periods.
- A one-time exposure of the magnetic field is enough to achieve the high speed of hydrogen production for over 45 minutes, i.e. more energy-efficient.

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# 3 BIOLOGY

## 1. Autosomal DNA

**Context:** A technique based on 'autosomal DNA' has been used for the **first time** to identify the great-grandson and closest living relative of **Sitting Bull**, a prominent **19th century Native American leader.**

### What is Autosomal DNA?

- DNA comes in long stretches called chromosomes and people typically have 23 pairs of **chromosomes** for a total of 46.
- There are two broad categories of chromosomes—
  - autosomal
  - sex chromosomes
- **Sex chromosomes** are made up of X and Y chromosomes and people typically have either a pair of X chromosomes or X and Y chromosomes.
- **Autosomal chromosomes** make up the other 22 pairs and most everyone has a complete set of these.
  - An autosomal DNA test only looks at the DNA from these 22 **chromosome pairs.**
  - The autosomal DNA technique can be used even when very limited genetic data are available, like in this case.
  - It could be used in the future to identify living descendants of other long-dead historical figures.

### Significance

- Usually, DNA techniques such as **mitochondrial DNA**, have been used in genetic searches.
- The autosomal DNA test provides results that are more relevant to recent family connections than either **mitochondrial DNA (mtDNA) or Y-DNA tests**, because it considers genetic information that you share with all members of your family.
- While a Y-DNA test traces only paternal lineage, and mtDNA test traces matrilineal (mother's female) ancestry, an autosomal DNA test will yield meaningful results to everyone.

### Sitting Bull

- Sitting Bull is most famous for his victory over **US General George Armstrong Custer** in the **Battle of the Little Bighorn River in 1876.**
- Five companies of the US Army were completely wiped out in the battle, considered widely to be the most significant Native American military victory in US history.
- Sitting Bull, who hailed from the Lakota branch of the **Great Sioux Nation or Oceti Sakowin**, was killed in 1890 by 'Indian Police', acting on behalf of the US government.

## 2. Smuggling of Ambergris

**Context:** In the multiple raids this year, the Mumbai Police arrested five persons trying to sell **Ambergris or whale vomit.**

### What is Ambergris?

- Ambergris is generally referred to as **whale vomit.**
- Often described as one of the **world's strangest natural occurrences**, it is produced by **sperm whales** and has been used for centuries, although remain a mystery.
- It is a solid waxy substance that floats around the surface of the water body and at times settles on the coast.
- There are conflicting opinions as to how ambergris emerges from the whale. Some believe that the whale regurgitates the mass, earning it its well-known nickname **'whale vomit'.**
- Some think the whale will pass the mass, whereas others believe the obstruction grows so large it eventually fatally ruptures the whale's rectum.

### How valuable is this?

- This excretion is so valuable it is referred to as **floating gold.**
- As per the latest estimates, 1 kg of ambergris is **worth Rs 1 crore in the international market.**
- **Ambrein**, an odourless alcohol, is extracted from ambergris and used to make a perfume's scent last longer.
- It is also believed to be used in some **traditional medicines.**

# 3. Monoclonal antibody therapies

## Context:

- India is facing shortages of the two **monoclonal antibody** therapies the:
  - Itolizumab
  - Tocilizumab

## About the Monoclonal antibodies

- The immune system is able to create antibodies which are **tiny Y-shaped proteins** in our blood.
- Monoclonal antibodies are artificially created antibodies which aim to aid the **body's natural immune system.**
- They target a specific antigen which is a protein from the pathogen that induces immune response.

## What is monoclonal antibodies therapy?

- In 1900, the **Nobel Laureate German immunologist, Paul Ehrlich** proposed the idea of a 'Zauberkugel' (magic bullet).
  - It is a compound which **selectively targets the pathogen.**
- **Muromonab-CD3** was the **world's first monoclonal antibody** to be approved for clinical use in humans.
- Monoclonal antibodies are created in the lab by exposing white blood cells to a particular antigen.
- In the case of Covid-19, these are produced by using the spike protein of the **SARS-CoV-2 virus.**
- To increase the quantity of antibodies produced, a single white blood cell is **cloned**, which in turn is used to create identical copies of the antibodies.

## Itolizumab

- It was developed by **Bengaluru-based biopharma company Biocon.**
- The **Drugs Controller General of India** had authorized it for **"restricted emergency use"** in the country in June 2020.
- It targets **CD6**, a protein found in the outer membrane of a **T-cell (plays a central role in the body's immune response)**
- By binding to **CD6** it tones down T-cell activation and causes reduction in synthesis of **pro-inflammatory cytokines.**

## Tocilizumab

- This monoclonal antibody has got approved from the FDA to treat **rheumatologic disorders.**
- It also inhibits **IL-6 activity**, and was proposed as a potential therapy for severe Covid.
- The drug is currently approved for off-label use in India, which means it can be used after informed consent of patients.

## Other monoclonal antibody therapies developed worldwide

- The US FDA authorised the emergency use of the combination **bamlanivimab and etesevimab.**
  - Both the antibodies target the spike protein of the **SARS-CoV-2 virus.**

- US-based biotechnology company **Regeneron Pharmaceuticals developed a drug REGN-COV2.**
  - The drug REGN-COV2 is a cocktail of two antibodies, **casirivimab and imdevimab.**
- The drug is meant for use in mild-to-moderate Covid-19 patients who are not on oxygen support, but who may be at risk of severe disease.

## 4. Detailed genome of the malaria mosquito vector

**Context:** In a latest development, scientists have unveiled the **detailed genome** of the **malaria mosquito vector**, revealing thousands of **new genes** vital for the development of genetic control strategies of disease transmission.

### About Malaria

- Malaria is a parasitic infection transmitted by **Anopheline mosquitoes.**
- **Host:** Humans and anopheline mosquitoes are both considered to be the parasite's hosts.

- **Vectors:** Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans.
- **Vector-borne diseases:** Vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by vectors.

### Key highlights of the findings

- New 'gold standard' reference genome reveals thousands of new genes vital for targeting **pathogen transmission and immunity.**
- Scientists produced a new reference genome for the **Asian malaria vector mosquito *Anopheles stephensi***, a malaria vector mosquito in South Asia and invaded the horn of Africa.
- The newly revealed genes play key roles in blood feeding and the metabolism of ingested blood meal, reproduction and immunity against microbial parasites.
- The findings include 29 previously undetected genes that play critical roles in resistance to chemical insecticides.
- The new genome assembly is a comprehensive and accurate map of genomic functional elements and will serve as a foundation for the new age of active genetics in A. Stephensi.

### Genome

- A genome is all genetic material (coding as well as noncoding regions) of an organism. It consists of **DNA (or RNA in RNA viruses).**
- It also included **mitochondrial DNA and chloroplast DNA (in photosynthetic organisms).**
- The study of the genome is called **Genomics.**

## 5. Depletion of particular brain tissue linked to chronic depression, suicide: Study

**Context:** In a recent research, a common characteristic has been found in the brain structure of people who died by suicide. There was a sharp fall in the density of **'Astrocytes'**, a particular nerve cell throughout the brain.

### What is Astrocytes?

- It is a type of supportive **nerve cells**, look like the end of a frayed rope.
- They are **highly heterogeneous neuroglial cells** with distinct functional and morphological characteristics in different parts of the brain.
- They are responsible for maintaining a number of complex processes needed for a healthy **central nervous system (CNS).**

### Key-highlights of the Study

- Three regions of the brain that are considered to be responsible for emotion regulation — **dorsomedial prefrontal cortex, dorsal caudate nucleus and mediodorsal thalamus**
- Scientists found that the number of astrocytes, was much lower in brains of people who had died by suicide.
- The density was five times lower in the mediodorsal thalamus and caudate nucleus and half in the prefrontal cortex in the subjects who had died by suicides than those with no psychiatric conditions.
- The research also noted that depression impacted the quantity of these nerve cells rather than their structure.
- It, however, doesn't establish the reason behind this depletion of astrocyte volume.

## 6. DNA from air may help identify, track animals in the wild: Studies

### Context:

Researchers from two teams have independently shown that **environmental DNA (e-DNA)** can potentially identify and monitor terrestrial animals.

### About e-DNA

- Animals shed DNA through their **breath, saliva, fur or faeces** into the environment. These samples are called **e-DNA or environmental DNA.**
- Tracking animals through e-DNA isn't a new idea. Biologists have frequently observed aquatic organisms by sequencing e-DNA from water samples.

### Studies

- The experiments were performed by filtering air at different locations in two zoos — in Copenhagen and in the UK.
- Researchers have found that **Airborne DNA** can yield valuable genetic material that can identify ecological interaction between different species, besides recognizing the animals.

- After extracting DNA from the air, **polymerase chain reaction (PCR)** and then DNA sequencing was performed.

### Advantages of e-DNA sampling

- Airborne e-DNA sampling is a bio monitoring method that is rising in popularity among biologists and conservationists as it provides abundant information.
- Airborne e-DNA capturing can aid after predator-prey interactions and predation events, i.e. when an animal eats another.
- It can aid in tracking long-distance migratory birds and other birds' flying patterns.
- It can also capture DNA from smaller animals including insects. Last year, a proof-of-concept study used airborne e-DNA to monitor terrestrial insects.

## 7. Dementia cases in India to be increased by 197% by 2050

**Context:** As per the **Global Burden of Disease Study 2019** published in **Lancet**, in India, the number of people with dementia will increase by 197% between 2019 and 2050.

### Key Highlights of the Report

- Worldwide, the caseload is set to almost triple to 153 million in 2050 from 57 million in 2019, said the report.

### What is Dementia?

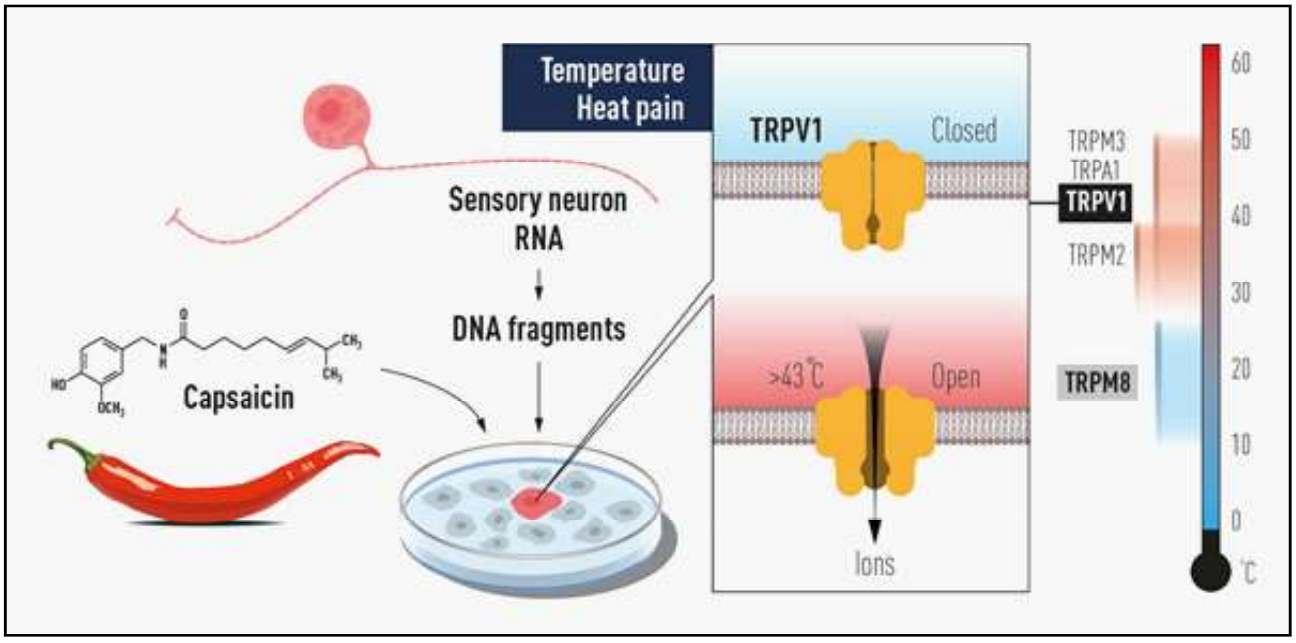
- It is currently the **seventh leading cause of death** worldwide and one of the major causes of disability and dependency among older people worldwide.
- It is a term used to describe a group of symptoms affecting memory, thinking and social abilities severely enough to interfere with your daily life.
- It is caused by damage to or loss of nerve cells and their connections in the brain.
- It isn't a specific disease, but several diseases can cause dementia.
- Alzheimer's disease is the most common cause of a progressive dementia in older adults, but there are a number of other causes of dementia.
- Although dementia mainly affects older people, it is not an inevitable consequence of ageing.
- Up to 40% of dementia cases could be prevented or delayed if exposure to 12 known risk factors were eliminated.
- These are low education, high blood pressure, hearing impairment, smoking, midlife obesity, depression, physical inactivity, diabetes, social isolation, excessive alcohol consumption, head injury, and air pollution.

## 8. Nobel Prize in Physiology and Medicine, 2021

**Context:** The Nobel Assembly at **Karolinska Institute** decided to award the **2021 Nobel Prize in Physiology or Medicine** jointly to **David Julius** and **Ardem Patapoutian** for their discoveries of receptors for temperature and touch.

## Research of these Laureates

- David Julius utilized capsaicin, a pungent compound from chili peppers that induces a burning sensation, to identify a sensor in the nerve endings of the skin that responds to heat.
- **Ardem Patapoutian** used pressure-sensitive cells to discover a novel class of sensors that respond to mechanical stimuli in the skin and internal organs.
- These breakthrough discoveries launched intense research activities leading to a rapid increase in our understanding of how our nervous system senses heat, cold, and mechanical stimuli.
- The laureates identified critical missing links in our understanding of the complex interplay between our senses and the environment.
- Capsaicin was already known to activate nerve cells causing pain sensations, but how this chemical actually exerted this function was an unsolved riddle.
- Julius and his co-workers created a library of millions of DNA fragments corresponding to genes that are expressed in the sensory neurons which can react to pain, heat, and touch.
- They expressed individual genes from this collection in cultured cells that normally do not react to capsaicin.
- A single gene was identified that was able to make cells capsaicin sensitive.
- The gene for capsaicin sensing had been found.
- Further experiments revealed that the identified gene encoded a novel ion channel protein and this newly discovered capsaicin receptor was later named TRPV1.
- When Julius investigated the protein's ability to respond to heat, he realized that he had discovered a heat-sensing receptor that is activated at temperatures perceived as painful.




- Independently of one another, both David Julius and Ardem Patapoutian used the chemical substance menthol to identify TRPM8, a receptor that was shown to be activated by cold.
- Additional ion channels related to TRPV1 and TRPM8 were identified and found to be activated by a range of different temperatures.

## 9. DBT-NII Receives Trademark for India's First Indigenous Tumour Antigen SPAG9

**Context:** In a recent development, the **SPAG9 antigen** which was discovered by **Dr Anil Suri in 1998**, has received the trademark **ASPAGNIITM.**

### ASPAGNIITM and Immunotherapy

- Immunotherapy is a new approach that exploits the **body's inner capability** to put up a fight against cancer.
- With this approach, either the immune system is given a boost, or the T cells are "trained'' to identify recalcitrant cancer cells and kill them.

> T-cells are a type of white blood cell that work with **macrophages**. Unlike macrophages that can attack any invading cell or virus, each T-cell can fight only one type of virus.

- Currently, **ASPAGNIITM** is being used in **dendritic cell (DC)** based immunotherapy in cervical, ovarian cancer and will also be used in breast cancer.
- In this personalized intervention, those patients expressing SPAG9 protein can be treated with DC-based vaccine approach.
- In DC-based vaccine, patient's cells called monocytes from their blood are collected and modified into what are called dendritic cells.
- These dendritic cells are primed with ASPAGNIITM and are injected back to the patient to help the 'fighter' cells, or T-cells, in the body to kill the cancer cells.
- DC-based immunotherapy is safe, affordable and can promote antitumor immune responses and prolonged survival of cancer patients.

## 10. GlycoRNAs, a new kind of biomolecule

**Context:** Stanford researchers make **'bombshell'** discovery of an entirely **new kind of biomolecule**, consisting of **RNA modified by sugars**, could be present in all forms of life and might contribute to autoimmune disease.

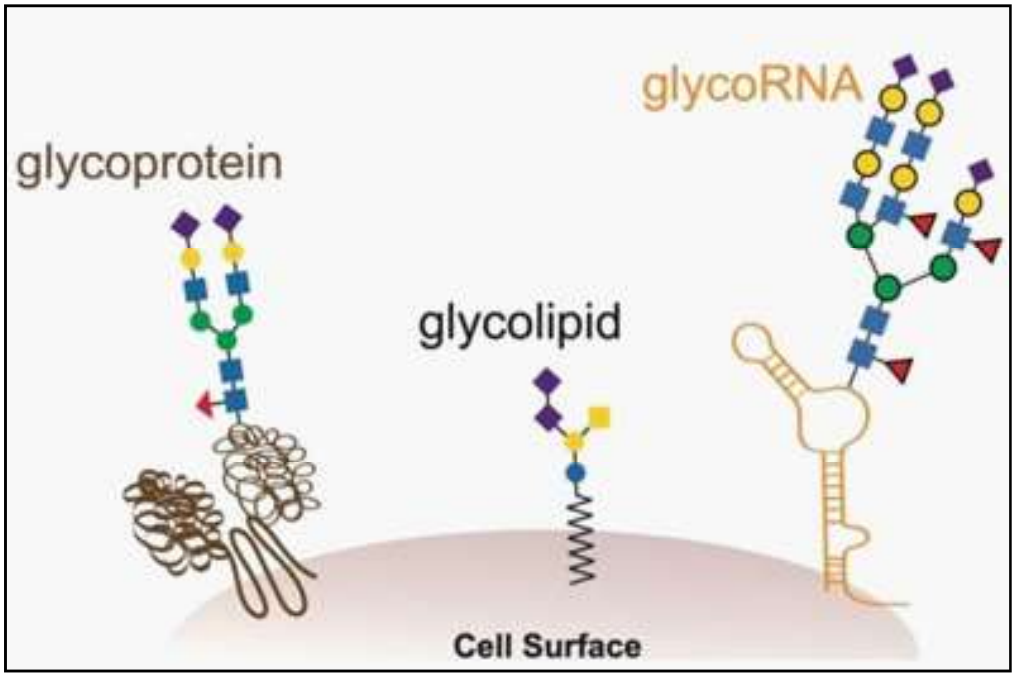
### About the finding

- Glycans are a **common carbohydrate** found on **cell surfaces** that are known to modify **lipids (fats) and proteins** in a process called **glycosylation.**
- Now there's evidence that some living things use RNA as a third scaffold for glycosylation.

### GlycoRNA

- GlycoRNA is a small ribbon of **ribonucleic acid (RNA)** with sugar molecules, called glycans, dangling from it.
- Up until now, the only kinds of similarly **sugar-decorated biomolecules** known to science were **fats (lipids) and proteins.**
- These glycolipids and glycoproteins appear ubiquitously in and on animal, plant and microbial cells, contributing to a wide range of processes essential for life.

- Analysis of living cells revealed that the majority of **glycoRNAs** are present on the cell surface and can interact with anti-dsRNA antibodies and members of the **Siglec receptor family.**
- Collectively, these findings suggest the existence of a direct interface between RNA biology and glycobiology, and an expanded role for RNA in extracellular biology.

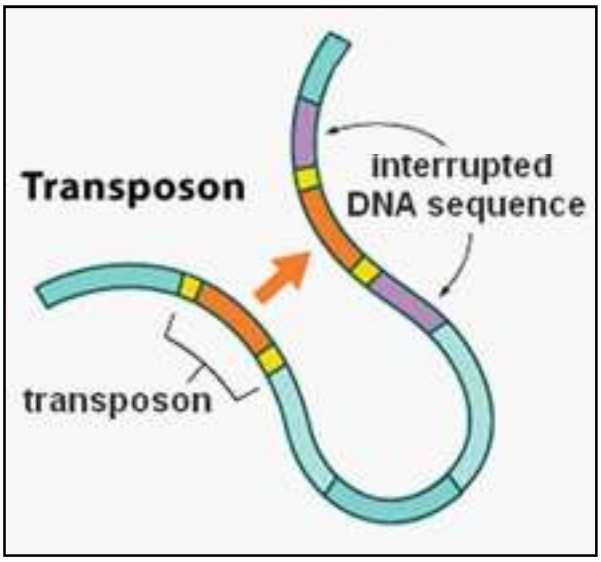



## 11. Jumping' genes role in blood cancers

**Context:** US scientists have found that jumping genes can protect against certain blood cancers and they can also help in developing **new therapeutic targets.**

### What are Jumping genes?

- Jumping genes are also known as **transposons.**
- They are DNA sequences that can move or jump from one location to another location in the genome after activation.
- Jumping genes act as **mutating agents** and are behind several human diseases. They change the gene sequence and genome size.




### About the key findings

- The findings show that jumping genes can help in **predicting the response of cancer therapies.**
- It can also help suggest the **therapeutic targets** for acute myeloid leukemia.
- A transposon that is known as long interspersed element-1 (L1) retro transposons was studied during the study.

- Activation of L1 leads to genome instability which can activate DNA damage response that triggers cell death or prevents the cell's ability to replicate.
- A known regulator of L1, that is **MPP8**, is found to be essential for cancer cell survival.
- MPP8 blocks the activity of L1 and helps in cancer cell survival
- Inactivation of MPP8 triggers L1 to turn on its damaging activity.

### Significance of the study

- As they help in the degeneration of the DNA sequence of cancer cells, they could be a potential source of therapeutic agent for **cancer therapy.**

## 12. Artificial photosynthesis to provide solutions for carbon capture and conversion

**Context :** Scientists at **Jawaharlal Nehru Centre for Advanced Scientific Research** have found a method to mimic nature's process of reducing carbon dioxide in the atmosphere, namely photosynthesis, to capture excess carbon dioxide in the atmosphere.

### About the finding

- Scientists designed and fabricated an integrated catalytic system based on a **metal-organic framework (MOF-808).**
- It comprises a **photosensitizer** (molecules that absorb light and transfer the electron from the incident light into another nearby molecule).
- It can harness solar power and the catalytic center can eventually reduce CO2.
- **Artificial photosynthesis (AP)** can harness solar energy and converts the captured **carbon dioxide to carbon monoxide (CO)**, which can be used as a fuel for internal combustion engines.

### What are artificial photosynthesis and the process involved?

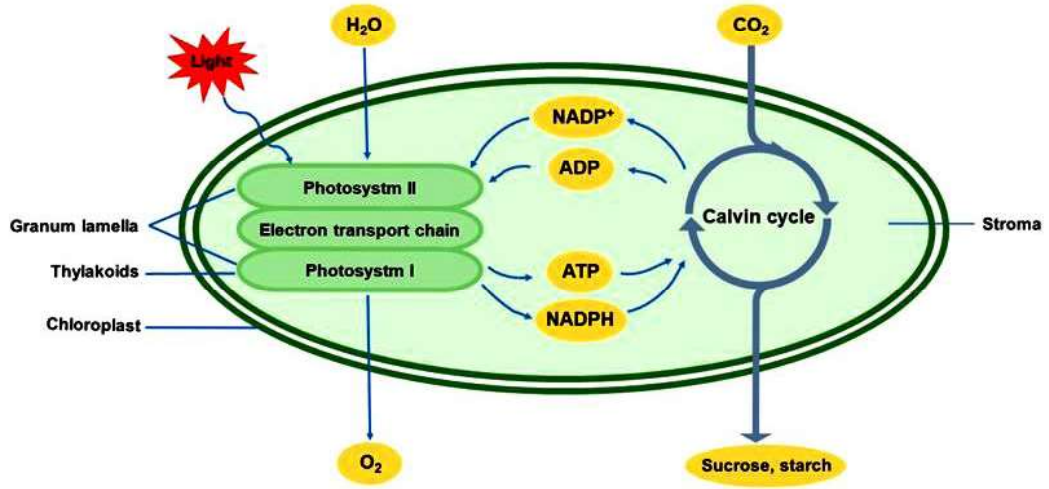
- Artificial photosynthesis is a chemical process that bio-mimics the natural process of photosynthesis to convert sunlight, water, and Carbon dioxide into carbohydrates and oxygen.
- It involved the immobilization of a photosensitizer, the **Tris (bipyridine) ruthenium (II) chloride or, [Ru (bpy)3]2+ 2Cl−.**
- It also has a catalytic part which is another chemical called **rhenium carbonyl complex ([Re (CO) 5Cl]).**
- Both these molecular entities stay nearby in the **nano-space** of a **porous metal-organic framework** system resulting in excellent CO2 uptake capability at room temperature.
- This synthetic strategy empowers efficient solar light-driven photo-catalysis.

### Chemical Process

- **Reduction of CO2:** The developed catalyst exhibited excellent visible-light-driven CO2reduction to CO with more than 99% selectivity.
- **Water Oxidation:** The catalyst also oxidizes water to produce oxygen (O2).

**Natural Photosynthesis**

- **Photosynthesis** is the process by which green plants and certain other organisms transform light energy into chemical energy.




## 13. Plumbing the 'dark' genome for new genes

**Context:** A team from the University of Cambridge set out to find whether new genes emerge in the genome of living organisms or they are present in the dark genome.

### What is a dark genome?

- The human genome contains "dark" gene regions.
- These genes cannot be adequately assembled or aligned using standard short-read sequencing technologies.
- It prevents researchers from identifying mutations within these gene regions that may be relevant to human disease.

### Novel Open Reading Frames (nORFs)

- The number of 'known' genes – encoding around 20,000 'known' proteins - has remained constant. Only 1.5% of the entire human genome codes for proteins.
- Some 'novel' genomic regions cannot be defined by our current 'definition' of a gene. These novel regions are called novel Open Reading Frames or as nORFs.
- The nORFs were seen as dysregulated in 22 cancer types.
- Dysregulated is a term that means that they could either be mutated, upregulated, or downregulated, or they could be uniquely present.
- They have also identified 50 such novel proteins disrupted in schizophrenia and bipolar disorder.

# 14. India's first biobank for heart failure research

**Context:** The first **National Heart Failure Biobank (NHFB)** is inaugurated at the **Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum.**

## National Heart Failure Biobank (NHFB)

- **NHFB** is set up to understand **molecular pathways** and to improve the diagnosis, prognosis, and treatment of Heart Failure.
- The researchers will be able to get access to well-annotated biological specimens which is linked to clinical data with the appropriate standards of quality and security.
- The bio samples will include the blood, serum, tissue samples that are obtained during open-heart surgery and **peripheral blood mononuclear cells (PBMCs)** and genomic DNA collected from heart failure patients.
- The biobank activity will be supervised by a **Technical Advisory Committee (TAC)** with a member from ICMR.
- The samples stored and cataloged will be linked to the clinical data such as physiological measures, imaging data like **ECG, Echocardiography MRI, and follow-up data.**

## Significance

- As there is no heart failure biobank in India, this would help in guiding future therapies and technologies and will be beneficial for the heart failure patients significantly.
- The biobank will provide insights into heart diseases and heart failure among Indian children and adults.
- It will open a new era in research in Heart Failure in India.
- It will change the persona of diagnosis and treatment for heart failure patients.
- The facility will be useful for the research and treatment of post-covid heart failure.

## What is heart failure?

- Heart failure is a chronic, progressive condition in which the heart muscle is unable to pump enough blood to meet the body's needs for blood and oxygen.
- Basically, the heart can't keep up with its workload.

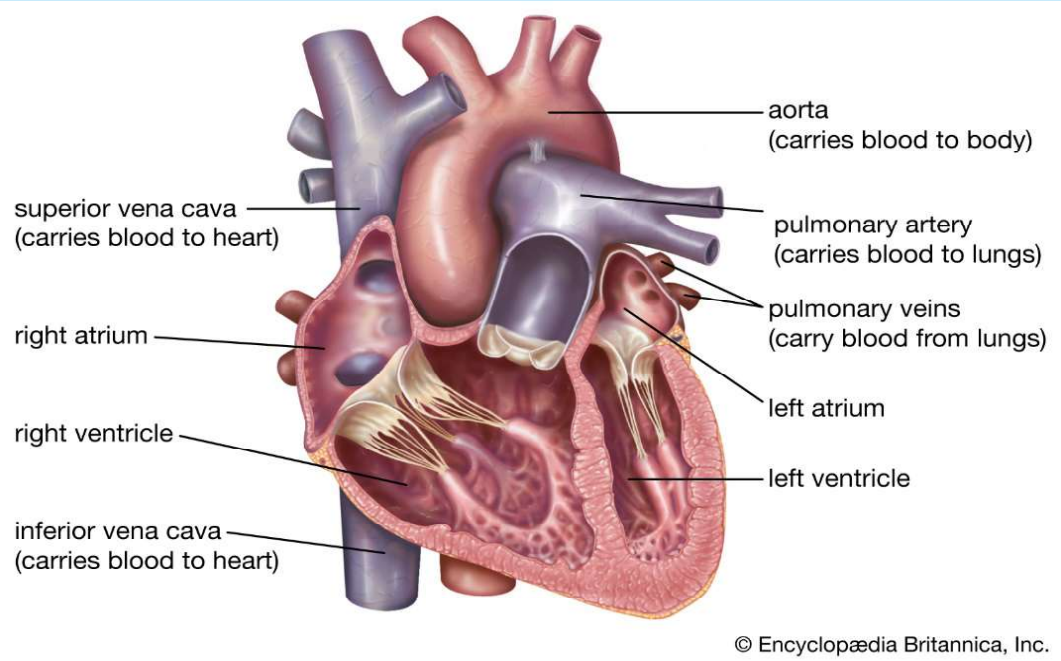
## What is heart attack?

- A heart attack is when adequate blood flow is blocked from reaching an area of the heart.
- This means that tissues in this area aren't getting the oxygen that they need to survive.
- When a heart attack isn't treated promptly, the heart tissue can be damaged and even begin to die.
- The medical term for a heart attack is **myocardial infarction.**

### Working of heart

- The normal healthy heart is a strong, muscular pump a little larger than a fist. It pumps blood continuously through the circulatory system.
- The heart has four chambers, two on the right and two on the left:
  - Two upper chambers called **atria (one is called an atrium)**
  - Two lower chambers called **ventricles**

- The right atrium takes in oxygen-depleted blood from the rest of the body and sends it through the right ventricle where the blood becomes oxygenated in the lungs.
- Oxygen-rich blood travels from the lungs to the left atrium, then on to the left ventricle, which pumps it to the rest of the body.
- The heart pumps blood to the lungs and to all the body's tissues through a sequence of highly organized contractions of the four chambers.
- For the heart to function properly, the four chambers must beat in an organized way.




## 15. Researchers find Therapeutic Effects of Yoga in Depression

**Context:** A new research led by **National Institute of Mental Health & Neurosciences (NIMHANS), Bangalore** suggests that **Yoga** in addition to **standard antidepressant treatment** can bring relief to patients with **Major Depressive Disorder (MDD)** both clinically and biologically and can also bring about earlier remission.

### Major Depressive Disorder (MDD) or Depression?

- **Depression** is a mood disorder that causes a persistent feeling of sadness and loss of interest.
- Also called **major depressive disorder or clinical depression**, it affects how you feel, think and behave and can lead to a variety of emotional and physical problems.

### About the finding

- Yoga is beneficial in reducing MDD symptoms, associated stress hormone levels and improving levels of **inhibitory neurotransmitter** (chemical messengers in the brain) called **Gamma aminobutyric acid (GABA)** in the brain as well as autonomic functioning of the brain.

### Gamma aminobutyric acid (GABA)

- Gamma aminobutyric acid (GABA) is a naturally occurring amino acid that works as a neurotransmitter in brain.
- Neurotransmitters function as chemical messengers.
- GABA is considered an inhibitory neurotransmitter because it blocks, or inhibits, certain brain signals and decreases activity in your nervous system.

- Early intervention of yoga can lead to good outcomes and better prognosis and also effective as monotherapy in mild to moderate depression.

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# 4 HEALTH AND DISEASE

## 1. Rare Disease Day

**Context:**

- **Rare Disease Day (RDD)** is observed **every year on the last day of February**. This year in 2022 it falls on February 28, 2022.
- The day is observed to **raise awareness for rare diseases and improve access to treatment and medical representation for individuals with rare diseases and their families.**
- The Rare Disease Day (RDD) theme for **2022 "Share Your Colors."**

### What are 'rare diseases'?

- **Rare diseases** are often serious, chronic and life-threatening conditions.
- WHO defines a rare disease as often debilitating lifelong disease or disorder with a prevalence of 1 or less, per 1000 population.

### National Policy on Rare Diseases

- **The National Policy on Rare Diseases aims to provide treatment up to Rs 15 lakhs.**
- It proposes to set up a **registry under ICMR (Indian Council of Medical Research).**
- The policy categorises rare diseases into t**hree categories namely disorders requiring long term or long-life therapy, disorders amenable to one-time treatment and incurable rare disease disorders that require lifelong supportive care.**

## 2. World Leprosy Day

**Context:** **Every year the last Sunday of January** is dedicated to the observation of **World Leprosy Day.** This year the event is being marked on **30 January, which is the last Sunday of January, 2022.**

### Important facts about Leprosy

- **Leprosy (Hansen's disease)** is an infectious disease caused by **Mycobacterium leprae that involves the skin and peripheral nerves.**

- The disease mainly affects the **skin, the peripheral nerves, mucosa of the upper respiratory tract and eyes.**
- The disease is not hereditary, leprosy does not trasmit from parents to children.
- Transmission: While the mode of transmission of leprosy is not known, the most widely held belief is that the disease was transmitted by contact between those with leprosy and healthy persons.
  - More recently, the possibility of transmission by the respiratory route is gaining ground.
  - There are also other possibilities such as transmission through insects which cannot be completely ruled out.
- **Most affected:** Although leprosy affects both sexes, in most parts of the world males are affected more frequently than females, often in the ratio of 2:1, according to **WHO's Global Leprosy Report.**
- **Treatment:** Leprosy is curable with **MDT (multi drug therapy)** and treatment in the early stages can prevent disability.

## 3. National Deworming Day

**Context:** National Deworming Day is observed on **10 February** annually to spread awareness about the importance of deworming in all preschool and children of school age between 1 to 19 years.

### About the National Deworming Day

- The National Deworming Day is a **single fixed-day approach** to treating i**ntestinal worm infections** in all children aged 1- 19 years.
- It aims to mobilize health personnel, state governments and other stakeholders to prioritize investment in control of **Soil Transmitted Helminth (STH) infections**, one of the most common infections.
- All the children are provided deworming tablets in schools and anganwadis.
  - Besides the deworming tablet, various health promotion activities related to **Water, Sanitation and Hygiene (WASH)** are organised in schools and anganwadis.
- The NDD program is a cost-effective program at scale that continues to reach crores of children and adolescents with deworming benefits through a safe medicine **Albendazole.**

### Background

- India carries the highest burden of worm infestation and 64% of the Indian population less than 14 years of age are at risk of **Soil Transmitted Helminths (STH) or worms' infestation (WHO).**
- **Soil Transmitted Helminths (STH)** interfere with nutrients uptake in children; can lead to anaemia, malnourishment and impaired mental and physical development.
- The situation of undernutrition and anaemia which is linked to STH ranges from 40% to 70% in different population groups across the country (WHO).
  - They also pose a serious threat to children's education and productivity later in life.

# 4. International Epilepsy Day

**Context:** **International Epilepsy Day** is observed **every year on the second Monday of February across the world.**

### What is Epilepsy?

- **Epilepsy** is derived from the **Greek word which means 'to be seized, to be overwhelmed by surprise'.**
- **Suffering from epilepsy means having a tendency to have recurring seizures.**
- It is said that if the brain is exposed to a strong enough stimulus then anyone can have a seizure.

### It is not necessarily a lifelong diagnosis.

- Doctors may consider that a **person has no longer epilepsy if he or she goes without seizures for a long enough time.**

### Cause of Epilepsy

- There are various types of epilepsy. Some types of it **start at a young age and some in later life.**
- Some types **last for a short period of time and some for the whole life.**
- It could be **due to brain damage occurring by a difficult birth, a severe blow to the head, or due to an infection of the brain like meningitis.**
- Occasionally it is **caused by a brain tumour.** It is said that in around **six of ten people, doctors don't know the reason for their epilepsy.**

### What are the treatments for Epilepsy?

- **Epilepsy medicines like anti-epileptic drugs (AEDs)** are referred.
- Medicine for epilepsy **acts on the brain and tries to reduce seizures from happening.**
- Other treatments when epilepsy medicines do not work are **brain surgery, vagus nerve stimulation, ketogenic diet, deep brain stimulation, and trigeminal nerve stimulation.**

# 5. First death reported from Lassa fever

**Context:** First death has been reported in the **United Kingdom** from a rare rat-borne virus called Lassa fever, and two other cases are now being investigated who recently returned from West Africa.

### Lassa fever

- Lassa fever is an animal-borne, or zoonotic, acute viral illness.
- **Lassa virus:** The "multimammate rat" **(Mastomys natalensis)**
- The Lassa fever-causing virus is **found in West Africa.** It was **first discovered in 1969 in Lassa, Nigeria.**
- The discovery of this disease was made after two nurses died in Nigeria.
- **The fever is spread by rats** and is primarily found in countries in **West Africa including Sierra Leone, Liberia, Guinea, and Nigeria where it is endemic.**

- A person can become infected **if they come in contact with household items of food that is contaminated with the urine or feces of an infected rat.**
- **It can also be spread, though rarely, if a person comes in contact with a sick person's infected bodily fluids or through mucous membranes such as the eyes, nose or the mouth.** Person-to-person transmission is more common in healthcare settings.

### Symptoms

- Symptoms typically appear 1-3 weeks after exposure.
- Mild symptoms include slight fever, fatigue, weakness and headache and more serious symptoms include **bleeding, difficulty breathing, vomiting, facial swelling, pain in the chest, back, and abdomen and shock.**
- Death can occur from two weeks of the onset of symptoms, usually as a result of multi-organ failure.
- The most common complication associated with the fever is deafness.

## 6. CT value in a Covid-19 test

### Context:

Among various scientific terms that the Covid-19 pandemic has made part of the public vocabulary, one is the 'Ct value' in RT-PCR tests for determining whether a patient is positive for Covid-19.

### What is Ct value?

- Short for cycle threshold, **Ct** is a value that emerges during **RT-PCR tests,** the gold standard for detection of the **SARS-CoV-2 coronavirus.**
- In an RT-PCR test, **RNA** extracted from the patient, converted into DNA, which is then amplified.
- This amplification improves the ability of the test to detect the presence of virus.
- **Amplification** takes place through a series of cycles — one copy becomes two, two becomes four, and so on — and it is after multiple cycles that a detectable amount of virus is produced.
- The **Ct value** of an **RT-PCR reaction** is the number of cycles at which fluorescence of the PCR product is detectable over and above the background signal.
- Hence, it refers to the number of cycles after which the virus can be detected.
- If a higher number of cycles is required, it implies that the virus went undetected when the number of cycles was lower.
- The lower the Ct value, the higher the viral load — because the virus has been spotted after fewer cycles.

### Why is CT value important?

- According to the ICMR, a patient is considered **Covid-positive** if the **Ct value** is below 35.
- Although Ct value is inversely correlated with viral load, it does not have any bearing on the severity of the disease, experts have said.
- A patient can have a low Ct value, which means her viral load is high enough to be detected rapidly, but she may still be asymptomatic.
- The Ct value tells us about the viral load in the throat and not in the lungs.

# 7. Neglected Tropical Diseases

**Context:** **World Neglected Tropical Diseases Day (World NTD Day)** is observed on **January 30** every year.

## About Neglected Tropical Diseases (NTD)

- NTDs are a group of infections found among marginalized communities in the developing regions of Africa, Asia and the Americas.
- They 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.
- These diseases cause devastating health, social and economic consequences to more than one billion people.
- The epidemiology of NTDs is complex and often related to environmental conditions.
- Many of them are vector-borne, have animal reservoirs and are associated with complex life cycles.
- All these factors make their public-health control challenging.

**NTDs include:** Buruli ulcer, Chagas disease, dengue and 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), rabies, scabies and other ectoparasitoses, schistosomiasis, soil-transmitted helminthiases, snakebite envenoming, taeniasis/cysticercosis, trachoma, and yaws and other endemic treponematoses.

## NTDs in India

- India is home to the world's largest absolute burden of at least **11 of these major NTDs.**
- As per WHO data, India ranks **number 1 in the number of cases for many major NTDs in the world.**
- **The most common NTDs in India:** Lymphatic Filariasis, Visceral Leishmaniasis, Rabies, Leptospirosis, Dengue and Soil-Transmitted Helminth Infections (STH).

### Progress made by India

India has made tremendous progress in controlling many such diseases.

- Leprosy is no longer a public health concern in the country and mass treatment coverage has also been achieved for **Filaria.**
- India has already eliminated several other NTDs, including **guinea worm, trachoma, and yaws.**

# 8. African swine fever

**Context:** Thailand has detected **African swine fever** in a surface swab sample collected at a slaughterhouse in Nakhon Pathom province, marking the country's first official confirmation of the disease.

### What is African swine fever?

- It is a highly **contagious viral disease of pigs.** In its acute form the disease generally results in high mortality.
- ASF is a different disease to **swine flu.**
- It does not affect humans.

### Transmission

- Its routes of transmission include direct contact with an infected or wild pig (alive or dead), indirect contact through ingestion of contaminated material such as food waste, feed or garbage, or through biological vectors such as ticks.

### Symptoms

- The disease is characterised by sudden deaths in pigs. Its symptoms include:
  - vomiting
  - diarrhoea (sometimes bloody)
  - reddening or darkening of the skin, particularly ears and snout
  - gummed up eyes
  - laboured breathing and coughing
  - abortion, still births and weak litters
  - weakness and unwillingness to stand

# 9. Kyasanur forest disease (KFD)

**Context:** A new point-of-care test for KFD has been developed by **Indian Council of Medical Research (ICMR)** which is a battery-operated **Polymerase Chain Reaction (PCR)** analyzer that aids in sample processing at the point of care.

### About KFDV

- It is a **tick-borne viral hemorrhagic fever,** also referred as monkey fever.
- It is caused by **Kyasanur Forest disease virus (KFDV),** a member of the virus family **Flaviviridae.**
- KFDV was first identified in 1957 when it was isolated from a sick monkey from the **Kyasanur Forest in Karnataka (formerly Mysore) State.**
- **Hard ticks (Hemaphysalis spinigera)** are the reservoir of KFD virus and once infected, remain so for life.
- Rodents, shrews, and monkeys are common hosts for KFDV after being bitten by an infected tick.
- KFDV can cause epizootics with high fatality in primates.

### Transmission

- Transmission to humans may occur after a tick bite or contact with an infected animal, most importantly a sick or recently dead monkey.
- No person-to-person transmission has been described.

### Signs and Symptoms

- Chills, fever, and headache are initial symptoms.
- Muscle pain with vomiting, gastrointestinal symptoms and bleeding are the later symptoms.
- Patients may experience abnormally low blood pressure, and low platelet, red blood cell, and white blood cell counts.

### Treatment

- There is no specific treatment for KFD, but early hospitalization and supportive therapy is important.
- Supportive therapy includes the maintenance of hydration and the usual precautions for patients with bleeding disorders.

## 10. HIV drug, Dolutegravir (DTG)

**Context:** Recently, WHO has released its HIV drug resistance report, 2021. The report further emphasize the need to accelerate the transition to **dolutegravir.**

### About

- It is an antiretroviral medication used, together with other medication, to treat HIV/AIDS.
- It is sold under the brand name **Tivicay.**

### Benefits

- DTG is considered more effective, easier to take and has fewer side effects than alternative drugs.
- It also has a high genetic barrier to developing drug resistance, which is important, given the rising trend of resistance.

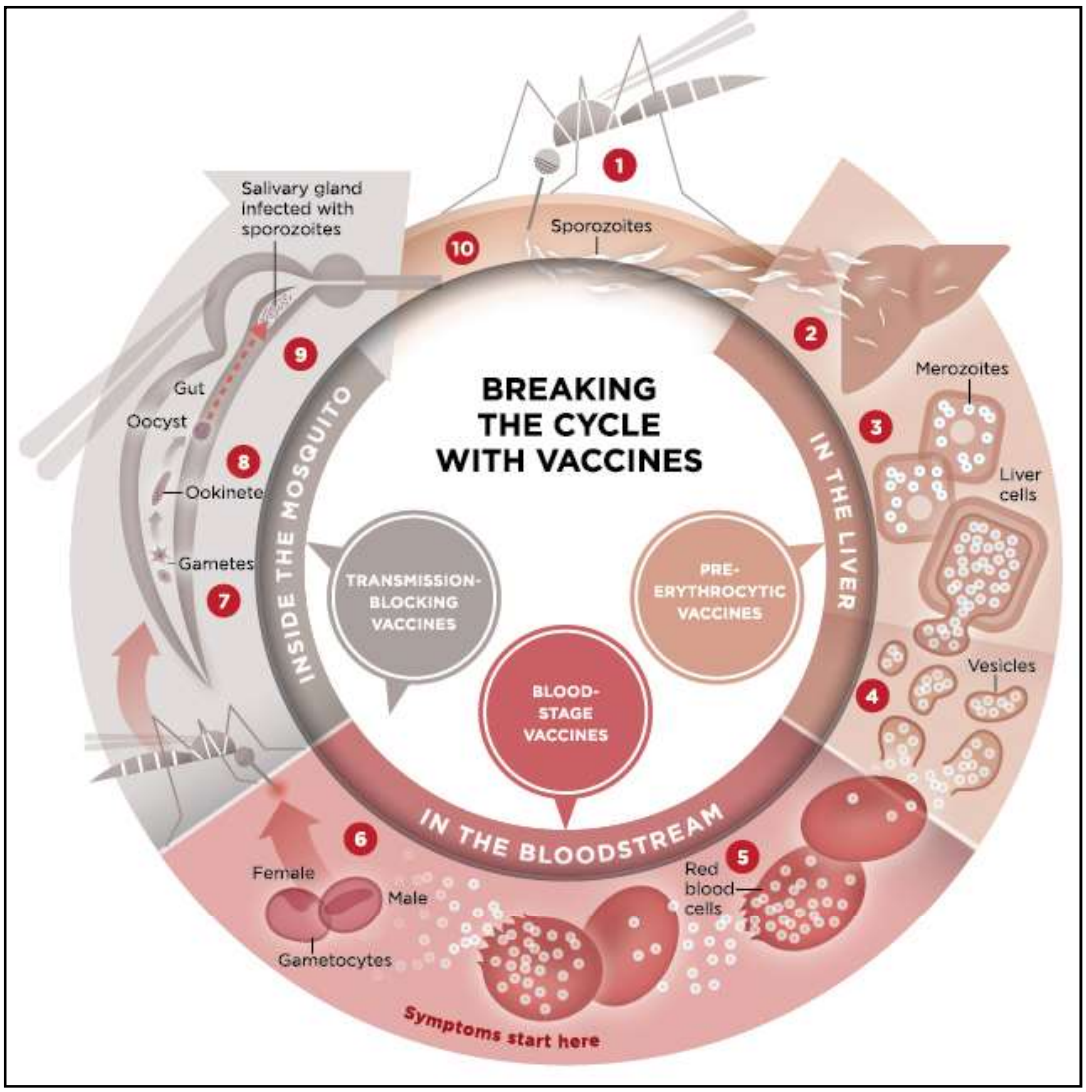
## 11. First Malaria Vaccine: Mosquirix

**Context:** **World's first Malaria Vaccine** has been endorsed recently by the **World health Organization.**

### About the Vaccine

- The vaccine is named **RTS, S - or Mosquirix.**
- It is developed by British drug maker **GlaxoSmithKline.**
- The active ingredient in **Mosquirix** is made up of proteins found on the surface of **Plasmodium falciparum parasites (PFP).**
- RTS, S aims to start the immune system in the early stages of malaria when PFP enters the bloodstream through a mosquito bite and infects liver cells.

- The **RTS malaria vaccine, S / AS01** is used to prevent falciparum malaria in children living in regions with moderate to high transmission.
- ***P. falciparum*** is the most common form of malaria in Africa and exacts the highest toll in terms of human morbidity and mortality.
- It is the first vaccine and the only one that shows partial protection against young children.
- The malaria vaccine should be given in a 4-dose program to children from five months of age to reduce the incidence of malaria and the burden.
- The vaccine adds to the development of the malaria tool and can help get malaria control back on track.
- It also helps prevent liver infection with the **Hepatitis B virus.**




## 12. Human trials for the first mRNA HIV vaccine

**Context:** Recently, **Moderna,** the **Massachusetts-based American biotechnology company**, have started human trials for a vaccine for HIV (human immunodeficiency virus) that uses the same kind of **mRNA technology** found in Moderna's successful COVID-19 vaccine.

### About the Vaccine

- The vaccine is collaboration between **Moderna**, the International AIDS Vaccine Initiative (IAVI) and the Bill and Melinda Gates Foundation (BMGF).
- The vaccine is expected to work similar to the Covid-19 vaccine — by getting the body's cells to produce the HIV viruses' spike protein triggering an immune response.
- The vaccine is designed to prompt white blood cells to turn into antibodies that can neutralize HIV. A booster shot to work with the HIV vaccine is also being studied.
- Several research has found that the candidate molecule used in this vaccine was able to produce the expected immune response by activating a group of cells called naive B cells.
- 56 participants uninfected with HIV will be divided into four groups to test the combinations of two versions of the vaccine, called:
  - eOD-GT8 60mer mRNA Vaccine (mRNA-1644)
  - Core-g28v2 60mer mRNA Vaccine (mRNA-1644v2-Core)
- The participants will receive the doses and will be monitored for adverse effects and signs of immune response after ten months or immunogenicity.
- Unlike live-attenuated or viral-vectored vaccines, mRNA is non-infectious and poses no concern for DNA integration—mainly because it cannot enter the nucleus, which contains DNA.

## 13. Chikungunya Vaccine

**Context:** 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)** has begun in **Costa Rica.**

### About vaccine

- It is funded by the **Coalition for Epidemic Preparedness Innovations (CEPI)** with support from the **Ind-CEPI mission Department of Biotechnology (DBT).**
- It is an initiative of the **United Nations Development Programme (UNDP)**, as part of the **Global Chikungunya Vaccine Clinical Development Program (GCCDP).**
- The vaccine is named **BBV87** and going through a controlled trial to evaluate the safety and immunogenicity of a 2-dose regimen in healthy adults across five countries with endemic Chikungunya.
- BBV87 vaccine is an inactivated whole virion vaccine based on a strain derived from an **East, Central and South African genotype.**
- Inactivated vaccines contain viruses whose genetic material has been destroyed by heat, chemicals or radiation so they cannot infect cells and replicate.
- Inactivated virions technology has a safety profile that potentially makes this vaccine accessible to special populations, such as the immuno compromised and pregnant women that some other technologies cannot reach.

### International Vaccine Institute (IVI)

- It is an international non-profit organization devoted to developing and introducing new and improved vaccines to protect the people, especially children, against deadly infectious diseases.
- It was established in 1997 on the initiatives of the **United Nations Development Programme (UNDP).**

- IVI has 160 partners worldwide ranging from government, industry, academia and civil society to intergovernmental organizations.
- India has become a **full-time member of IVI.**

### About Chikungunya disease

- A viral illness transmitted by mosquitoes that causes the sudden onset of fever and severe joint pain
- Most often spread to people by Aedes aegypti and Aedes albopictus mosquitoes
- **Symptoms:** fatigue, muscle pain, headache and rash, usually appear within two to seven days after being bitten by an infected mosquito
- First identified in **Tanzania** in 1952, with sporadic outbreaks of the disease reported subsequently across Africa and Asia

## 14. Rise of Zika virus cases in India

**Context:** Uttar Pradesh and Kerala saw multiple cases of Zika this year.

### What is Zika?

- Zika is a mosquito-borne flavivirus, transmitted mostly by the bite of infected Aedes species mosquitoes (A. aegypti and A. albopictus).
- These are the same mosquitoes that spread dengue and chikungunya viruses.
- Zika can be passed from a pregnant woman to her fetus.
- Additionally, it can be transmitted sexually and blood transfusion (very likely but not confirmed).

### History of Zika Virus

- First discovered in **1947** and named after the **Zika Forest in Uganda.**
- **First human cases of Zika** were detected in 1952.
- Since then, outbreaks of Zika have been reported in tropical Africa, Southeast Asia, and the Pacific Islands.
- In 2015, a major outbreak in Brazil led to the revelation that Zika can be associated with microcephaly, a condition in which babies are born with small and underdeveloped brains.
- WHO declared the Zika infection with clusters of microcephaly and other neurological disorders as a **Public Health Emergency of International Concern.**

### Zika symptoms

- Many people infected with Zika virus won't have symptoms or will only have mild symptoms.
- During pregnancy, they can cause a birth defect of the brain called microcephaly and other severe brain defects.
- It is also linked to other problems, such as miscarriage, stillbirth, and other birth defects.
- There have also been increased reports of **Guillain-Barré syndrome**, an uncommon sickness of the nervous system, in areas affected by Zika.

### Treatment

- There is no specific medicine or vaccine for **Zika virus.**
- But the symptoms are managed which includes rest, consumption of plenty of fluids, common pain and fever medicines, etc.

## 15. ZyCov-D vaccine, the world's first DNA Covid-19 vaccine

**Context:** **Ahmedabad-based Zydus Cadila** has applied to **Central Drugs Standard Control Organisation (CDSCO),** the national drugs regulator, seeking emergency use authorisation for **ZyCov-D**, the world's first DNA Covid-19 vaccine.

### About

- **ZyCov-D** is a "plasmid DNA". These bacterial DNA are engineered to show the desired results.
- The plasmids used in the vaccine are coded with the instructions to make the spike protein of **SARS-CoV-2.**
- Vaccination gives the code to cells in the recipient's body, so they can begin making the spiky outer layer of the virus.
- The immune system is expected to recognize this as a threat and develop antibodies in response.
- ZyCov-D will be given in three doses, with an interval of 28 days between the first and second and second and third shots.
- No needle is used to deliver the vaccine, instead, a spring-powered device delivers the shot.
- ZyCov-D has been developed with the support of the central government's Department of Biotechnology and the **Indian Council of Medical Research (ICMR).**

### Safety concerns

- Safety concerns to integrate into cellular DNA or cause auto-immune diseases.

### Plasmid

- A plasmid is a small, circular, double-stranded DNA molecule that is distinct from a cell's chromosomal DNA.
- Plasmids naturally exist in bacterial cells, but they also occur in some lower eukaryotes.
- Often, the genes carried in plasmids provide bacteria with genetic advantages, such as antibiotic resistance.

## 16. New drug for Alzheimer's disease

**Context:** The **US Food and Drug Administration** has approved **Biogen's aducanumab**, the first drug to target an underlying cause of Alzheimer's disease. The drug, to be sold under the brand **Aduhelm**. It is the first new approval of an **Alzheimer's drug** since 2003 and the only treatment designed to slow progression of the mind-robbing disease.

### About the drug

- The drug, to be given as a monthly intravenous infusion, is a monoclonal antibody that is designed to reduce the presence of amyloid beta.
- It is a novel drug that is designed only to slow the progression of Alzheimer's and not a cure.

### Alzheimer's disease

- Alzheimer's disease is the most common type of **dementia.** It affects tens of millions of people worldwide, and this number is rising dramatically.
- Forgetfulness and memory problems are often early symptoms.
- But as the illness progresses, patients tend to become confused, may lose their way around familiar places, and have difficulties with planning and completing simple tasks.

### Cause

- The **amyloid hypothesis** proposes **β-amyloid (Aβ)** as the main cause of the disease.
- The mis-folding of the extracellular Aβ protein accumulated in senile plaques and the intracellular deposition of misfolded protein in **neurofibrillary tangles** cause memory loss and confusion and result in personality and cognitive decline over time.
- Accumulated Aβ peptide is the main component of senile plaques and derives from the proteolytic cleavage of a larger glycoprotein named **amyloid precursor protein (APP).**
- APP is a type 1 membrane glycoprotein that plays an important role in a range of biological activities, including neuronal development, signaling, intracellular transport, and other aspects of neuronal homeostasis.
- Several APP cleavage products may be major contributors to Alzheimer's disease, causing neuronal dysfunction.

## 17. The silent pandemic of antimicrobial resistance

**Context:** As serious as the current health and economic crisis is, COVID-19 may just be the harbinger of future crises. **Antimicrobial resistance (AMR)** is one of the greatest challenges of the 21st century.

### About antimicrobial resistance

- It is the phenomenon by which bacteria and fungi evolve and become resistant to presently available medical treatment.
- **Antimicrobial Resistance (AMR)** occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.

### Probable reasons for AMR

- misuse of antimicrobials in medicine
- inappropriate use in agriculture
- contamination around pharmaceutical manufacturing sites where untreated waste releases large amounts of active antimicrobials into the environment

### National Action Plan on AMR (NAP-AMR)

- Government of India (GoI) adopted the National Action Plan on AMR (NAP-AMR) in 2017.
- **Nodal Ministry:** Ministry of Health and Family Welfare (MoHFW)
- **Key surveillance body:** National Centre for Disease Control (NCDC)

### Standards for antibiotic residues

- In January 2020, when the **Ministry of Environment, Forest and Climate Change (MoEFCC)** published draft standards for antibiotic residues in pharmaceutical industry effluents under the proposed **Environmental (Protection) Amendment Rules 2019.**

## 18. Portable medical oxygen concentrator tech

**Context:** ISRO announced to transfer the technology to make **portable medical oxygen concentrators, Shwaas.**

### About the Concentrator, Shwaas

- It is developed by **ISRO's rocket centre Vikram Sarabhai Space Centre (VSSC).**
- It can deliver an enriched level (over 95 per cent) of oxygen than in air to support patients with respiratory illness or who are on oxygen therapy.
- The device enhances the oxygen gas content by selectively separating the nitrogen gas from ambient air through **Pressure Swing Adsorption (PSA).**
  - Pressure swing adsorption (PSA) is a technology used to separate some gas species from a mixture of gases under pressure.
  - It separates them according to the species' molecular characteristics and affinity for an adsorbent material.
- Shwaas is capable of supplying enriched oxygen continuously at 10 litres per minute (LPM) adequate for two patients at a time.
- It is a 600 W device and operates at a voltage of 220 V/50 Hz.
- It has a controllable oxygen flow of 0.5-10 LPM.
- It has two oxygen outlets for oxygen concentration of 82 per cent and 95 per cent normal at a pressure of 50-80 kPa.
- Shwaas has audible alarm for low purity, low & high levels of pressure and flow rate of oxygen.
- The device has a LCD display showing oxygen concentration, flow rate, and pressure.

## 19. SpO2 based Supplemental Oxygen Delivery System

**Context:** **Defence Research and Development Organisation (DRDO)** developed **SpO2 (Blood Oxygen Saturation) supplemental Oxygen Delivery System** for the soldiers who are posted at extreme high-altitude areas.

### About the Device

- It has been developed by **Defence Bio-Engineering & Electro Medical Laboratory (DEBEL), Bengaluru.**
- It is an automatic system that delivers supplemental oxygen on the basis of SpO2 levels.
- It prevents the state of Hypoxia in person, which is fatal in most cases.
- This system can also prove crucial during the current Covid-19 situation.

### Hypoxia

- It is a situation in which the amount of oxygen which reached the tissues is inadequate to fulfill the energy requirements of the body.
- This situation gets replicated in a Covid patient due to the virus infection.
- The system is designed to function at extreme altitudes which have low barometric pressures, low temperatures and humidity.
- It is a simple to use facility by a common person.
- It will reduce the workload and exposure time of doctors and paramedics to monitor the SpO2 levels of the patient.

### Oxygen levels

- A **pulse oximeter** is used to measure the amount of oxygen present in blood.

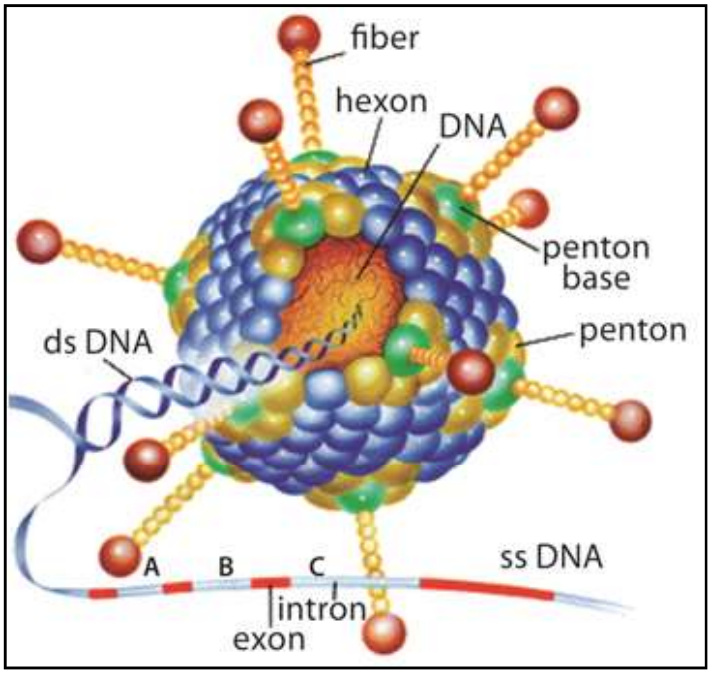
- The **"SpO2"** reading on a pulse oximeter shows the percentage of oxygen in blood.
- SpO2 is known as **Blood oxygen saturation.**
- It is a measure of the amount of oxygen-carrying hemoglobin in the blood relative to the amount of hemoglobin which does not carry oxygen.
- The normal level of oxygen is usually 95% or higher in a healthy person.
- In Covid patients, it goes below than this level.
- A moderate Covid patient requires longtime moderate O2 supply 10Litre/150bar–10kg–1500 litres which can sustain up to 750 minutes.

## 20. Adenovirus antibodies reduce vector vaccine efficacy

**Context:** Studies have shown that using the same adenovirus subtypes for repeated vaccination might result in reduced efficacy.

### Adenovirus

- **Adenoviruses (family Adenoviridae) are double-stranded DNA (dsDNA) icosahedral (20-sided) nucleocapsid viruses** approximately 70 nm in diameter with protruding **spikes** called **pentons.**
- They are **non-enveloped (without an outer lipid bilayer) viruses.**
- They are common pathogens of humans and animals.
- More than 100 serologically distinct types of adenovirus have been identified, including 49 types that infect humans.




### Adenoviral infection

- Infection may be **productive, abortive, or latent.**
- In productive infections, the viral genome is transcribed in the nucleus, mRNA is translated in the cytoplasm, and virions self-assemble in the nucleus.
- In latent infections and in transformed and tumor cells, viral DNA is integrated into the host genome.
- Virus-host DNA recombinants are also found in productive infections.
- Infection is usually transmitted in droplets of respiratory or ocular secretions.

### Adenovirus as Vector

- Adenoviruses are excellent vectors for delivering genes or vaccine antigens. Adenovirus-based vectors offer several advantages over other viral vectors such as:

- a broad range of tissue tropism
- well-characterized genome
- ease of genetic manipulation including acceptance of large transgene DNA insertions
- inherent adjuvant properties
- ability to induce robust transgene-specific T cell and antibody responses
- non-replicative nature in host
- ease of production at large scale

### How these antibodies illicit response action against vector-based vaccine?

- Pre-existing antibodies cause the relatively low efficacy of the adenovirus-based vaccine in some people.
- It affects the development of antibodies against the new target.
- Pre-existing antibodies against adenoviruses will stop the adenovirus particles from getting into cells and making the SARS-CoV-2 spike protein they carry the code for.

## 21. Haemorrhagic septicaemia

**Context:** Six elephants died of **Haemorrhagic septicaemia** in **Karlapat Wildlife Sanctuary** in Odisha's Kalahandi district within 14 days of time.

### About Haemorrhagic septicaemia

- It is a contagious bacterial disease which infects animals that come in contact with contaminated water or soil.
- It is caused by certain serotypes of *Pasteurella multocida*, a Gram negative *Coccobacillus* residing mostly as a commensal in the nasopharynx of animals.
- The disease generally spreads in the period right before and after the monsoons. It can affect cattle, buffalo and other animals.
- It occurs in parts of Asia and Africa and is often fatal.
- Vaccination against this disease is widely practiced

### Karlapat sanctuary

- **Karlapat sanctuary** is spread over an area of 175 square km in **Odisha's Kalahandi district.**
- The sanctuary home to varieties of flora including medicinal plants, and fauna including tigers, apart from elephants.
- There are several small and big waterfalls inside the sanctuary like **Phurlijharan, Ghusrigudi, Dumnijhola, Kamalajharan, Koyirupa, Kuang and Raja Rani.**

## 22. Ebola virus can hide away in the brain

**Context:** According to groundbreaking new research, EBOV can persist in certain areas of the brain, which is an immune-privileged organ.

### About the study

- It has been found that even after treatment with **monoclonal antibodies (mAbs), EBOV** can remain latent in the **ventricular system** – fluid filled spaces of the brain.
- It, then, can re-emerge to cause fatal disease.
- The researchers had previously shown that the virus can hide and persist in other specific regions of immune-privileged organs (such as the vitreous chamber of the eyes and the seminiferous tubules of the testes), despite being cleared from all other organs.

### Ebola virus disease

- It is a severe, often fatal illness affecting humans and other primates.
- The virus is transmitted to people from wild animals such as **fruit bats, porcupines and non-human primates.**
- It spreads in the human population through direct contact with the blood, secretions, organs or other bodily fluids of infected people, and with surfaces and materials.
- The average EVD case fatality rate is around 50%; varied from 25% to 90%.
- It is thought that fruit bats of the **Pteropodidae family** are **natural Ebola virus hosts**.

### Treatment and prevention

- Supportive care - rehydration with oral or intravenous fluids - and treatment of specific symptoms improves survival.
- **Two mAbs (Inmazeb and Ebanga)** have been approved by the US FDA.
- The **Ervebo vaccine** has been shown to be effective in protecting people.
- A 2-component vaccine called **Zabdeno-and-Mvabea** by European Medicines Agency has also been authorized.

## 23. Silk-based scaffolds for screening anticancer drugs

**Context:** Researchers from IIT Guwahati have come up with **silk-protein–based tumour 3D model** for testing cancer drugs. Such scaffolds may even aid in novel drug discovery.

### Key features of the Model

- **Bio-activity:** It involves fabrication of a bio-active composite of silk proteins from two species of silk moths.
- **3-D base:** It builds a scaffold that provides a three-dimensional base for growing tumours.
- **Imitate native environment:** This 3D silk-based tumour model imitates native tumour microenvironment, complex tumour physiology and metastasis, thus improving drug screening efficacy.

### How scientists built scaffolds?

- The scientists mixed the silk fibroins extracted from the cocoons of the domestic silk moth (Bombyx mori) and the silk glands of the muga silk moth (Antheraea assama) in equal proportions.
- Then they used them to build up scaffolds on which they grew breast and liver tumour cell cultures.
- These showed similar tumour physiology in 3D spatiotemporal arrangements and drug-resistance, as in native solid tumours.
- They also tested the screening capacity of the tumours on known anticancer drugs, Doxorubicin and Paclitaxel.

- The tumoroids grown on the silk composite exhibited increased resistance to cancer drugs (as in native conditions) compared to monolayers and spheroids.

## 24. India's 1st Indigenously Developed Pneumococcal Vaccine "Pneumosil"

**Context:** The Government launched the country's first pneumococcal conjugate vaccine ''Pneumosil'' developed by Serum Institute of India in collaboration with the Bill and Melinda Gates Foundation.

### What is Pneumonia?

- It is a form of acute respiratory infection that affects the lungs.
- In pneumonia, the alveoli (air sacs in lungs) are filled with pus and fluid, which makes breathing painful and limits oxygen intake.
- Pneumonia is the single-largest infectious cause of death among children under five years, worldwide.

### Causative agents

- **Bacteria:** *Streptococcus pneumonia, Haemophilus influenzae* type b*, Mycoplasma pneumonia, etc.*
- **Virus:** influenza virus, rhinovirus), Respiratory syncytial virus (RSV)
- **Fungi:** Pneumocystis *jirovecii*

### Treatment

- Pneumonia should be treated with antibiotics with first line treatment amoxicillin.

### The PNEUMOSIL (Pneumococcal Polysaccharide Conjugate Vaccine)

- It is similar as the **paediatric pneumococcal vaccine**, already in the market.
- The 10- valent vaccine is a sterile suspension of saccharides of the capsular antigens of Streptococcus pneumoniae serotypes 1, 5, 6A, 6B, 7F, 9V, 14, 19A, 19F and 23F.
- It is individually conjugated by using 1 **cyano-4-dimethylamino pyridinium tetrafluoroborate (CDAP)** to non-toxic diphtheria CRM197 protein.
- The polysaccharides are chemically activated and then covalently linked to the protein carrier CRM197 to form the **glycoconjugate.**
- Individual conjugates are compounded and then polysorbate 20 and aluminium phosphate are added to formulate the vaccine.
- The potency of the vaccine is determined by the quantity of the saccharide antigens and the saccharide-to-protein ratios in the individual **glycoconjugates.**
- The vaccine meets the requirements of WHO, IP and BP when tested by the methods outlined in WHO TRS 977, IP and BP.

# 25. Havana Syndrome

**Context:** Recently, the **US Federal Bureau of Investigation (FBI)** has said that dealing with the issue of Havana Syndrome is a top priority and that it will keep investigating the cause and how to protect staff.

### About the illness

- It refers to a set of **mental health symptoms**, experienced by US intelligence and embassy officials in various countries.
- Symptoms include hearing certain sounds without any outside noise being present, nausea, vertigo and headaches, memory loss and issues with balance.
- It traces its roots to **Cuba** in 2016, about a year after the US opened its embassy in Havana.
- A study of affected diplomats in Cuba published in the medical journal JAMA in 2019 found evidence that the diplomats experienced some form of brain injury, but did not determine the cause or specific character of the trauma.
- In 2020, a report by the **National Academies of Sciences** (NAS), US found directed microwave radiation to be the plausible cause of the Havana syndrome.
- It built a pressure inside the brain that generated the feeling of a sound being heard.

# 26. Norovirus detected in Kerala

**Context:** Recently, a highly contagious virus named **Norovirus** has been detected in **Kerala's Wayanad district.** The state government has asked people to remain vigilant and stepped up measures to prevent the spread of the virus.

### Norovirus

- It is similar to the **diarrhoea-inducing rotavirus** that causes **gastrointestinal illness.**
- It is thought to be the most common cause of acute gastroenteritis (diarrhea and vomiting illness) around the world by causing inflammation of the lining of the stomach and intestines.
- Norovirus was originally called the **Norwalk** virus, where the first confirmed outbreak happened in 1972.
- Norovirus is resistant to many disinfectants and can heat up to 60°C. Therefore, merely steaming food or chlorinating water does not kill the virus.

### Symptoms

- The most common symptoms are:
  - Diarrhea
  - Vomiting
  - Nausea
  - Stomach pain
- In extreme cases, loss of fluids could lead to dehydration.

### Transmission

- Norovirus is highly contagious and can be transmitted through contaminated food, water, and surfaces.

- The primary route is **oral-faecal.** One may get infected multiple times as the virus has different strains.

### Treatment

- No specific treatment, generic medications for diarrhoea and vomiting can help.
- The disease is self-limiting — the infection normally lasts only two to three days.
- Sufficient rest and hydration are needed for the recovery.

## 27. WHO releases new roadmap to defeat meningitis

**Context:** The World Health Organization (WHO) and its partners launched the **first-ever global strategy to defeat meningitis**, a debilitating disease that kills hundreds of thousands of people each year.

### WHO's Strategy

- The global road map sets out a plan to tackle the main causes of acute bacterial meningitis through three strategic goals:
  - Eliminate epidemics of bacterial meningitis.
  - Reduce cases of vaccine preventable bacterial meningitis by 50% and deaths by 70%.
  - Reduce disability and improve quality of life after meningitis of any cause

### What is Meningitis?

- Meningitis is an inflammation of the membranes (meninges) that protect the spinal cord and brain, causing life-threatening problems.
- An infection of the fluid surrounding the brain and spinal cord usually causes the swelling.
- However, injuries, cancer, certain drugs, and other types of infections also can cause meningitis.

### Types of meningitis

- **Viral meningitis** is the most common type of meningitis.
- **Bacterial meningitis** caused by infection from certain bacteria and it is most deadly.
- **Fungal meningitis** is a rare type of meningitis.
- **Parasitic meningitis** is less common than Viral and Bacterial.
- **Non-infectious meningitis** can be caused by cancers, certain drugs, injury, head surgery, etc.

### Spread

- Generally, the germs that cause bacterial meningitis spread from one person to another.
- Certain germs can spread through food. How people spread the germs often depends on the type of bacteria.
- People can spread the viruses that cause viral meningitis to other people.

### Meningitis versus Meningococcal Disease

- Having meningitis doesn't always mean having meningococcal disease and vice versa.
- Meningococcal disease is any illness caused by a type of bacteria called Neisseria meningitidis.
- These illnesses are serious and include meningitis and bloodstream infections (septicemia).

# 28. New hope for mitochondrial disorders

**Context:** A team of researchers at the National Institute of Immunology has figured out a way to tackle **autosomal dominant progressive external ophthalmoplegia (adPEO),** which is a widely prevalent mitochondrial disorder.

### Mitochondrial genetic disorders

- These refer to a group of conditions that affect the **mitochondria.**
- Brain, muscles, heart, liver, nerves, eyes, ears and kidneys are the organs and tissues most commonly affected.
- They can be caused by changes (mutations) in either the **mitochondrial DNA or nuclear DNA** that lead to dysfunction and inadequate production of energy.
- **Mutations** in **mitochondrial DNA** are transmitted by maternal inheritance, and the mutations in nuclear DNA follow an autosomal dominant, autosomal recessive or X-linked pattern of inheritance.
- Treatment varies based on the specific type of condition and the signs and symptoms present in each person.

### New study

- In the new study, the researchers at NII focused on **autosomal dominant progressive external ophthalmoplegia (adPEO)** as it is one of the most common mitochondrial disorders.
- The disorder occurs when there is a problem in the replication and removal of mismatches in the **mitochondrial DNA.**
- In healthy mitochondria, a protein called **Polymerase Gamma** carries out vital functions: It has to move inside the mitochondria to do its work.
- So far, the dogma was that the transport into mitochondria was determined by a peptide called **Mitochondrial Localization Signal (MLS).**
- The researchers have found that along with MLS, a process called **ubiquitylation**, also decides whether **Polymerase Gamma A** will optimally enter the mitochondria.
- The study also zeroed in on another protein called MITOL, which is present on the outer membrane of the mitochondria, was behind the **ubiquitylation** of **Polymerase GammaA.**
- The team also determined the site on the **Polymerase GammaA** that gets ubiquitylated by MITOL.

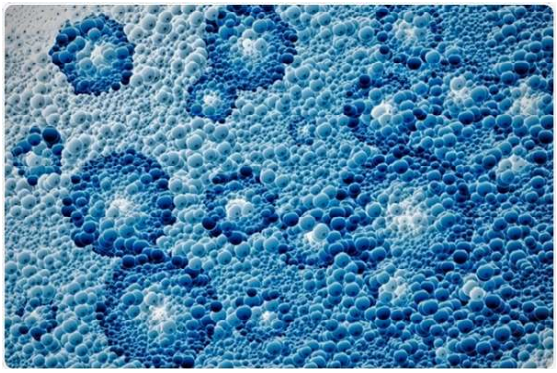
# 29. Nanomicelles: using nanoparticles for cancer treatment

### Context:

- With the advance in nanotechnology, researchers across the globe have been exploring how to use **nanoparticles** for efficient drug delivery.
- Now researchers have created a **nanomicelle** that can be used to deliver a drug named **docetaxel**, which is commonly used to treat various cancers including breast, colon and lung cancer.

### About

- Similar to **nanoshells and nanovesicles, nanomicelles** are extremely small structures and have been noted as an emerging platform in targeted therapy.



- Nanomicelles are globe-like structures with a hydrophilic outer shell and a hydrophobic interior.
- The hydrophobic core interacts with hydrophobic drugs/agents, whereas the hydrophilic tail helps surrounding with water and enhances solubility.
- This dual property makes them a perfect carrier for delivering drug molecules.
- The nanomicelles are less than 100nm in size and are stable at room temperature.
- Once injected intravenously these nanomicelles can easily escape the circulation and enter the solid tumours where the blood vessels are found to be leaky.

### Advantages

- small size (10–50 nm)
- structural stability
- less toxicity
- ability to entrap large amounts of hydrophobic drugs/contrast agent and solubilize in water
- conjugation with target ligand and stimuli-sensitive regions

## 30. Types of Vaccines

**Context:** There has been an increased focus on **vaccine development** using the **viral-vector** and **nucleic-acid based platforms** since the appearance of the **SARS-CoV-2 virus** and **COVID-19 disease** in late 2019.

### 1. Whole Pathogen Vaccine

- It is the oldest and most well-known method of vaccination.
- It uses the whole disease-causing pathogen in a vaccine to produce an immune response similar to that seen during natural infection.
- Using the pathogen in its natural state would cause active disease and could potentially be dangerous to the individual receiving it and risk the disease spreading to others.
- To avoid this, modern vaccines use pathogens that have been altered.

#### A. Live attenuated Vaccines

- They contain whole bacteria or viruses which have been "weakened" (attenuated) so that they create a protective immune response but do not cause disease in healthy people.
- This "weakening" is achieved through genetic modification of the pathogen either as a naturally occurring phenomenon or as a modification specifically.
- They tend to create a strong and lasting immune response and include some of the best vaccines.

- However, live vaccines may not suitable for people whose immune system doesn't work, either due to drug treatment or underlying illness.
- This is because the weakened viruses or bacteria could in some cases multiply too much and might cause disease in these people.
  - **Examples** include vaccine against Rotavirus, Measles, Chickenpox, oral polio vaccine, etc.

### B. Inactivated Vaccines

- They contain whole bacteria or viruses which have been killed or have been altered, so that they cannot replicate.
- Because they do not contain any live bacteria or viruses, they cannot cause the diseases against which they protect, even in people with severely weakened immune systems.
- However, inactivated vaccines do not always create such a strong or long-lasting immune response as live attenuated vaccines.
  - **Example:** Inactivated polio vaccine or IPV, Hepatitis A vaccine, Rabies vaccine, Japanese encephalitis vaccine, etc.

## 2. Subunit Vaccines

- They do not contain any whole bacteria or viruses at all.
- Instead, these vaccines typically contain one or more specific antigens (or "flags") from the surface of the pathogen.
- The advantage of subunit vaccines over whole pathogen vaccines is that the immune response can focus on recognizing a small number of antigen targets ("flags").
- They do not always create such a strong or long-lasting immune response as live attenuated vaccines.
- They usually require repeated doses initially and subsequent booster doses in subsequent years.
- Adjuvants are often added to subunit vaccines. These are substances which help to strengthen and lengthen the immune response to the vaccine.
- As a result, common local reactions may be more noticeable and frequent with these types of vaccines.

### A. Recombinant Protein Vaccines

- They are made using bacterial or yeast cells to manufacture the vaccine.
- A small piece of DNA is taken from the virus or bacterium against which we want to protect and inserted into the manufacturing cells.
  - **Example:** HPV vaccine, Hepatitis B vaccine, etc.

### B. Toxoid Vaccines

- Some bacteria release toxins when they attack the body, and it is the toxins rather than the bacteria itself that we want to be protected against.
- The immune system recognizes these toxins in the same way that it recognizes other antigens on the surface of the bacteria, and is able to mount an immune response to them.

- Some vaccines are made with inactivated versions of these toxins. They are called 'toxoids' because they look like toxins but are not poisonous.
- They trigger a strong immune response.
  - **Example:** Diphtheria vaccine, Tetanus vaccine, Pertussis vaccine etc.

### C. Conjugate Vaccines

- 'Conjugate' means 'connected' or 'joined'.
- With some bacteria, to get protection from a vaccine the body needs to train the immune system to respond to polysaccharides (complex sugars on the surface of bacteria) rather than proteins.
- Researchers discovered that they worked much better if the polysaccharide was attached (conjugated) to something else that creates a strong immune response.
- In most conjugate vaccines, the polysaccharide is attached to diphtheria or tetanus toxoid protein.
- The immune system recognises these proteins very easily and this helps to generate a stronger immune response to the polysaccharide.

### D. Virus Like Particles

- Virus-like particles (VLPs) are molecules that closely resemble viruses, but are non-infectious because they contain no viral genetic material.
- They can be naturally occurring or synthesized through the individual expression of viral structural proteins, which can then self-assemble into the virus-like structure.
  - **Example:** Hepatitis B vaccine, HPV vaccine, etc.

### E. OMV Vaccines

- Outer Membrane Vesicles (OMVs) are naturally produced by bacteria and are essentially a bleb of the bacterial outer cell membrane.
- This contains many of the antigens found on the cell membrane but is a non-infectious particle.
- In the lab these OMVs can be harvested from bacteria to use as vaccines.
- The OMVs can also be modified so that toxic antigens are removed and antigens suitable for stimulating an immune response can be kept.
- OMVs also naturally act as adjuvants.
- **Example:** MenB vaccine (meningococcal B vaccine), etc.

## 3. Nucleic Acid Vaccines

- Nucleic acid vaccines work in a different way to other vaccines in that they do not supply the protein antigen to the body.
- Instead they provide the genetic instructions of the antigen to cells in the body and in turn the cells produce the antigen, which stimulates an immune response.
- Nucleic acid vaccines are quick and easy to develop, and provide significant promise for the development of vaccines in the future.

### A. RNA vaccines

- They use mRNA (messenger RNA) inside a lipid (fat) membrane.
- This fatty cover both protects the mRNA when it first enters the body, and also helps it to get inside cells by fusing with the cell membrane.
- Once the mRNA is inside the cell, machinery inside the cell translates it into the antigen protein.
- This mRNA typically lasts a few days, but in that time sufficient antigen is made to stimulate an immune response.
- It is then naturally broken down and removed by the body.
- RNA vaccines are not capable of combining with the human genetic code (DNA).
  - **Example:** Moderna COVID-19 vaccine, The Pfizer BioNTech, etc.

### B. DNA vaccines

- DNA is more stable than mRNA so doesn't require the same initial protection.
- DNA vaccines are typically administered along with a technique called electroporation.
- DNA must be translated to mRNA within the cell nucleus before it can subsequently be translated to protein antigens which stimulate an immune response.
  - **Example:** ZyCov-D – World's first DNA vaccine for Covid

## 4. Viral Vectored Vaccines

- They are a newer technology, using harmless viruses to deliver the genetic code of target vaccine antigens to cells of the body, so that they can produce protein antigens to stimulate an immune response.
- They are grown in cell lines and can be developed quickly and easily on a large scale.
- They are significantly cheaper to produce in most cases compared to nucleic acid vaccines and many subunit vaccines.

### A. Replicating

- They retain the ability to make new viral particles alongside delivering the vaccine antigen when used as a vaccine delivery platform.
- They produce a stronger immune response. A single vaccine may be enough to give protection.
- They are typically selected so that the viruses themselves are harmless, or are attenuated, so whilst they are infecting the host, they cannot cause disease.
- Despite this, as there is still viral replication going on there is an increased chance of mild adverse events (reactions) with these vaccines.
  - **Example:** Ervebo ebola vaccine (using recombinant vesicular stomatitis virus)

### B. Non-replicating

- They do not retain the ability to make new viral particles during the process of delivering the vaccine antigen to the cell.

- This is because key viral genes that enable the virus to replicate have been removed in the lab.
- This has the advantage that the vaccine cannot cause disease and adverse events associated with viral vector replication are reduced.
- However, vaccine antigen can only be produced as long as the initial vaccine remains in infected cells (a few days).
- This means the immune response is generally weaker than with replicating viral vectors and booster doses are likely to be required.
  - **Example:** Oxford-AstraZeneca COVID-19 vaccine

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CSE RESULTS

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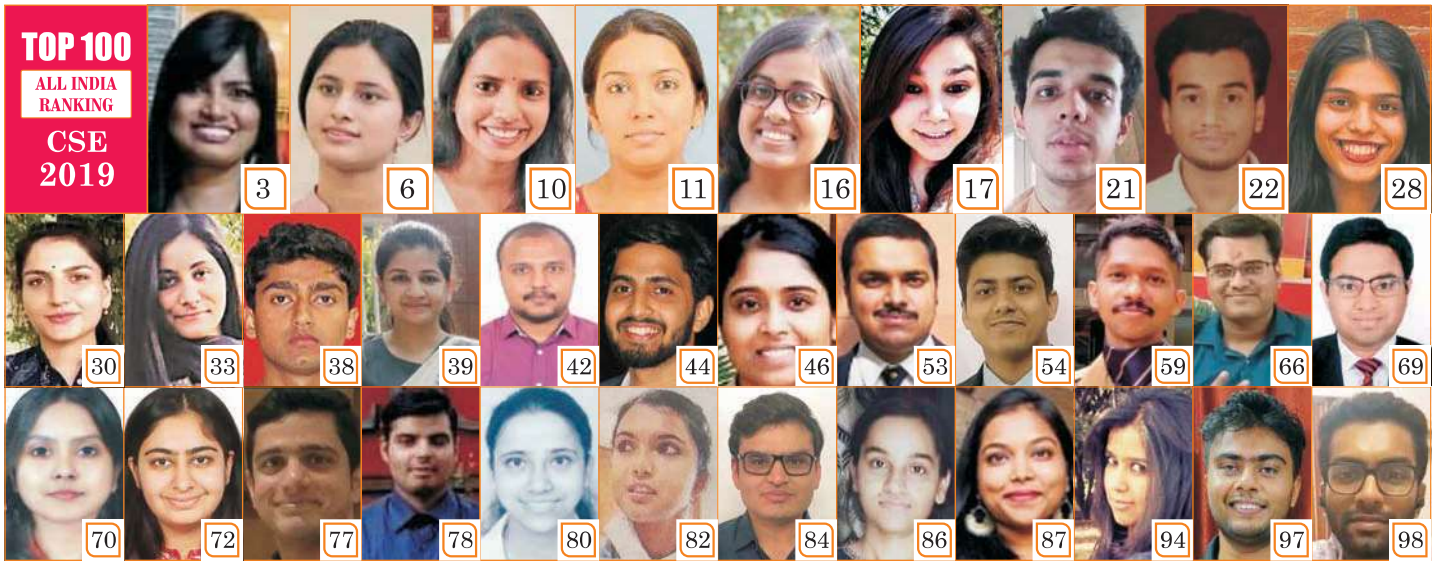


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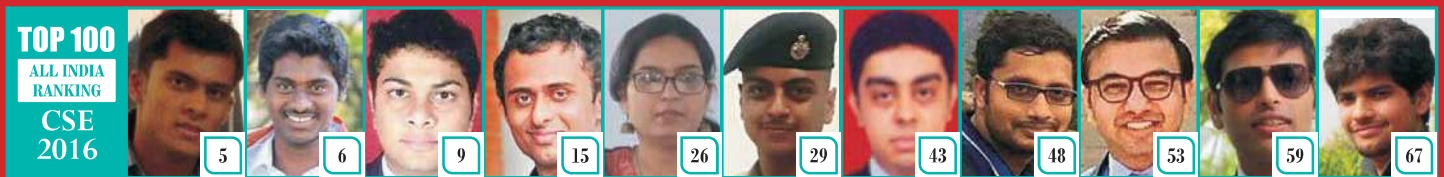


## TOP 100 ALL INDIA RANKING CSE 2015