CURRENT AFFAIRS PROGRAM
PRE CUM MAINS 2024
DEC 2023: BOOKLET-4

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1. GENERAL STUDIES – 3: S&T UPDATES

1) SPACE: CHANDRAYAAN-3 PROPULSION MODULE RETRACES STEPS BACK TO EARTH'S ORBIT (DEC 2023)

- **What happened?**
  - Scientists have brought the propulsion module (PM) of Chandrayaan 3 mission back into earth orbit.
  - This was **not part of original mission plan**. It utilized the logistics advantage of near perfect mission, especially the availability of more than 100 Kg of fuel.

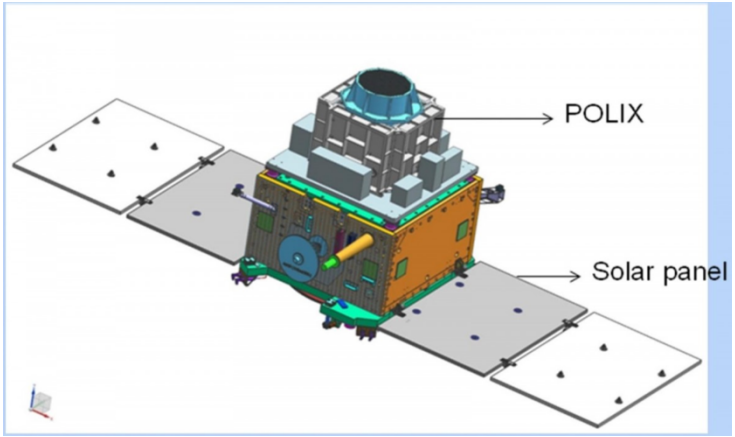
  - **How was this achieved?**
    - ISRO performed maneuver to raise the orbit of the PM around the moon (from 150 km to 5,112 kms)
    - Second maneuver targeted an earth orbit of 1.8 lakh X 3.8 lakh km.

- **Significance:**
  - This experiment prepares ISRO for future missions, especially the ambitious **Lunar Sample Return Mission**.
  - Through this ISRO has been able to understand what is involved in the "planning and execution of trajectory and maneuvers to return from Moon to Earth"

2) SPACE: XPOSAT

- **Why in news?**
  - India (ISRO) set to launch its first X-Ray Polarimeter Satellite (Nov 2023)

- **More Details**
  - XPoSat will be a specialized science mission that will study the **polarization of X-Rays** in space.
    - The **mechanization of polarization of radiation gives away the nature of its source,** including the strength and distribution of the magnetic field and the nature of radiation around it.



  - XPoSAT will carry two scientific payloads in a **low earth orbit**.

- The **Primary Payload** (POLIX) (**Polarimeter Instrument of X-Rays)** will measure the polarimetry parameters (degree and angle of polarization) in medium X-ray range of 8-30 KeV photons of astronomical origin.
- The **XSPECT (X-Ray Spectroscopy and Timing)** payload will give spectroscopic information in the energy range of 0.8 – 15 keV.
  - **The POLIX** payload is developed by the Raman Research Institute (RRI), Bangalore, with support from ISRO centres.
  - The **XSPECT** payload is developed by the UR Rao Satellite Centre (URSC), ISRO.

- **Need**: The emission mechanisms from various astronomical sources such as blackhole, neutron stars, active galactic nuclei, pulsar wind nebulae etc. originates from complex physical processes and are challenging to understand.
  - **The Polarimetry measurement adds two more dimension to our understanding**, the degree of polarization and the angle of polarization and thus is an excellent diagnostic tool to understand the emission processes from astronomical sources.

- **International Trend in Space-Based X-Ray Polarimetry**
  - Internationally, space-based x-ray polarimetry is gaining importance.
    - The **Imaging X-Ray Polarimetry Explorer** (IXPE) mission, launched on Dec 09, 2021, represents NASA's inaugural space-based endeavor, focused on scrutinizing X-Ray Polarization across various celestial bodies.
    - **Note:** XPoSAT energy range of 8-30 keV for polarization measurement is complimentary to IXPE energy range of 2-8 KeV. Therefore, XPoSat and IXPE spacecrafts will collectively probe different emission mechanisms and physics for bright x-Ray sources. Their coordinated observation will provide a wide window in the energy range of **2-30 KeV** for polarimetric observations for bright X-Ray sources.

3) SPACE: PSYCHE MISSION

- **Example Questions:**
  - Launched on 13th October 2023, Psyche Mission has been much in news since then. What are the key goals of the mission? What potential benefit does it hold for human race? [10 marks, 150 words]

- **About Psyche Asteroid:**
  - Psyche is one of the asteroids in the asteroid belt. What makes the asteroid unique is that it appears to be the exposed **nickel-iron core** of an early planet, one of the building blocks of our solar system.

- **About Psyche Mission**:

- The *Psyche Mission* is a NASA space mission launched on 13th Oct 2023 to explore origin of planetary cores by orbiting and studying the metallic asteroid Psyche in 2029. The mission consists of Psyche Aircraft.

- **Significance:**
  - **Understanding the Core of a Planet**: Deep within rocky terrestrial planets – including Earth – scientists infer the presence of metallic cores. But these remain unreachably far below the planets' rocky mantles and crusts. Psyche offers a unique window into the violent history of collisions and acceleration that created terrestrial planets.
  - **Science Goals include**:
    - **Understand a previously unexplored building block of planet formation**: **Iron cores**.
    - **Look inside terrestrial planets, including Earth**, by directly examining the interior of a different body, which otherwise couldn't be seen.
    - **Explore a new type of world** made of metal (and not of rock and ice)

  - **Science Objectives:**
    - Understanding Psyche – Whether it is a core, or if it is an unmelted material, relative ages of psyche's surface etc.

  - **Deep Space Optical Communication (DSOC)**: The Psyche mission is also testing a sophisticated new laser communication technology that encodes data in photons at near-infrared wavelength (rather than radio waves) to communicate between a probe in deep space and Earth.

- **Conclusion:**
  - Overall, the Psyche mission will not only explore the Psyche Asteroid, but it will also unlock a deeper understanding of earth and our solar system

4) SPACE: DEEP SPACE OPTICAL COMMUNICATION

- **Why in news?**
  - » NASA's Deep Space Optical Communication Demo sends, receives first data (Nov 2023)

- **Example Questions:**
  - » Discuss the significance of NASA's Deep Space Optical Communication (DSOC) experiment for future space exploration. [10 marks, 150 words]

- **Need of Deep Space Optical Communication:**
  - » **Low bandwidth of radio frequency communications**: Future space missions are going to required higher bandwidth of communication as they will need to transmit higher volumes of science data, images, videos etc.

» **Higher frequencies (shorter wavelengths)** which can carry more data suffer from the problems of getting blocked by atmosphere, and higher scattering when it is contacted with any interference.

- **NASA's Psyche Spacecraft** is on its way to Psyche asteroid and will reach there by 2029. But in between it is involved in experiments related to Deep Space Optical Communication (DSOC).

- **Primary Objective of DSOC** is to give tools and technology to future NASA initiatives to communicate at much higher bandwidth.

- **Demo:**
  - » DSOC has achieved 'first light' sending data via laser to and from far beyond the Moon for the first time.
  - » NASA's DSOC experiment **has beamed a near-infrared laser encoded with test data from nearly 16 million kms away** – about 40 times further than the Moon is from Earth – to the Hale Telescope at Caltech's Palomar Observatory in San Diego County, California. This is the **farthest ever demonstration** of optical communication.

- **Key features:**
  - » It is pioneering the use of **near-infrared laser signal for communication with spacecraft**.
  - » **Its bandwidth is more than 10 times higher** that the state of art radio-telecommunication system of comparable size and power. This enables higher resolution images, larger volumes of science data, and streaming of videos.

- **Advantages:** Higher Bandwidth, faster data transmission, improved image resolution, reduced power consumption, potential for streaming video and real-time communication

- **How were the limitations of high frequency communication overcome?**
  - » Extremely **precise pointing**: To achieve this, the transceiver aboard the spacecraft needs to be isolated from the craft's vibration.
  - » **Compensating for movements of spacecraft and Earth**: The targeting has to adjust for this continuous movement.
  - » **Extracting information from weak signal**: Since the signal will travel several million kms, the received signal will be very weak. New Signal processing tools have to be utilized to extract precise information from the communication.

- Psyche spacecraft is the first to carry a DSOC transceiver and will be testing high bandwidth optical communications to Earth during the first two years of the spacecraft's journey to the main asteroid belt.
- Achieving the first light is **one of many critical DSOC milestones in the coming months, paving the way toward higher-data-rate communication**.

- **Has Space based optical communication happened in past?**

» In 2013, **NASA's Lunar Laser Communications Demonstration** tested record breaking uplink and downlink rates between Earth and the Moon using similar technology.

» **But DSOC** is taking optical communication to Deep Space, paving the way for high-bandwidth communication far beyond the Moon and over 1,000 times farther than any optical communication test to date.

- **Significance:**
  - » The DSOC holds the key for future space missions. As humans travel deep into space, they would want fast way of sending and receiving large amount of data from earth.
  - » It would pave the way for high data rate communications capable of sending scientific information, high-definition imagery, and streaming video in support of humanity's next giant leap: **Sending humans to Mars**.

- **Conclusion:**
  - » While some challenges remain, the DSOC's potential for faster, richer space communication illuminates the path forward for future deep space missions.

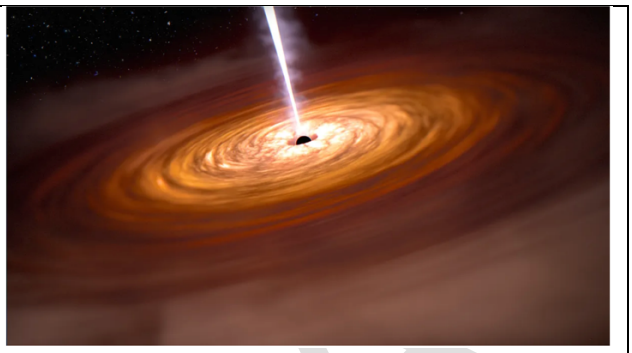
- **Useful Video: https://youtu.be/VsKgYmQS-Kw?si=4HhQDlcTEyH8Xqfw**

5) BLACK HOLES

- **Why in news?**
  - » Ferocious black holes reveal 'time dilation' in early universe (July 2023: Source: The Hindu)
  - » Spotting black holes (Sep 2023: Source – The Hindu)

- **What is a Black Hole?**
  - » A Black hole is a place in space where gravity pulls so much that **even light can't get out**. This strong gravity is because matter has been squeezed into a tiny space. This can happen when a star is dying.
  - » Since, no light is emitted from them, they are invisible.
  - » They are generally **detected** by telescopes by analyzing the behavior of stars that are very close to this black hole.
  - » **How large is a black hole?**
    - A black hole can be as small as an **atom** (but having the mass of a mountain) and they can be **very large as well**.
    - **Stellar** is a kind of blackhole whose mass is around 20 times the mass of sun. There are many many steller blackholes in our Milky Way Galaxy.
    - **"Supermassive"** are the largest black holes. These black holes have masses that are more than 1 million suns together. Every large galaxy contains a supermassive blackhole at its

center. The Supermassive blackhole at the center of the **Milky Way galaxy** is called **Sagitarrius**. It has a mass of 4 million suns and would fit inside a very large ball that could hold a few million earths.

Quasars: Quasars are a subclass of active galactic nuclei (AGNs), extremely luminous galactic cores where gas and dust falling into a supermassive black hole emit electromagnetic radiation across the entire electromagnetic spectrum. They are among the brightest objects in the Universe. **Note:** All Quasars are AGN, but not all AGN are Quasar	

» **The boundary of black hole** is called **event horizon** which acts as one way towards the black hole and allows nothing to get out of it.

- **Singularities and Blackhole**
  - » In 1915 Karl Schwarzschild noticed that Einstein's then new-general theory of relativity predicted the existence of strange objects known as "**singularities**". They were places where his **new equation describing gravity seemed to go haywire**. Inside them there was a bizarre place where **time stopped, and space became infinite**. Over the years evidence have piled up explaining that **singularities do exist** in our universe as **black holes**.

- **Spotting black holes: How do we identify blackholes?**
  - » A blackhole is identified by the **gravitational force** it exerts on nearby stars.
    - If the unseen companion happens to be a black hole, then because of its high gravity it will start pulling matter off the surface of the visible star. This matter start falling towards the blackhole in a characteristic spiral path. In the process it also emits X-Rays which can be detected from earth.
    - From the observed orbit of visible star one can determine the lowest possible mass of the black hole.

- **Recent Updates about Blackholes**

A) SCIENTISTS HAVE DISCOVERED OLDEST BLACK HOLE YET (NOV 2023)

- A study published in Nov 2023 have confirmed that supermassive blackholes existed at the dawn of the universe. NASA's JWST and Chandra X-Ray Observatory have teamed up to confirm this observation.

- Given the age of the Universe is 13.7 billion years old, the age of this black hole is 13.2 billion years. Further, this blackhole is whopper – 10 times bigger than the black hole in our milky way galaxy. It is believed to weigh from 10% to 100% the mass of all the stars in its galaxy.

- **How was it formed?**
  - » The researchers believed that the black hole was formed from colossal clouds of gas that collapsed in a galaxy next door to one with stars. The two galaxies merged, and the black hole was formed.

- **Role of Chandra X-Ray Observatory**: The fact that Chandra X-Ray detected it confirms without doubt that it is a black hole. With X-rays you discover the gas that is being gravitationally pulled into the black hole, sped up and it starts glowing int the X-Ray.

- This one is considered quasar since it is actively growing, and the gas is blindingly bright.

B) FEROCIOUS BLACKHOLES REVEAL TIME DILATION IN EARLY UNIVERSE (JULY 2023)

- Scientists have used observation of a ferocious class of black holes called quasars to demonstrate "time dilation" in the early Universe, showing how **time then passed only about a fifth as quickly as it does today**. The observation stretches back to about 12.3 billion years ago, when the universe was roughly $1/10^{th}$ of its present age.
- **Quasars were used as a "clock"** in the study to measure time in the deep past. The researchers used observations involving the brightness of 190 quasars across the universe dating to about 1.5 billion years after the Big Bang even that gave rise to the Cosmos. **They compared the brightness of these quasars at various wavelengths to that of quasars existing today**, finding that certain fluctuations that occur in a particular amount of time today did five times more slowly in the most ancient quasars.

6) NEUTRINO PARTICLES

- **Introduction**
  - » Neutrinos are one of the fundamental particles which make up the Universe. It is a fermion. They are similar to electrons but without any charge.
  - » Neutrinos are affected by weak subatomic force of much shorter range than electromagnetism and are therefore able to pass through great distances in matter without being affected by it.
    - Neutrinos **interact very weakly with most of the things** - trillions of them pass through every human body every second without anyone noticing.
  - » **A neutrino spin** always points in the opposite direction of its motion, and until a few years ago, neutrinos were believed to be massless. It is now generally believed that the phenomenon of neutrino oscillations requires neutrinos to have **tiny mass**.
  - » **Three types of neutrinos are known,** there are strong evidence that no additional neutrinos exist, unless their properties are unexpectedly very different from the known types.

» Each type or flavor of neutrino is related to a charged particle (which gives the corresponding neutrino its name). Hence, the "electron neutrino" is associated with the electron, and two other neutrinos are associated with heavier version of electrons called muon and the tau.
» The table below list the known types of neutrinos (and their electrically charged partners)

Neutrino	**n_e**	**n_m**	**n_t**
Charged Partners	**Electron (e)**	**Muon (m)**	**Tau (t)**

- **How are neutrinos formed?**
  - » Neutrinos are produced copiously in nuclear reactions in the Sun, stars, and elsewhere.
  - » Majority of neutrinos in the vicinity of earth are from the nuclear reactions in the Sun.
  - » They are formed on earth when unstable atoms decay, which happens in the planet's core and nuclear reactors.

- **Active Research Areas**
  - » **Large neutrino detectors**
    - Measure the neutrino masses and determine the precise values for the magnitude and rates of oscillations between neutrino flavors.

- **Motivation for research**
  - » Neutrino's low mass and neutral charge mean that they interact weakly with other particles and fields. This feature of weak interaction interests' scientists because it means **neutrinos can be used to probe environments that other radiation (such as light or radio wave cannot penetrate)**
    - Thus, Neutrinos can be used to probe the Universe, areas beyond our Solar system and phenomenon like Supernova.
  - » They can also enhance the understanding of basic physical laws as it provides a tool to study the structure of nucleons (protons and neutrons)

A) INDIAN NEUTRINO OBSERVATORY (INO) PROJECT IN THENI, TN

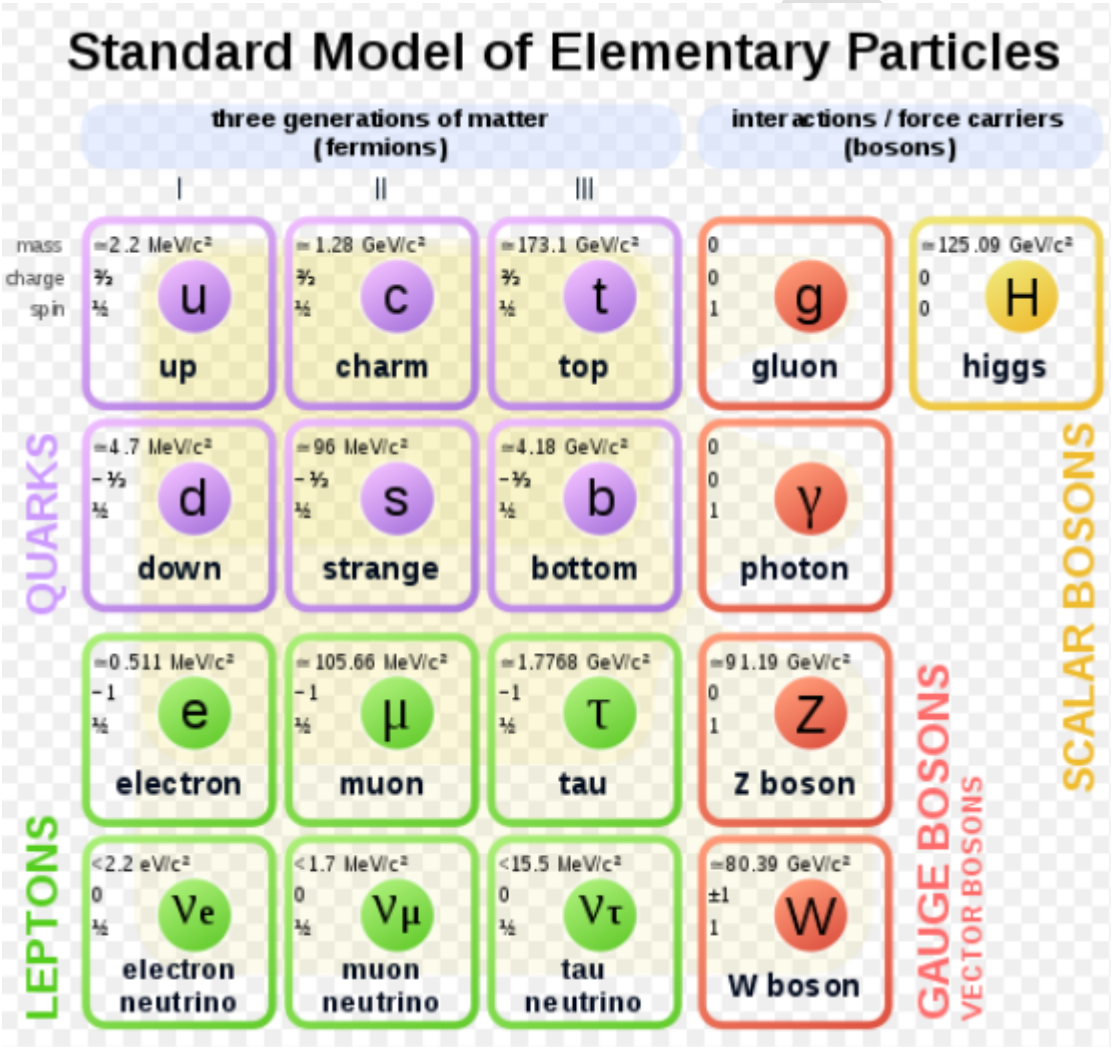
- It is a Rs 1600 Crore Science Project conceived nearly 20 years ago and can put India on the world map in the field of Neutrino Physics. It will house a **massive iron detector which will be placed more than a Kilo meter below the surface of the earth**. With a weight of nearly 50,000 tonnes, it will be the **largest particle detector in the world**.
  - » The project is led by TIFR and has more than 25 top research institutions in the country as collaborators.

- Setting up of this opportunity would mean revival of a lost opportunity for India because in 1965 pioneering Indian Scientists at the Kolar Gold Field (KGF) observatory were among the first in the world to discover the traces of atmospheric neutrinos. With the closure of KGF mines in 1990s, experimental research on neutrinos came to an end in India.

- The project will be jointly supported by the **Department of Atomic Energy** and **The Department of Science and Technology**.

- **Issue Associated with INO: Environment Clearance** (Matter pending in the SC)
- **Useful Video:**
  - » India based Neutrino Observatory A Mega Science Project

B) NOTE: STANDARD MODEL OF PARTICLE PHYSICS



C) IN A FIRST, SCIENTISTS SEE NEUTRINO EMITTED BY THE MILKY WAY (JUNE 2023)

- For the first time, scientists have seen neutrinos originating from the central disk of the Milky Way. It was achieved with the help of IceCube Experiment. They detected high-energy neutrinos in pristine ice deep below Antarctica's surface, then traced their source back to locations in the Milky Way - **the first time these particles have been observed arising from our galaxy**.
- **About IceCube Experiment**:
  - » For the past 10 years, an array of small light sensors drilled into Antarctic ice has been detecting neutrinos as they zip through our planet. IceCube is an actual cube of these sensors, a km long on each side, that was sunk 1.5 and 2.5 km deep in the ice. In this translucent medium, the sensors pick up tiny flashes of so-called **Cherenkov radiation** that forms when a vanishingly rare neutrino hits the ice and creates a shower of secondary particles.
- **Significance:**
  - » The experiment established the galaxy as a neutrino source.
  - » Milky Way neutrinos may help scientists understand the origin of high-energy particles known as cosmic rays, which kick of the formation of neutrinos.

7) HEALTH: FLU

A) INFLUENZA A VIRUS

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

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

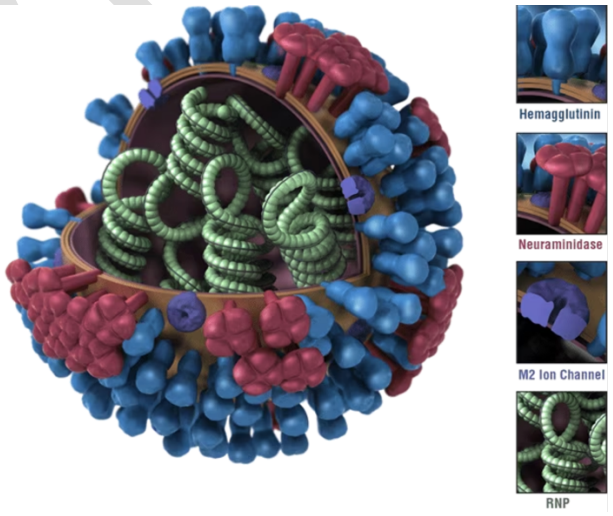
Influenza A virus is the only species of the genus *Alphainfluenzavirus*. It is an RNA virus.

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

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

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

Reassortment is a process by which influenza viruses swap gene segments. It can occur when two influenza viruses



infect a host at the same time and swap genetic information.	

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

B) SWINE FLU

- **Swine Flu** is a respiratory disease caused by **influenza A viruses** that infects respiratory tract of pigs and result in barking cough, decreased appetite, nasal secretion, and restless behavior; the virus **can be transmitted to human.**

- **The first case** of **influenza A H1N1** was reported in Mexico in **April 2009**. Since then this infection has affected almost all the countries of the world.
  - » **The Virus**
    - Investigators decided to name it **H1N1** flu since it was mainly found infecting people and **exhibits two main surface antigens, H1 (hemagglutinin type 1**) **and N1 (neuraminidase type 1**). The eight RNA strands from novel H1N1 flu have one strand derived from human flu strains, two from avian (bird) strains, and 5 from swine strains.
    - Most common virus causing swine flu is H1N1 but the flu virus can sometimes also come from other subtypes such as **H1N2, H3N1, and H3N2**. Since 2017, H3N2 is becoming a dominant strain.
  - » **Cross Species infections** (swine to humans, humans to swine) etc. have **mostly remained local and haven't caused national or worldwide infections** in either pig or humans.
  - » **Transmission to humans**:
    - Most common way for humans to catch swine flu is through **contact with an infected pig** (not through properly cooked pork)
    - Swine flu is transmitted from **person to person** by inhalation or ingestion of droplets containing virus from people sneezing or coughing**.**
  - » **Symptoms**
    - **Similar to most influenza infections**: - fever, cough, nasal secretion, fatigue and headache.
  - » **Prevention and cure**
    - **Vaccination** is the best way to prevent or reduce the chances of becoming infected with influenza virus
    - Two antiviral agents, **zanamivir (Relenza)** and **oseltamivir (Tamiflu),** have been reported to help prevent or reduce the effects of swine flu if taken within 48 hours of the onset of symptoms.

C) AVIAN INFLUENZA: BIRD FLU

- **Intro**
  - Bird flu (Avian Influenza) is caused by influenza A viruses.
    - Only viruses of the **H5 and H7 subtypes** are known to cause the **highly pathogenic form of the bird diseases**.
      - Most avian influenza virus don't infect humans; however, some such as A(H5N1) and A(H7N9), have caused serious infections in people.
    - Recently, China reported that **H10N3** has also infected humans.

- **There are several subtypes of Avian Influenza**
  - **AH5N1** is the most common virus causing bird flu, or avian influenza. It is largely restricted to birds, and often fatal **(high pathogenicity)** to them. it can sometimes cross over to other animals, as well as human.
    - According to WHO, the H5N1 was first discovered in humans in 1997 and has killed almost 60% of those infected. Though, it is not known to transmit easily among humans, the risk remains.
  - **A-H7N9**: It was reported in China in 2013. An outbreak of H7N9 strain killed around 300 people in 2016 and 2017.

- **Risk Factors for human infections**
  - The primary risk factor for human infection appears to be direct or indirect exposure to infected live or dead poultry or contaminated environments, such as live bird markets.

- **Impacts**
  - Outbreaks of AI in poultry may raise global public health concerns due to their effect on poultry population, their potential to cause serious disease in people and their pandemic potential.
  - Can impact local and global economies and international trade.

- **Note**
  - There is no evidence to suggest that the virus can be transmitted to humans through properly prepared poultry or eggs.

D) NISHAD

- The **National Institute of High Security Animal Diseases (NISHAD)** of ICAR is a premiere institute of India for research on exotic and emerging pathogens in animals.
  - It came into existence on 8th Aug 2014 as an independent institute under ICAR, from its original status as High Security Animal Disease Laboratory (HADSL), a regional station of Indian Veterinary Research Institute (IVRI).
- **Recent updates:**
  - 'Inactivated low pathogenic avian influenza (H9N2) vaccine for chickens', developed by scientists of ICAR-NISHAD, Bhopal was transferred to various private companies. (Dec 2022)

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

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

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

- Avian flu has been detected for the first time in Antarctic region and has raised concerns for birds and mammals which feed on these bids.
- **Which type?**
  - Highly Pathogenic Avian Influenza (HPAI) was detected in brown skua (a predatory seabird) populations on Bird Island, South Georgia, making it the first known case in the Antarctic region.
- The ongoing pandemic of HPAI H5N1 was first reported in 2022 in northern hemisphere. In July 2022, outbreaks were reported in northern hemisphere's wildlife, especially seabirds.
- Later in 2022 and 2023, HPAI H5N1 spread rapidly in south America and eventually to Antarctic and sub-Antarctic region.
- **Risk Assessment:**
  - Sea-Gulls and Skuas are the most threatened avian group. They are followed by bird's prey such as hawks and carcasses, terns and shorebirds.
  - Among marine mammals, fur seals and sea lions are reportedly most vulnerable, followed by southern elephant seals and dolphins.