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MCQs**

THE HINDU

What made optogenetics research Nobel-worthy?

Prelims: General Studies Paper - 1

Current events of national and international importance

Mains: General Studies - 3

Science and Technology- developments and their applications and effects in everyday life.

Why in Focus?

- The **2026 Nobel Prize in Physiology or Medicine** was awarded jointly to **Karl Deisseroth, Peter Hegemann and Georg Nagel** for their discoveries concerning **light-sensitive ion channels and optogenetics**.
- **Optogenetics** helps scientists study how specific brain cells control **memory, emotions and behaviour**, with potential applications in treating neurological disorders.

Key Highlights:

- **Optogenetics** combines genetics and optics to control and study nerve cells using light.
- **Peter Hegemann and Georg Nagel** discovered **channelrhodopsin**, a light-sensitive protein in single-celled algae that allows charged ions to pass through cell membranes when exposed to light.

- **Karl Deisseroth** introduced the channelrhodopsin gene into nerve cells, enabling scientists to control their activity using blue light.
- Scientists insert genes for **light-sensitive proteins** into selected cells and use light pulses to control their activity.

Light Pulses: Short bursts of light used to activate or inhibit specific nerve cells in optogenetics.

- The technique helps researchers study **brain circuits** linked to memory, emotions and behaviour, with research applications in **Alzheimer's disease, dementia, addiction and depression**.
- Researchers are exploring optogenetics to **restore vision in people with visual impairment**, although wider clinical use requires further development.

Implications:

- **Understanding brain functions** improves knowledge of how the brain controls behaviour, memory and emotions.
- **Identifying disease-related brain circuits** helps researchers investigate neurological and psychiatric disorders.
- **Developing targeted treatments** creates opportunities to address selected brain-related conditions.
- **Restoring vision** offers potential research applications for people with visual impairment.
- **Establishing clinical safety** requires further testing to determine the safety



and effectiveness of optogenetics-based treatments.

Way Forward:

- **Increase research funding** for optogenetics and related neuroscience technologies.
- **Conduct human studies** to assess the safety and effectiveness of optogenetics in clinical applications.
- **Strengthen interdisciplinary collaboration** among neuroscientists, geneticists and medical researchers.
- **Translate laboratory discoveries into treatments** by developing practical approaches for clinical application.
- **Ensure affordable access** so that successful treatments become accessible to patients.

Mains Question:

Explain the principle of optogenetics and examine its significance in understanding brain functions and developing treatments for neurological disorders. (250 words, 15 marks)

What was the Chemistry Nobel Prize given for?

Prelims: General Studies Paper - 1

Current events of national and international importance

Mains: General Studies - 3

Awareness in the fields of IT, Space, Computers, robotics, nano-technology, bio-technology and issues relating to intellectual property rights.

Why in Focus?

- The **2026 Nobel Prize in Chemistry** was awarded to **Henri Kagan and Kenso Soai** for their work on increasing the purity of molecules with a particular **handedness**.

Molecular Handedness: The property of a molecule that makes it non-superimposable on its mirror image, similar to the difference between the left and right hands.

Key Highlights:

- **Chirality** means a molecule cannot be

superimposed on its mirror image, like the left and right hands.

- These mirror-image forms are called **enantiomers**.
- A **racemic mixture** contains equal amounts of both forms, whereas **homochirality** means living organisms mainly use one form of a molecule.
- **Henri Kagan and Kenso Soai** studied how chemical reactions can favour one enantiomer over the other, helping explain how **molecular handedness** can become dominant.
- **Kagan** used catalysts to increase the proportion of a desired molecular form, while **Soai** demonstrated **autocatalysis**, in which a product helps produce more of the same form.

Catalysts: Substances that speed up a chemical reaction without being consumed in the process.

- Their research was recognised by the **2026 Nobel Prize in Chemistry** for advancing understanding of how one molecular form can become dominant.

Implications:

- **Drug effectiveness and safety** can be better understood by studying how different **enantiomers** affect a drug's action.
- **More efficient chemical manufacturing** can be supported by producing chemicals with specific molecular forms.
- **Understanding homochirality** provides insights into why living organisms predominantly use particular forms of biological molecules.
- **Origin-of-life research** can investigate chemical processes that may have contributed to the emergence of life.

Way Forward:

- **Apply chirality amplification techniques** to improve pharmaceutical production.
- **Evaluate drug safety and effectiveness** by studying different enantiomers before their pharmaceutical use.
- **Advance catalysis research** to understand how catalysts influence reactions and amplify molecular handedness.
- **Promote interdisciplinary research** across



chemistry, biology and origin-of-life studies to investigate the emergence of molecular homochirality.

Mains Question:

Explain molecular chirality and examine its significance in pharmaceutical production and understanding the origin of life. (250 words, 15 marks)

Why was IceCube founder given the physics Nobel?

Prelims: General Studies Paper - 1

Current events of national and international importance

Mains: General Studies - 3

Awareness in the fields of IT, Space, Computers, robotics, nano-technology, bio-technology and issues relating to intellectual property rights.

Why in Focus?

- Belgian-American physicist **Francis Halzen** won the **2026 Nobel Prize in Physics** for his contribution to developing the **IceCube Neutrino Observatory** in Antarctica.
- IceCube helps scientists detect **high-energy neutrinos from space** and investigate the origins of cosmic rays and other energetic events in the universe.

Neutrinos: Tiny subatomic particles with no electric charge, very little mass and weak interactions with matter, allowing them to travel vast distances through space with minimal interference.

Key Highlights:

- **Cosmic rays** are high-energy particles from space, mainly protons and atomic nuclei.

Protons and Atomic Nuclei: Protons are positively charged subatomic particles, while atomic nuclei are the central parts of atoms, containing protons and usually neutrons.

- Scientists **study neutrinos to identify the sources of these powerful cosmic events**.
- **Francis Halzen and John G. Learned** proposed the IceCube concept in 1987–1988. Halzen led the effort to build the observatory with

support from the **U.S. National Science Foundation**.

- IceCube became fully operational in **2011**. It has **5,160 optical sensors installed on 86 cables**, buried 1.4–2.4 km beneath Antarctic ice and covering about **one cubic kilometre**.
- When neutrinos collide with atoms in the ice, they produce particles that emit faint blue light called **Cherenkov radiation**.

Cherenkov Radiation: A faint blue glow produced when a charged particle travels through a medium, such as water or ice.

- IceCube's sensors **detect this light to estimate neutrinos' energy and direction**.
- IceCube **detected high-energy neutrinos** from space in **2013**, identified a neutrino linked to a distant galaxy in **2017**, and found an increased neutrino signal from **NGC 1068** in 2022, a galaxy about 46 million light-years away.

Implications:

- **Neutrino astronomy** helps scientists investigate powerful cosmic events and identify their possible sources.
- **Studying neutrinos** can improve understanding of cosmic rays and energetic processes around black holes.
- **Combining neutrino data with observations from other telescopes** can improve understanding of the universe.

Way Forward:

- **Expand neutrino observatories** and improve the sensitivity of their detectors.
- **Strengthen international cooperation** and long-term funding for scientific research.
- **Combine neutrino observations with data from other telescopes** to identify their sources.
- **Improve data analysis techniques** to estimate neutrinos' energy and direction more accurately.
- **Promote fundamental physics research** to understand cosmic rays, black holes and other high-energy phenomena.

Mains Question:



Discuss the significance of the IceCube Neutrino Observatory in advancing our understanding of high-energy astrophysical phenomena. Examine the challenges and opportunities associated with neutrino astronomy. (250 words, 15 marks)

T.N. may encounter El Niño differently from rest of India

Prelims: General Studies Paper - 1

Current events of national and international importance

Mains: General Studies - 1

Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclone etc.

Why in Focus?

- Global weather agencies are monitoring a possible “**super**” **El Niño in 2026**, with Pacific Ocean surface temperatures reportedly rising about **2°C above average**.
- The **India Meteorological Department (IMD)** has forecast normal to above-normal northeast monsoon rainfall across southern Tamil Nadu amid unusual Indian Ocean warming.

Key Highlights:

- El Niño** is the warm phase of the **El Niño–Southern Oscillation (ENSO)**, a climate phenomenon occurring every two to seven years that affects global atmospheric circulation and rainfall patterns.

El Niño–Southern Oscillation (ENSO): A recurring climate phenomenon involving fluctuations in sea surface temperatures and atmospheric pressure over the tropical Pacific Ocean, comprising El Niño, La Niña and the neutral phase. El Niño is generally associated with weaker Indian monsoons, while La Niña is often associated with stronger monsoons.

- Unlike the usual association between El Niño and deficient rainfall across India, **strong El Niño events can intensify Tamil Nadu’s northeast monsoon** by altering wind and pressure patterns and directing moisture towards its coast.
- The **Indian Ocean Dipole (IOD)** involves differences in sea-surface temperatures

between the western and eastern equatorial Indian Ocean.

- A **positive IOD** occurs when the western Indian Ocean is warmer than the eastern region.
- During the **2015 El Niño**, Chennai received **1,522 mm of rainfall in four days (December 1–4)**, contributing to devastating floods despite a weak southwest monsoon across India.
- Sea-surface temperatures in the southern Bay of Bengal reportedly rose by about **1°C by September 2026**, while the **East India Coastal Current (EICC)** showed an unusual westward flow, potentially influencing coastal temperatures and low-pressure systems.

East India Coastal Current (EICC): A seasonally reversing ocean current flowing along India’s eastern coast in the Bay of Bengal. It generally flows northward from February to September and southward from October to January, with seasonal and regional variations.

- Satellites, buoys, ships, deep-water stations and coastal radars** monitor ocean conditions, while the **EU and Canada** announced the **OceanEye real-time ocean data collection initiative** at the United Nations General Assembly.

Implications:

- Increased ocean warming and moisture supply** may raise the risk of intense rainfall, flooding and cyclones along the Tamil Nadu coast.
- Complex interactions between El Niño, the Indian Ocean and atmospheric systems** make seasonal rainfall forecasts less predictable.
- Urban flooding** can disrupt transport, livelihoods, infrastructure and essential services.
- Limited ocean observations** may delay the detection of emerging climate anomalies and intensifying weather systems.
- Rising ocean temperatures** may increase the likelihood of extreme ocean–atmosphere events, creating greater disaster-management demands.

Way Forward:

- Expand real-time ocean observation**



networks using satellites, buoys, coastal radars and deep-water monitoring stations.

- **Strengthen institutional coordination** among the IMD, oceanographic institutions and international ocean-data initiatives.
- **Improve forecasting models** to account for interactions among ENSO, the IOD, sea-surface temperatures and coastal currents.
- **Develop location-specific disaster preparedness plans** covering flood management, drainage and cyclone response
- **Strengthen public early-warning systems** and ensure timely dissemination of rainfall and cyclone alerts to coastal communities.

Mains Question:

Examine how El Niño and Indian Ocean warming can influence Tamil Nadu's northeast monsoon. Discuss the challenges in forecasting extreme rainfall and cyclones and suggest measures to strengthen India's ocean observation and disaster preparedness systems. (250 words, 15 marks)

KEYWORDS

Exercise Tarang Shakti 2026

- **Exercise Tarang Shakti** is a multinational air exercise hosted by the **Indian Air Force (IAF)** to strengthen international defence cooperation and interoperability among participating air forces.
- The **first edition** of the exercise was conducted in **August–September 2024** in two phases.
- The **2026 edition** is being held from **26 September to 12 October 2026** at **Air Force Station Jodhpur, Rajasthan**.
- **Participants:** The exercise includes eight air forces from **Australia, Bangladesh, France, Germany, Greece, Sri Lanka, the UAE and the USA**, while **32 nations** attend as observers.
- The exercise aims to enhance **operational coordination, interoperability and the exchange of professional expertise**, while showcasing **India's air combat capabilities**.

Nuclear Clocks

- **Nuclear clocks** are highly precise timekeeping devices that use transitions in an atom's **nucleus**, rather than its electrons.
- They aim to complement or surpass the precision of existing **atomic clocks**, which rely on electronic transitions. **Atomic clocks** are highly precise timekeeping devices that measure time using the frequency of **electronic transitions in atoms**.
- Nuclear clocks may use the **thorium-229 nucleus**, whose unusually low-energy nuclear transition is accessible using laser technology.
- They could improve **timekeeping, navigation, geodesy and tests of fundamental physics** through highly precise measurements.

Durga Puja

- **Durga Puja in Kolkata, West Bengal**, is an annual festival celebrated mainly in **September or October**.
- The festival celebrates **Goddess Durga's victory over Mahishasura**, symbolising the triumph of good over evil.
- Artisans create elaborate **clay idols and artistic pandals**, reflecting Bengal's rich cultural and artistic traditions.
- The festival concludes with the **immersion of the idols**, accompanied by community celebrations, music and cultural performances.
- In **2021**, **Durga Puja in Kolkata** was inscribed on UNESCO's **Representative List of the Intangible Cultural Heritage of Humanity**, recognising its cultural significance and community participation.

Office of the United Nations High Commissioner for Human Rights (OHCHR)

- Office of the United Nations High Commissioner for Human Rights was established by the **United Nations General Assembly in 1993** to promote and protect human rights worldwide.



- It is part of the **UN Secretariat** and is headquartered in **Geneva, Switzerland**.
- It works to protect human rights guaranteed under the **UN Charter, the Universal Declaration of Human Rights (UDHR)** and international human rights treaties.
- The **High Commissioner for Human Rights** heads the office and coordinates UN human rights activities.
- OHCHR provides **technical assistance to States**, monitors human rights concerns and supports UN human rights mechanisms, including the **Human Rights Council**.

Places in News

Kulsi River

- A proposed **hydropower project on the Kulsi River** is facing opposition from local residents.
- The **Kulsi River** is a **south-bank tributary of the Brahmaputra River**, flowing through **Meghalaya and Assam**.
- It is formed by three rivers: **Khri, Krishniya and Umsiri**, which originate in the **West Khasi Hills of Meghalaya**.
- The river is approximately **220 km long**, with about **100 km in Meghalaya** and **120 km in Assam**.
- The Kulsi River is one of the last refuges of the endangered **Gangetic dolphin** in Assam.

Zaporizhzhia Region (Oblast)

- The region remains in the news due to the ongoing **Russia–Ukraine war** and attacks affecting civilian areas and infrastructure.
- **Zaporizhzhia Oblast** is located in **southeastern Ukraine**, along the northern coast of the **Sea of Azov**.
- Its administrative centre is **Zaporizhzhia city**, which remains under Ukrainian government control.

- The region borders **Donetsk, Dnipropetrovsk and Kherson oblasts** and has significant industrial and agricultural importance.
- The **Zaporizhzhia Nuclear Power Plant**, located near **Enerhodar**, is situated in the region and remains a major concern for **nuclear safety and security**.



Black Sea

- The Black Sea has **gained attention due to escalating Russia–Ukraine attacks on commercial vessels and maritime routes** in October 2026.
- The **Black Sea** is a semi-enclosed inland sea located between **Eastern Europe and Western Asia**.
- It is bordered by six countries: **Bulgaria, Romania, Ukraine, Russia, Georgia and Türkiye**.
- It connects to the **Sea of Azov through the Kerch Strait** and to the Mediterranean Sea through the **Bosporus Strait, Sea of Marmara and Dardanelles Strait**.
- The Black Sea is strategically important for **grain and energy exports**, particularly from Russia and Ukraine, and for maritime access between the Black Sea region and the Mediterranean.



Species in News



Gangetic Dolphin

- The **Kulsi River**, an important habitat of the endangered Gangetic river dolphin, has drawn attention due to a proposed hydropower project that could threaten the dolphin's habitat.
- The **Gangetic dolphin (Platanista gangetica)** is a freshwater mammal found in the **Ganga–Brahmaputra–Meghna and Karnaphuli–Sangu river systems** of India, Nepal and Bangladesh.
- It is known as the **“blind dolphin”** because its eyes lack a lens; it uses **echolocation** to navigate and locate prey in murky waters.
- The Gangetic dolphin was declared **India's National Aquatic Animal in 2009** and serves as an indicator of freshwater ecosystem health.
- **Conservation status: Endangered** on the IUCN Red List; listed under **Schedule I of the Wildlife (Protection) Act, 1972**, and **Appendix I of CITES**.