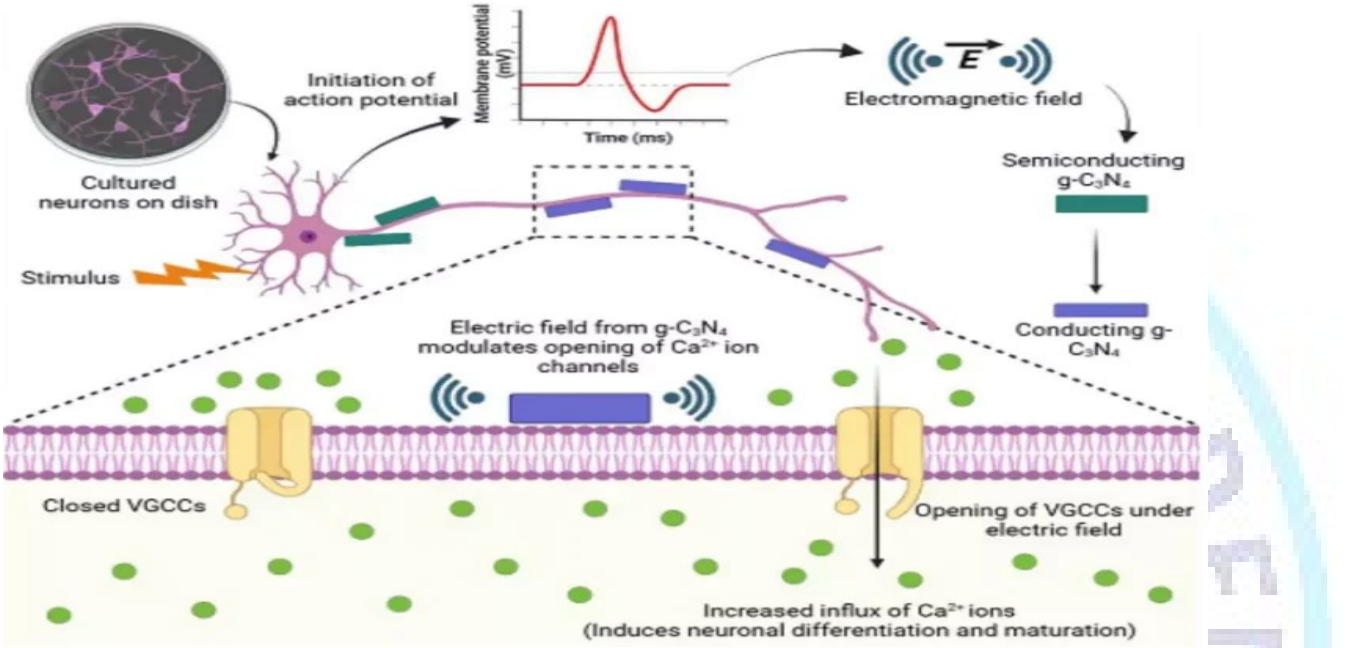
2. Nano Materials for Non-Invasive Brain Stimulation - S&T

Indian researchers pioneer nanomaterial that stimulates brain cells without surgery. Scientists at the Institute of Nano Science and Technology (INST) have made a groundbreaking discovery, demonstrating that a nanomaterial called graphitic carbon nitride ($g\text{-}C_3N_4$) can non-invasively stimulate brain cells. This offers a potential new pathway for treating neurological disorders without the need for surgery or external devices.

About Graphitic Carbon Nitride ($g\text{-}C_3N_4$)



Nature of the Material - It is a semiconducting nanomaterial that is uniquely capable of generating small, localized electric fields in response to the brain's own natural voltage signals.

Biocompatibility - The material has been found to be non-toxic and safe for direct interaction with sensitive brain tissue.

Mechanism of Action - $g\text{-}C_3N_4$ acts as a "smart switch" that modulates neuronal activity based on the cell's electrical state. In the presence of a negative membrane potential (a neuron's resting state), the material switches to an 'ON' state, generating an electric field that stimulates the neuron. Conversely, in the presence of a positive membrane potential (when a neuron is firing), it switches to an 'OFF' state, which helps prevent overstimulation and neuronal fatigue. The electric fields it generates open calcium channels in the neurons, a crucial step that promotes their growth, maturation, and ability to communicate with each other.

Key Findings of the Study

The research demonstrated several significant therapeutic effects of the nanomaterial in both lab-grown cells and animal models.

Enhanced Neuronal Growth - The material was shown to significantly improve the formation of neuronal connections and enhance communication between brain cells.

Increased Dopamine Production - In lab-grown brain-like cells (organoids), it successfully boosted the production of **dopamine**, a neurotransmitter critically deficient in conditions like Parkinson's disease.

Reduction of Toxic Proteins - In animal models of neurodegenerative diseases, the application of $g\text{-}C_3N_4$ led to a reduction in the accumulation of toxic proteins associated with conditions like Parkinson's.

Experimental Validation - The findings were rigorously confirmed through multiple advanced techniques, including calcium imaging studies, gene expression analysis, and immunofluorescence-based methods.

Advantages Over Existing Therapies

The nanomaterial approach represents a significant leap forward compared to current treatments for neurological disorders.

Feature	Current Methods (e.g., Deep Brain Stimulation)	Nanomaterial Approach (g-C_3N_4)
Invasiveness	Highly invasive; requires neurosurgery to implant electrodes (DBS) or uses external devices like magnets or lasers.	Non-invasive; directly interacts with neurons without surgery or external hardware.
Mechanism	Delivers externally generated electrical impulses to modulate brain activity.	Generates its own electric fields in response to the brain's natural signals.
Stimulation	Requires continuous external power and control.	Self-regulating; acts as a "smart switch" that turns on and off naturally, preventing fatigue.

Deep Brain Stimulation (DBS) is a neurosurgical procedure where electrodes are implanted into specific brain regions. These electrodes deliver controlled electrical impulses to manage symptoms of disorders like Parkinson's disease, dystonia, and epilepsy.

Future Applications

The discovery opens up exciting possibilities in both medicine and advanced computing. Therapeutic Potential - Development of non-invasive treatments for Alzheimer's, Parkinson's, and traumatic brain injuries..Use of semiconductors for advanced tissue engineering and regenerative medicine.

Future Technologies

1. **Brainware Computing** - Improving the efficiency of brain organoids that can be used as powerful biological processors.
2. **Bio-inspired Computing** - Merging nanomaterials with living tissues to create novel, highly efficient computational systems.

About the Institute of Nano Science and Technology (INST)

Establishment - INST is an autonomous research institution established in 2013 under the Department of Science and Technology (DST).
Nodal Ministry - Ministry of Science & Technology, Government of India.
Location - Mohali, Punjab.
Mandate - To be a premier research center in nanoscience and nanotechnology, focusing on applications in healthcare, agriculture, energy, and the environment.
Source - https - //www.pib.gov.in/PressReleseDetailm.aspx?PRID=2170135# - ~ - text=Indian%20researchers%20pioneer%20nanomaterial%20that%20stimulates%20brain%20cells%20without%20surgery&text=In%20a%20discovery%20that%20could,for%20electrodes%2C%20lasers%2C%20or%20magnets