Bio computers

March 7, 2023

In news– Scientists at Johns Hopkins University (JHU) recently outlined a plan for a potentially revolutionary new area of research called “organoid intelligence”, which aims to create “biocomputers.

What are biocomputers?

- Biological computers use biologically derived molecules such as DNA and/or proteins to perform digital or real computations.
- The development of biocomputers has been made possible by the expanding new science of nanobiotechnology.
- With this the brain cultures grown in the lab are coupled to real-world sensors and input/output devices.
- The scientists expect the technology to harness the processing power of the brain and understand the biological basis of human cognition, learning, and various neurological disorders.

Organoids to biocomputers-

- In a quest to develop systems that are more relevant to humans, **scientists are building 3D cultures of brain tissue in the lab, also called brain organoids.**
- These “mini-brains” (with a size of up to 4 mm) are built using human stem cells and capture many structural and functional features of a developing human brain.
- Researchers are now using them to study human brain development and test drugs to see how they respond.
- **However, the human brain also requires various sensory inputs (touch, smell, vision, etc**.) to develop into the complex organ it is, and brain organoids developed in the lab aren’t sophisticated enough.

- **The organoids currently also don’t have blood circulation, which limits how they can grow.**

- **Recently, scientists transplanted these human brain organoid cultures into rat brains**, where they **formed connections with the rat brain**, which in turn provided circulating blood.
- Since the organoids had been transplanted to the visual system, when the scientists showed the experimental rats a light flash, the human neurons were activated, too, indicating that the human brain organoids were also functionally active.
- **Scientists have touted such a system as a way to study brain diseases in a human context**.
- **However, human brain organoids are still nested in the rat-brain microenvironment,** including the non-neuronal cells.
- The effects of drugs in this model will also have to be interpreted through various behavioural tests in rats, which could be insufficiently representative.

What is the new 'bio-computer'?

- The JHU researchers' scheme will **combine brain organoids with modern computing methods to create "bio-computers".**
- They have announced plans to **couple the organoids with machine learning by growing the organoids inside flexible structures** affixed with multiple electrodes (similar to the ones used to take EEG readings from the brain).
- **These structures will be able to record the firing patterns of the neurons and also deliver electrical stimuli, to mimic sensory stimuli**.
- The response pattern of the neurons and their effect on human behaviour or biology will then be analysed by machine-learning techniques.
- Recently, **scientists were able to grow human neurons on top of a microelectrode array that could both record and stimulate these neurons.**

- Using positive or negative electric feedback from the sensors, they were able to train the neurons to generate a pattern of electrical activity that would be generated if the neurons were playing table tennis.

Benefits of bio-computers-

- While human brains are slower than computers at, say, simple arithmetic, they outshine machines at processing complex information.
- Brain organoids can also be developed using stem cells from individuals with neurodegenerative diseases or cognitive disorders.
- Comparing the data on brain structure, connections, and signalling between 'healthy' and 'patient-derived' organoids can **reveal the biological basis of human cognition,** learning, and memory.
- They could also **help decode the pathology of and drug development** for devastating neurodevelopmental and degenerative diseases such as Parkinson's disease and microcephaly.