Star-shaped glial cells act as the brain's 'motherboard'

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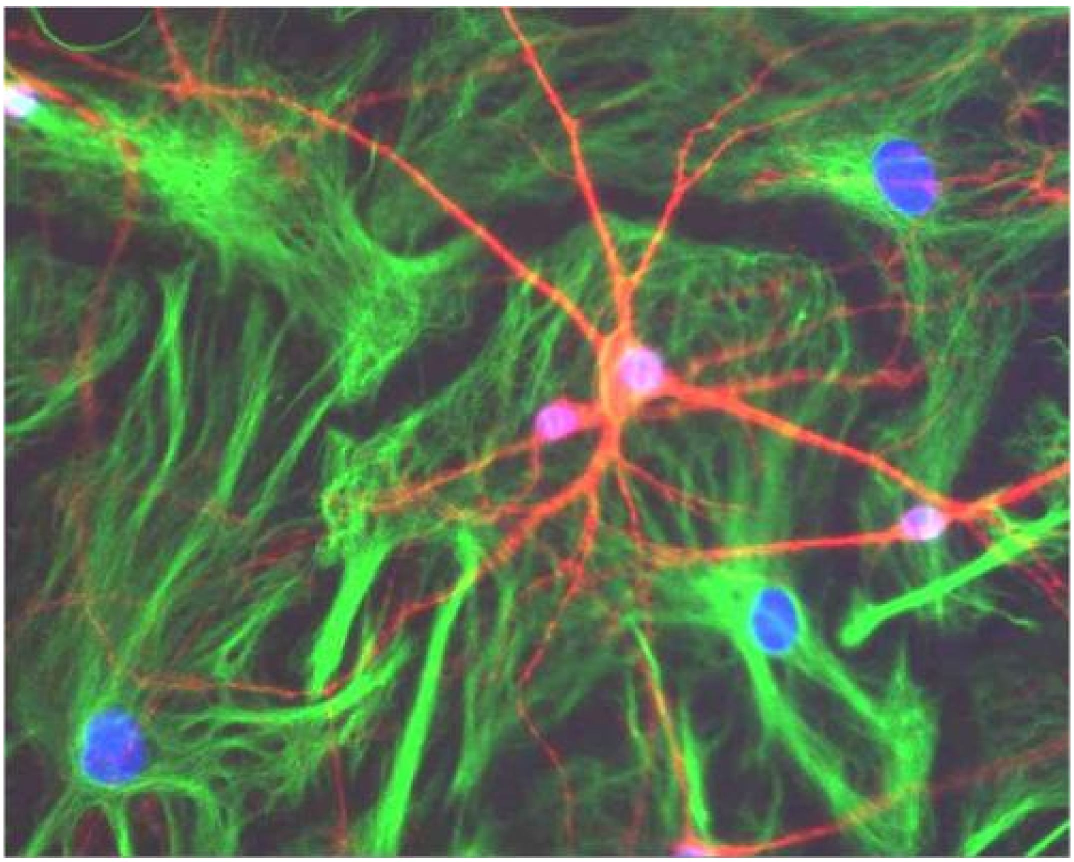

Neural networks (red) grow interspersed in the brain's glial networks (green). Credit: Pablo Blinder and Prof. Eshel Ben-Jacob of Tel Aviv University.

The transistors and wires that power our electronic devices need to be mounted on a base material known as a "motherboard." Our human brain is not so different—neurons, the cells that transmit electrical and chemical signals, are connected to one another through synapses, similar to transistors and wires, and they need a base material too.

But the cells serving that function in the brain may have other functions as well. PhD student Maurizio De Pittà of Tel Aviv University's Schools of Physics and Astronomy and Electrical Engineering says that astrocytes, the star-shaped glial cells that are predominant in the brain, not only control the flow of information between neurons but also connect different neuronal circuits in various regions of the brain.

Using models designed to mimic brain signalling, De Pittà's research, led by his TAU supervisor Prof. Eshel Ben-Jacob, determined that astrocytes are actually "smart" in addition to practical. They integrate all the different messages being transferred through the neurons and multiplexing them to the brain's circuitry. Published in the journal *Frontiers in* Computational Neuroscience and sponsored by the Italy-Israel Joint Neuroscience Lab, this research introduces a new framework for making sense of brain communications – aiding our understanding of the diseases and disorders that impact the brain.

Transcending boundaries

"Many pathologies are related to malfunctions in brain connectivity," explains Prof. Ben-Jacob, citing epilepsy as one example. "Diagnosis and the development of therapies rely on understanding the network of the brain and the source of undesirable activity."

Connectivity in the brain has traditionally been defined as point-to-point connections between neurons, facilitated by synapses. Astrocytes serve a protective function by encasing neurons and forming borders between different areas of the brain. These cells also transfer information more slowly, says Prof. Ben-Jacob – one-tenth of a second compared to one-thousandth of a second in neurons – producing signals that carry larger amounts of information over longer distances. Aastrocytes can transfer information regionally or spread it to different areas throughout the brain – connecting neurons in a different manner than conventional synapses.

De Pittà and his fellow researchers developed computational models to look at the different aspects of brain signalling, such as neural network electrical activity and signal transfer by synapses. In the course of their research, they discovered that astrocytes actually take an active role in the way these signals are distributed, confirming theories put forth by leading experimental scientists.

Astrocytes form additional networks to those of the neurons and synapses, operating simultaneously to co-ordinate information from different regions of the brain—much like an electrical motherboard functions in a computer, or a conductor ensuring that the entire orchestra is working in harmony, explains De Pittà.

These findings should encourage neuroscientists to think beyond neuron-based networks and adopt a more holistic view of the brain, he suggests, noting that the two communication systems are actually interconnected, and the breakdown of one can certainly impact the other. And what may seem like damage in one small area could actually be carried to larger regions.

A break in communication

According to Prof. Ben-Jacob, a full understanding of the way the brain sends messages is significant beyond satisfying pure scientific curiosity. Many diseases and disorders are caused by an irregularity in the brain's communication system or by damage to the glial cells, so more precise information on how the network functions can help scientists identify the cause or location of a breakdown and develop treatments to overcome the damage.

In the case of epilepsy, for example, the networks frequently become overexcited. Alzheimer's disease and other memory disorders are characterized by a loss of cell-to-cell connection. Further understanding brain connectivity can greatly aid research into these and other brain-based pathologies.

Provided by Tel Aviv University