Creating a miniature brain-on-a-chip

Øyvind Halaas, photo Geir Mogen/NTNU

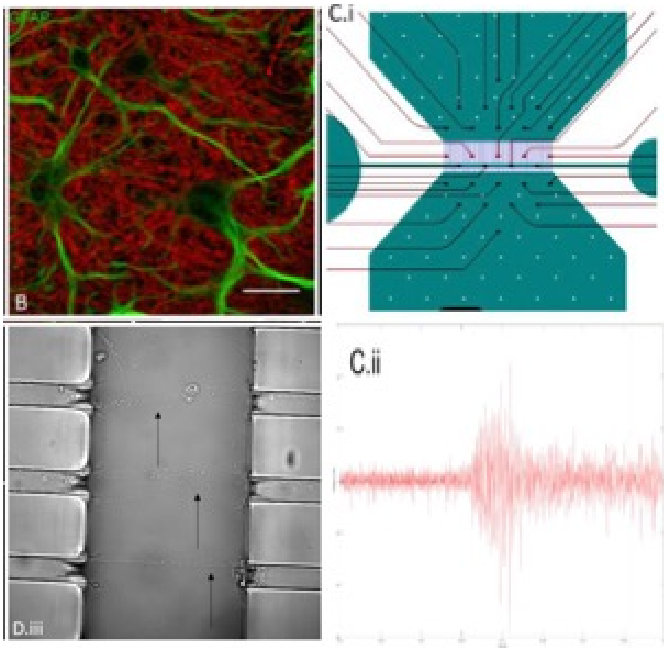
Growing a brain in the lab might still be a far-fetched idea, but perhaps it just got one step closer.

Øyvind Halaas, a professor of medicine at NTNU, in collaboration with neuroscientists Ioanna and Axel Sandvig and others, has created a mini-“brain-on-a-chip”. The biological neural network is made of just three nodes, compared to billions in a real brain, but the structure is an improvement on previous designs. Their project was part of the Cyborg initiative which aims to merge robotics and biology.

Researchers have previously tried to connect single neurons in networks, but those systems don’t always work because forming connections between individual neurons in patterns is inefficient. So Halaas and his colleagues decided to make each node a bundled group of brain cells instead.

The neurons themselves grew from stem cells, and the three nodes were connected by micro-tunnels that the neurons themselves couldn’t get through, but that did allow through their wire-like protrusions, called axons.

“The larger aim was to try to monitor the ‘thinking’ of this mini-brain-on-a-chip,” says Halaas. They used an existing commercial system to monitor the neurons’ electrical activity, and Halaas says they saw interconnection – and therefore communication – between the nodes.



The brain-on-a-chip could be used to study how brains develop and function and what exactly goes wrong when they stop working properly. “There's quite a bit of a gap from this system to trying to get neurons to form stable connections able to transmit signals, reminiscent of the thinking process in the brain,” he says. “But still, it’s kind of the beginning of a machine-learning/biology interface, which is truly fascinating.”

Brains aren’t the only organs researchers are replicating in the lab. Halaas’ other research focuses on the immune system. Though your body’s immune system isn’t a separate organ like your brain or your heart, it’s possible to recreate many of its workings using organ-on-a-chip models.

“The immune cells travel around the body, sensing their way forward towards infections or cancers, and initiating responses aimed at eliminating the threat,” says Halaas. “I've been trying to make artificial cell systems to learn how these cells communicate, develop, interact and react to stimuli.”

“The lymph node, where initiation of immune responses occurs, is particularly interesting when trying to create new solutions for vaccinations,” he added.

Ultimately, he wants to use these systems to develop cancer treatments through immunotherapy, a type of therapy that works with someone’s own body to fight off the disease. The idea would be to take cells from a cancer patient’s body and put them into the artificial immune system, before extracting the immune cells created in the artificial system and putting them back into patients.

It’s many years from being a reality, but Halaas believes it’s a promising route. “The current solutions for cancer therapy are not good enough for many patients,” he says.

This work has been carried out by Rosanne Van de Wijdeven, who worked in NTNU NanoLab on making microsystem and microelectrodes in collaboration with Ola Huse Ramstad and Ionna Sandvig who did the cell work at NTNU.

Kelly Oakes, Sept 2019