Fragment of rat brain simulated in supercomputer

Blue Brain Project announces results of a decade's work.

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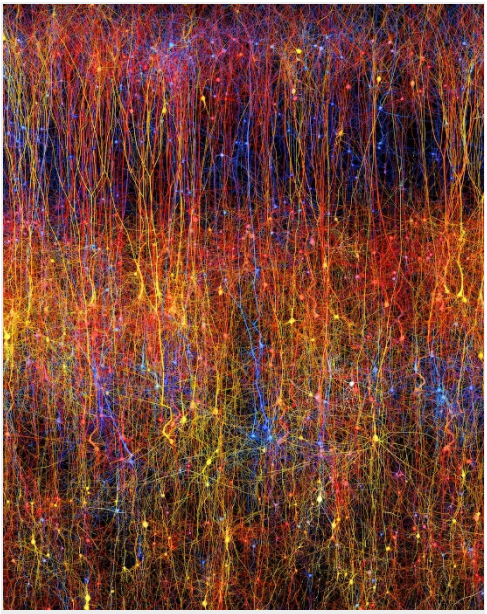
A controversial European neuroscience project that aims to simulate the human brain in a supercomputer has published its first major result: a digital imitation of circuitry in a sandgrain-sized chunk of rat brain. The work models some 31,000 virtual brain cells connected by roughly 37 million synapses.



BBP/EPFL

A simulated brain slice from the Blue Brain Project: neurons are coloured according to their levels of electrical activity.

The goal of the Blue Brain Project, which launched in 2005 and is led by neurobiologist Henry Markram of the Swiss Federal Institute of Technology in Lausanne (EPFL), is to build a biologically-detailed computer simulation of the brain based on experimental data about neurons' 3D shapes, their electrical properties, and the ion channels and other proteins that different cell types typically produce (see 'Brain in a box').

Such a simulation would provide deep insights into the way the brain works, says Markram. But other neuroscientists have argued that it will reveal no more about the brain's workings than do simpler, more abstract simulations of neural circuitry — while sucking up a great deal of computing power and resources.

The initiative has links with the Human Brain Project, a €1-billion (US$1.1-billion), decade-long initiative which Markram helped persuade the European Commission to fund, and which also aims to advance supercomputer brain simulation. It launched in 2013, with Markram as co-leader, although this March its leadership was switched and its scientific programme altered, after criticism of the way it was being managed.

Starter simulation

A paper describing the rat-brain model, published on 8 October in the journal *Cell*[1], provides a glimpse of Markram's vision. The result of a large collaborative effort involving more than 80 researchers from 12 different countries, the model represents a tiny region of circuits in the rat's primary somatosensory cortex, which receives sensory information from the whiskers and other parts of the body.

The computer model, which is freely available to explore online, does not simulate every aspect of the cortex: for example, it does not include glia — the brain's non-neuronal cells — or blood vessels, and leaves out more-complex aspects of neural circuitry, such as plasticity (how synaptic connections change in response to experience).

Nonetheless, Markram says that the model reproduces emergent properties of cortical circuitry, so that manipulating it in certain ways, such as by simulating whisker deflections, leads to the same results as real experiments. And he says that the model can be manipulated in ways that are difficult to do experimentally, providing insights into how individual cells contribute to the functions of neuronal networks.

But critics are sceptical that the simulation has provided fresh insights. "They try to stretch their model to say something interesting about actual biological function, but it falls far short on that front. The complexity of the model far outstrips the simplicity of what is being captured," says theoretical neuroscientist Chris Eliasmith of the University of Waterloo in Canada. Eliasmith leads a group that, in 2012, reported a large-scale simulation of the brain called Spaun, with 2.5 million virtual neurons, but which uses much-simpler mathematical representations of brain cells than does the Blue Brain Project. The latest paper, he feels, won't change the minds of scientists who are already opposed to Markram's vision.

But Markram is undeterred. The model is a first, imperfect draft, he points out, which will improve as details from further biological experiments are added to its workings. Simulating the human brain, he says, poses huge computational challenges: whereas the rat-

cortex simulation runs a billion calculations every 25 microseconds, a human simulation would require a billion times more than that. “This is a big challenge for supercomputers, but we're working very closely with IBM to improve the technology,” he says.

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References

1. Markram, H. *et al*. *Cell* **163,** 1–37 (2015).