Medical Xpress

The brain: probing its deep mystery

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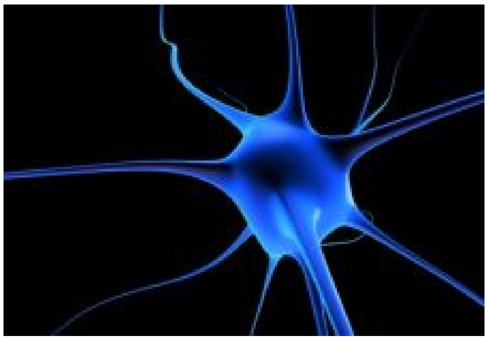

(PhysOrg.com) -- We know more about the cosmos than we do about the human brain, but work by European researchers will now allow scientists to probe further into the mysteries of our grey matter.

We know the cosmos better than we do the ocean floor, but even the ocean floor is better understood than the human brain. Estimated to contain 50-100 billion (1011) neurons, and these cells pass signals to each other via as many as 1000 trillion (1015) synaptic connections, the brain is a vast territory.

But it is not just the staggeringly large geography of the brain that makes this final frontier deeply mysterious; even where behaviour is predictable and reliable the reasons for this behaviour often remain unknown.

“Nowadays an implant that has gathered a lot of interest is the deep brain stimulator for Parkinson's disease," notes Herc Neves, scientist at IMEC and coordinator of the NeuroProbes project. "It works, but we don't know how it works."

Even when researchers succeed in combating a terrible disease, the fundamental mechanism remains deeply mysterious.
"Part of the problem is that we do not have good visualisation. It is not an imaging problem; what I mean is that we cannot see what is happening at a cellular level. We have some very, very interesting tools like functional magnetic resonance imaging (fMRI) that [give] us a pretty good idea about the inner workings of the brain, but this is at a macro level, not a cellular one."

So processes can be difficult to see; but even then understanding how the processes interact is a huge undertaking. "A Pentium computer chip has probably the processing power of a beetle brain. Even the retina, an extension of the brain, has many times the processing power of a Pentium chip. So we are a long way from being able to mimic the complexity of the human brain."

Key technology

Probes are a key technology to understand the fundamental mechanisms of the human brain at a cellular level. And this understanding provides the essential information to combat some of the most tragic and debilitating diseases known to man, including Alzheimer's, Parkinson's, schizophrenia and many others.

Probes are one of the key tools used by neuroscientists. They come in a variety of types and forms, and while they have been around for a while they have only enjoyed incremental advances over the last decade. Typically, they sense particular activity at a given location. Neuroscientists use them to study in detail areas highlighted by fMRI, for example.

NeuroProbes began its work by asking neuroscientists what was their wish list for 21st century research tools. “And they replied that, despite all the effort that had been going on to develop better probes for the brain, there was still a huge gap in terms of the needs of the community,” notes Neves.

By looking at the requirements of neuroscientists, the project was able to develop the specifications for a new probing platform. From an early stage, researchers decided that the new platform would be modular, so researchers could mix and match elements within the system.

“Because for starters, the brain is as much chemical as electrical,” stresses Neves. “So it was highly desirable to combine chemical sensing and actuation with electrical sensing and actuation. And very quickly we realised it was really something we could tackle in a modular way,” he adds.

Different groups specialising in different aspects of the technology, or different technologies, delivered their results independently and NeuroProbes combined the results into an overall platform.

Built for efficiency

Built into this modular approach was the concept of efficiency. “While [trying] to answer the needs of neuroscientists within the project, we stuck to standard fabrication processes and varied things as little as possible.”

The team also designed the platform to work in three dimensions, another novelty. In most modern probes, the active sensing and actuation elements are either in the vertical or horizontal plane. In NeuroProbes, both planes can contain active elements simultaneously, making it vastly more flexible.

It was a big challenge, but the consortium proceeded cautiously. The first year was a catch-up phase, proving the new platform could produce probes that were at least as good as the best available.

“It was a risk reduction approach. We wanted to start and become familiar with the platform doing something we knew we could do, then progressing in the second, third and fourth years to more ambitious probes,” declares Neves.

It worked for the neuroscientists, too. They were already testing NeuroProbes by the end of the first year, and in this way, they could become familiar with the new platform before it became too complex.

Conservative scientists

“Neuroscientists, for very good reasons, are quite conservative,” reveals Neves. “They prefer to stick with something that they know works reliably. Their work is sufficiently complex as it is, and so one of our major challenges was to prove that our platform could do as well or better than some of those standard electrodes. So we also designed our platform to work with whatever bench tools they had in the lab.”

The electronic depth-control probe was a special case, though. This particular probe was a major breakthrough for the project and, given its usefulness, neuroscientists have been very willing to experiment with the unfamiliar to access its functionality.

The electronic depth-control probe allows neuroscientists to accurately position individual electrodes with respect to cells. It was something the team realised during the project, as work continued it became obvious such a probe was both feasible and highly desirable, Neves tells ICT Results.

Initially, the team thought to move the probe mechanically in order to position it precisely. But while mechanical movement aligns one electrode, it could knock others out of position, and there was a risk of irritating the brain tissue, possibly leading to inflammation.

Eureka moment

During a brainstorming session, the Eureka moment came when the team realised they could virtually move the probe by electronically switching through a very large number of electrodes to get the best possible alignment with a given number of individual cells. It is something no other probe can do and neuroscientists are eager to use it.

The novelty of the probe meant the project team had to develop new control software, but even here the consortium was keen to cause as little disruption as possible, so they developed a simple and intuitive control interface. “Even a non-specialist would have no trouble understanding how to use the probe,” Neves states.

In all, NeuroProbes has significantly advanced the state of the art in neurological probing, developing a complete platform that serves everything from sensing and stimulation to data readout and recording on bench monitors. The platform will enable neuroscientists to move beyond the single electrode rods currently in vogue, to multi-electrode and micro-fluidic devices that enable more sophisticated and ambitious experiments.

The project’s work has been remarkable, but in many ways the greatest impact from the NeuroProbes research has yet to come; the insights and research breakthroughs that will lead to healthier brains in the future.

This is the first of a two-part special feature on NeuroProbes.
Part 2. www.physorg.com/news192804260.html

More information: NeuroProbes project - naranja.umh.es/~np/

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