

Frontiers in Brain Research

As part of its collaboration with [The Hebrew University Of Jerusalem](#), AtonRâ Partners had the pleasure to welcome **Professor Idan Segev**, the Head of the University's Department of **Neurobiology**. AtonRâ Partners and Idan Segev share the same passion for research, and as we always say at AtonRâ: knowledge is power, but sharing this **knowledge** is essential!

There are today many exciting projects trying to understand the brain and its diseases, and Prof. Idan Segev has the power to explain complicated science in a **very simple way**. During this conference, Idan presented what the future of brain research will be and its clinical and technological implications. Incredible advances in neuroscience, where technological advances meet biological discoveries, will change the way we treat many neurological diseases, from Parkinson's disease to Alzheimer's.

Before going into the details of some technologies, let's talk a little bit about **the brain, this amazing structure**.

The brain has inspired the most exciting technology today: Artificial Intelligence/machine learning. It is an incredible source of knowledge from which scientists never stop learning.

What makes our brain so unique?

One thing all mammals have in common is the **neocortex**. Humans have a unique evolutionary neocortex with billions of nerve cells (neurons), and many connections between these cells, called synapses. This network, which looks like a **big jungle (but it is not)**, generates electrical and chemical signals that eventually allow you to **move, talk, create, and feel**.



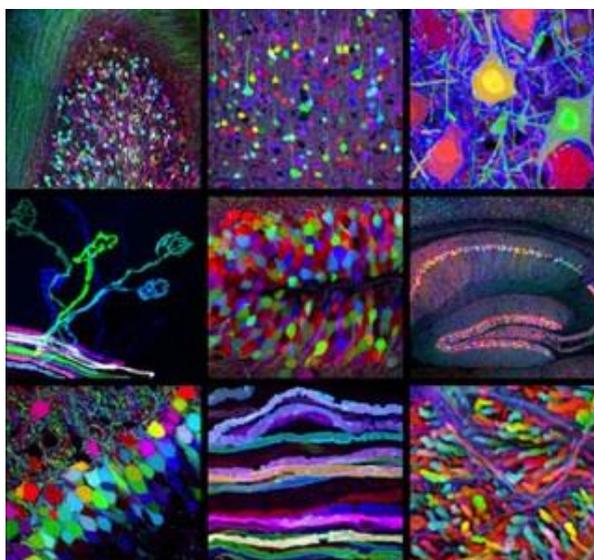
The beauty of the brain lies in its complexity: it can be studied at different levels, from its genome to protein expression and electrical activity and whole-brain operation to behavior.

Humans, or Homo Sapiens Sapiens, appeared ~300,000 years ago on earth. Since then, we have the same genome, which defines us as one species. Therefore, all developments that came later, language, art, modern computer, mathematics, are not due to genetic changes but rather to cultural evolution. This means that we created new and amazing things with the same brain as that of 300,000 years ago, and all the new and future possibilities are already available in our brains (depending on the changing environment and adaptation our brain undergoes with time and progress). There is, therefore, a huge potential in our brain that has yet to be expressed.

What happens in this brain that is able to create again and again with the same genetics? What is the physics behind it? These questions are still to be answered, but here are some amazing technologies that could one day help us understand how we learn, create, imagine... but also how brain diseases develop.

The Brainbow Technology

One new such technology is "brainbow" technology, which allows researchers to genetically design the mouse brain to have neurons with many colors rather than just grey or white matter. A team of researchers at Harvard University successfully engineered a mouse genome to insert pieces of DNA into it. These genes code for fluorescent proteins. When they are expressed, the nerve cells become colorful, and the brain looks like a rainbow (see Figure below). This technology enables to study the anatomy of the brain in a more refined manner exploring questions such as: What changes in your living brain when you learn? Apparently, much of the learning is based on new synaptic connections that are produced! With the Brainbow technology, you can observe these changes during the learning process.



During the learning process, we generate millions of new synapses. In Alzheimer's disease, however, these synaptic connections are not functioning well (and some also die) - and the cells no longer talk to each other. The memory mechanism is dramatically affected.

The Deep Brain Stimulation

The next breakthrough technology in brain research mentioned by Prof. Idan Segev was the Deep Brain Stimulation. DBS is a successful treatment for Parkinson's disease patients. Researchers are also exploring the use of DBS to treat other diseases from depression to disabilities after strokes.

Parkinson's disease occurs in the basal ganglia. In this part of the brain, millions of cells produce dopamine, a key transmitter, or chemical agent responsible for sending messages among the network of neurons in this region. In Parkinson's disease, the individual dopaminergic cells no longer produce dopamine. Without dopamine, patients can no longer control and coordinate their movements. We may replace the lack of dopamine via chemical treatment/drugs, but this treatment is not working well as a long-term solution.



The researchers suggested a novel approach to treating Parkinson's disease. They observed that Parkinson's disease generates a wrong electrical activity in the basal ganglia. Deep brain stimulation, through an electrode implanted in the right place, "pulses" the brain and recovers to a large extent the normal activity. It can help to improve movement control in a more stable (and consistent) way than dopamine replacement drugs do. The results are incredible, and patients can have almost a normal life. You don't fix the disease, but you fix the symptoms.

The Blue Brain Project

The mission of [the Blue Brain Project](#) is to model, in the computer, the activity of the neural network and synaptic connections. The objective is to develop a digital copy of the brain to understand the brain and build brain-inspired new technologies.

What does it mean to model a brain? It means writing mathematical equations whose solutions generate signals that closely mimic the electrical activity of real neurons. With enough computing power, simulation is possible not only for one cell but for millions of cells. The mathematical replication of synaptic connections is also essential. Indeed, the chemical reactions between cells are also replicated by other sets of equations. This project offers a radically new approach to understanding the structure and functions of the brain.

Researchers completed the first phase of the project: they successfully translated the biological properties of a rat brain fragment into mathematical simulation; they modeled 10,000 virtual neurons linked together by 30 million synapses. The Blue Brain Project ultimately aims to rebuild the whole human brain.

Biology and technology are inseparable

Our brains will continue to inspire technologies like AI. Technology also helps scientists to understand diseases in a new way. However, the brain is a highly complicated system and not so easy to repair when malfunctioning. But what we do know is that each brain disease is due to malfunctioning of a specific type of cell(s). The brain is a complicated jungle with different types of cell responsible for a specific activity in the circuit. One of the major efforts in the coming years is to link cell types to a particular disease. You will then be able to target the specific cell type and, hopefully, repair the corresponding disease. Electrical stimulation is more local than chemical medicine. However, it still affects all cell types in the region. There is a new technology called **optogenetics**, a combination of optics and genetics, where it can really target a cell type and then optically stimulate only that cell and not those nearby. The future of medicine lies in targeted treatment where you can stimulate one cell type to repair a particular disease and not causing just a general effect.

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is important for all to accelerate innovation and develop knowledge. **Sit with your kids and learn with them about the Future of Science**

We also invite you all to watch the video of the conference [here](#).

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