# CMSC 828D Report - The Blue Brain Project

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The Blue Brain Project is an attempt to build a working model of the mammalian brain on the molecular level. The team of 46 researches at the cole Polytechnique Fdrale de Lausanne (EPFL) in Lausanne, Switzerland, led by Dr. Henry Markram, is seeking to reverse engineer the brain for many reasons.

First, a high-fidelity model of the brain will allow researchers to gain a better understanding of its function. Such a model allows for experimentation that may otherwise be considered impractical or unethical.

Second, such a model would act as a collective storehouse, integrating the results of worldwide research collective over the span of decades. Markram has commented that it would serve as a sort of Noah's Ark, helping to warehouse and preserve our knowledge of the brain in a way that is easily understood (relatively speaking, of course).

Additionally, the Blue Brain project would be a major step in building a true artificial intelligence system from the bottom up. Markram fully believes that if they are successful, the team at the EPFL will have created a system no different in function from a biological brain. This would mean that their model would have the ability to learn or adapt to new situations and would even be capable of speech and natural language processing.

Finally, what could be the most widely compelling reason to pursue such an endeavor is the possible boon to medicine. Roughly one in four people suffer from one of nearly 560 identified diseases of the brain. Current medications are largely discovered through empirical means. The only real understanding of a drug's efficacy is based solely on a large battery of tests performed. These tests are expensive and inefficient. However, a simulation of the brain on the molecular level allows for rapid testing of new drugs, increasing the speed at which medications can be developed as well as offering the possibility of creating tailored drugs, designed to target a particular illness with a minimum of side-effects.

So how does one go about modeling such a complex system? It begins with an understanding of what is happening at the neuronal level. Thin slices of brain are placed under a microscope so that neurons can be very carefully measured, both for their shape, size, and synaptic connectivity to neighboring neurons. In addition, researches at the EPFL have developed a one-of-a-kind instrument that allows them to measure the electrical properties of up to 12 neurons at once.

Given this information, their location in the brain, and the population density of the neurons in this region, a precise mathematical model can be built of the neuron itself. This model is based largely on the original model developed by McCullough and Pitts, but is complex enough that it requires the processing power of a laptop to simulate just a single neuron. As such, the research team has partnered with IBM and is using a pair of their Blue Gene supercomputers in order to run their simulations. This is why the project is known as the Blue Brain.

Currently, the system is capable of simulating an entire cortical column (a basic, repeating unit found in the cerebral cortex) at about 300 times slower than real time. This means that simulating one second of the approximately 10,000 neurons that make up the column takes around 5 minutes. Of course, while time efficiency is necessary to a certain extent in order for the system to be practical, it is not the end concern of the project. Rather, the ability to process massive amounts of data is what is really needed.

Using the Blue Gene supercomputers, up to 100 cortical columns, 1 million neurons, and 1 billion synapses can be simulated at once. This is roughly equivalent to the brain power of a honey bee. Humans, by contrast, have about 2 million columns in their cortices. Despite the sheer complexity of such an endeavor, it is predicted that the project will be capable of this by the year 2023.

While the road ahead is long, already researches have been gaining great insights from their model. Markram himself has stated that he has learned more in the last three years working on the project than he has in the past two decades as a neural scientist. One of the project's great breakthroughs is the ability to, with great accuracy, predict where synaptic connections will occur between neurons.

Despite the projects ambitious nature and exciting results, there are still some detractors who object to the project. These objections generally fall within one of two categories.

First, some believe that an attempt to build such a model is folly based on the grounds that the brain is so utterly complex that it will never be possible to simulate it. Proponents, however, point to a combination of Moore's Law and the long lifespan of the project itself. It seems that while the technology might not exist at this very moment, it could be reasonable to assume that it will within the next decade. Markram, true to the spirit of exploration, believes that the question shouldn't be whether or not it is possible, but instead should be how do we make it possible.

The second objection to the project is given by those who view the process of thought and consciousness as being brought about by more than just the physical structure of the brain. This group believes (to be overly general) that there is some spiritual component that is impossible to simulate. Markram, however, is a reductionist, believing that consciousness is brought about as an emergent property of the brain. Regardless of either his beliefs or those taking the spiritual argument, Markram states quite rightly that this project could likely benefit both parties. After all, if a completed high-fidelity model fails to mimic a real brain, then there is strong support for the theory that there is more to the brain than simply its physical form.

## References


*The Blue Brain Project EPFL.* cole Polytechnique Fdrale de Lausanne. http://bluebrain.epfl.ch/

*Blue Brain Project.* Wikipedia. http://en.wikipedia.org/wiki/Vestibulo-ocular_reflex

*Blue Brain Project.* Artificial Brains. http://www.artificialbrains.com/blue-brain-project

*Neocortex.* Wikipedia. http://en.wikipedia.org/wiki/Neocortex

*Bluebrain: A Documentary Film.* http://bluebrainfilm.com/bb/