Symposium III - PHYSICS, COMPUTATION, AND THE BRAIN

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While most scientists agree that the brain "processes information" and many would claim that the brain "computes" in one sense or another, the precise meanings of "information processing" and "computation" in those claims are unclear. The purpose of this symposium is to provide needed background for a principled consideration of the questions "Does the brain compute?" and "If so, what and how?".

Chris Wood (Santa Fe Institute) will present an overview of the physics of information. While the theory of computation is mainly expressed as abstractions that are independent of any particular physical realization, once an abstract computation is actually implemented it becomes a physical phenomenon, governed like all such phenomena by the laws of physics. “Computers are physical systems: the laws of physics dictate what they can and cannot do. In particular, the speed with which a physical device can process information is limited by its energy and the amount of information that it can process is limited by the number of degrees of freedom it possesses.” (Lloyd, S. “Ultimate Physical Limits to Computation”, Nature, August 2000).

Stephan Mertens (University of Magdeburg) will present an overview of the theory of computation and computational complexity. Computers can do many things, many of them very well, and they are getting more powerful every day. There are, however, fundamental limits to what computers can do, and these limits are independent of technological advances. The theory of computational complexity enables us to pin down these limits. It also teaches us that it requires powerful brains to push the limits.

Chris Eliasmith (University of Waterloo) will present an approach to large-scale computational modeling of the brain. While detailed dynamic models of single neurons abound, there are few principled, quantitative methods for building large-scale models of brain function. This talk will introduce and provide examples of the application of the method described in his book Neural Engineering (2003, MIT Press). This method is simple, consisting of 3 basic principles, quantitative, and widely applicable to building biologically realistic neural models. Applications to the rat navigation system and human cognitive processes will be described.