INTRODUCTION

Of Bytes and Brains

COMPUTATIONAL NEUROSCIENCE IS NOW A MATURE FIELD OF RESEARCH. In areas ranging from molecules to the highest brain functions, scientists use mathematical models and computer simulations to study and predict the behavior of the nervous system. Simulations are essential because the present experimental systems are too complex to allow collection of all the data. Modeling has become so powerful these days that there is no longer a one-way flow of scientific information. There is considerable intellectual exchange between modelers and experimentalists. The results produced in the simulation lab often lead to testable predictions and thus challenge other researchers to design new experiments or reanalyze their data as they try to confirm or falsify the hypotheses put forward. For this issue of *Science*, we invited leading computational neuroscientists, each of whom works at a different organizational level, to review the latest attempts of mathematical and computational modeling and to give us an outlook on what the future might hold in store.

Understanding the dynamics and computations of single neurons and their role within larger neural networks is at the center of neuroscience. How do single-cell properties contribute to information processing and, ultimately, behavior? What level of description is required when modeling single neurons? Herz *et al*. (p. 80) review single-cell models, from detailed and reduced compartmental models to point neurons and black-box models and they highlight the merits and corresponding problems.

Single neurons are part of larger networks. Destexhe and Contreras (p. 85) review advances in the computations created by stochastic input in neurons and networks of neurons. They emphasize the importance of irregular activity in neuronal computations.

On a higher processing level, computational neuroscience based on the detailed anatomy and physiology of the human brain can help us understand the complexities of conscious awareness and human intelligence. O'Reilly (p. 91) reviews developments in models, of higher-level cognition. He develops the idea that the prefrontal cortex represents a synthesis between analog and digital forms of computation.

As this special issue's News section demonstrates, computational neuroscience attracts its share of atypical brain researchers. On page 76, Miller describes how Jeff Hawkins, an electrical engineer who invented the PalmPilot, has developed a theory for how the cortex makes predictions. He even founded a small neuroscience institute. And on page 78, Wickelgren looks into the work of Eero Simoncelli, an electrical engineer who seeks to model how the brain's visual system makes sense of the world.

Two Signal Transduction Knowledge Environment (STKE) Reviews concern adaptive and maladaptive consequences of neuronal activity. Lisman and Raghavachari develop a structural model that incorporates seemingly contradictory data to provide a coherent view of long-term potentiation at the hippocampal CA1 synapse. McNamara, Huang, and Leonard hypothesize that activity-dependent increases in Ca^{2+} concentration in dendritic spines are critical to limbic epileptogenesis. In an STKE Perspective on D-serine regulation of *N*-methyl-D-aspartate receptor activity, Wolosker discusses the possibility that D-serine released from neurons and glia may have distinct functions.

– PETER STERN AND JOHN TRAVIS

Modeling the Mind

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