Fundamentals of Computational Neuroscience 2e

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Chapter 1: Introduction

What is Computational Neuroscience?

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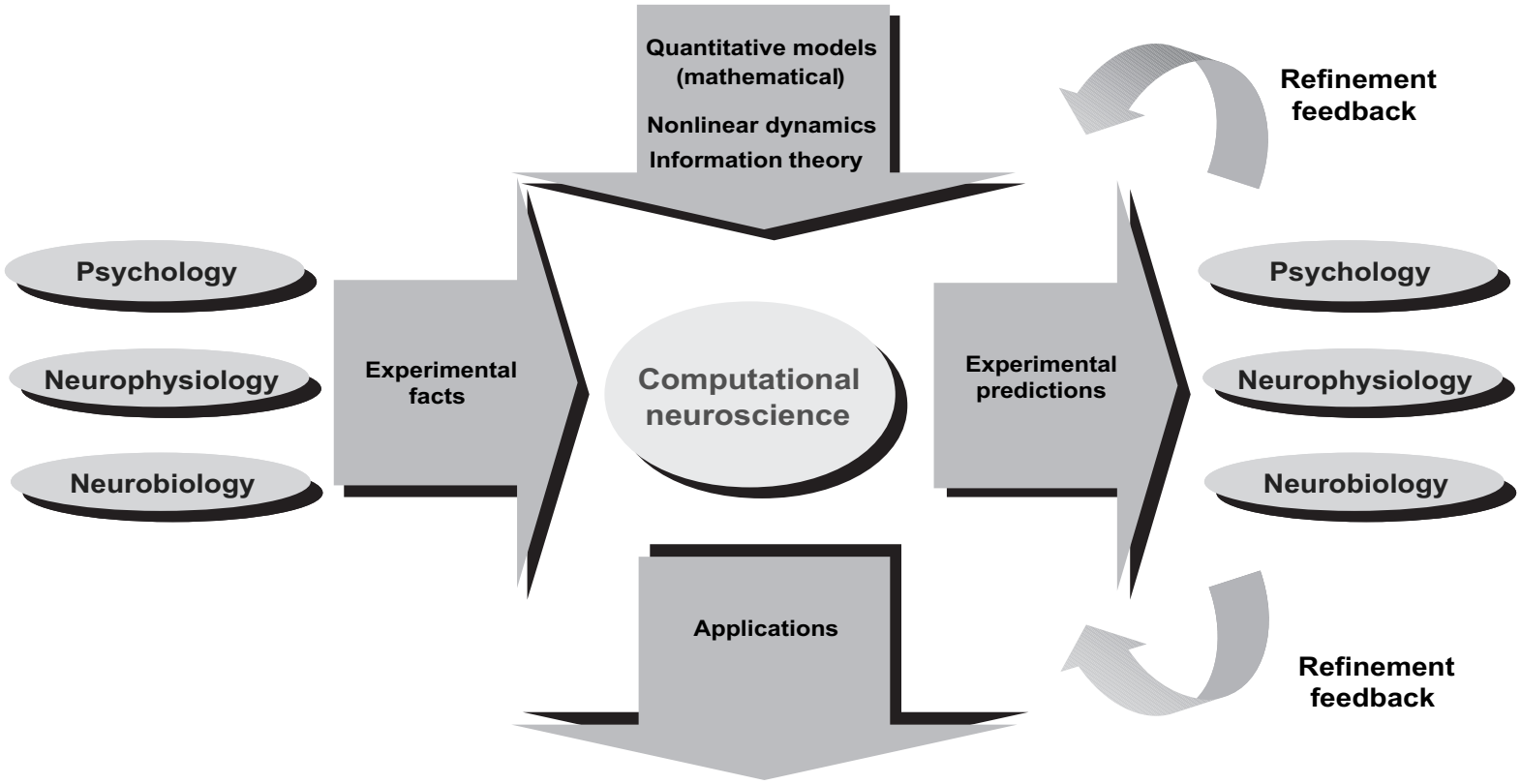
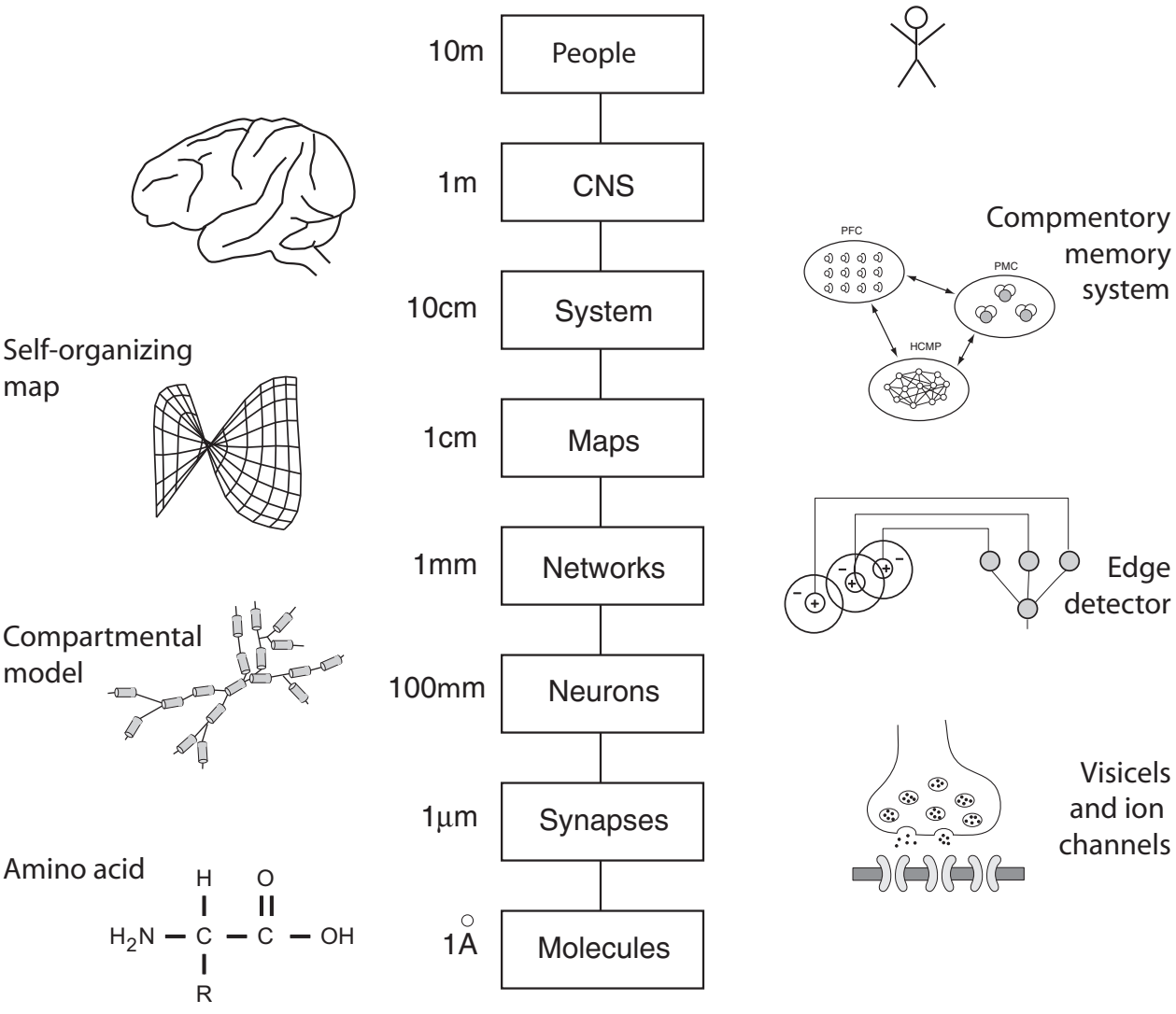
Computational Neuroscience is the theoretical study of the brain to uncover the principles and mechanisms that guide the development, organization, information processing and mental abilities of the nervous system.

Computational/theoretical tools in context



Levels of organizations in the nervous system



What is a model?

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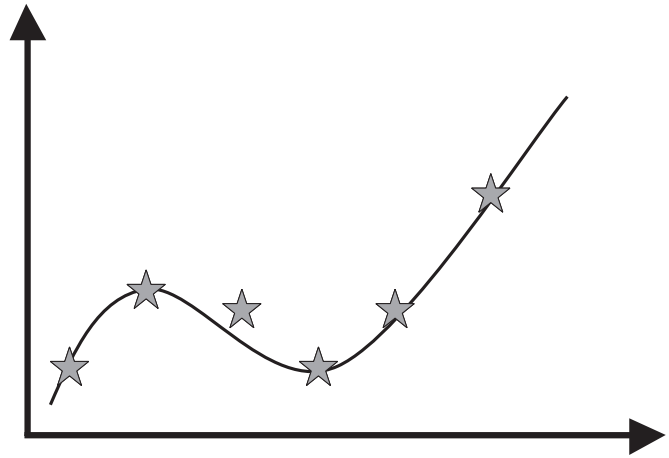

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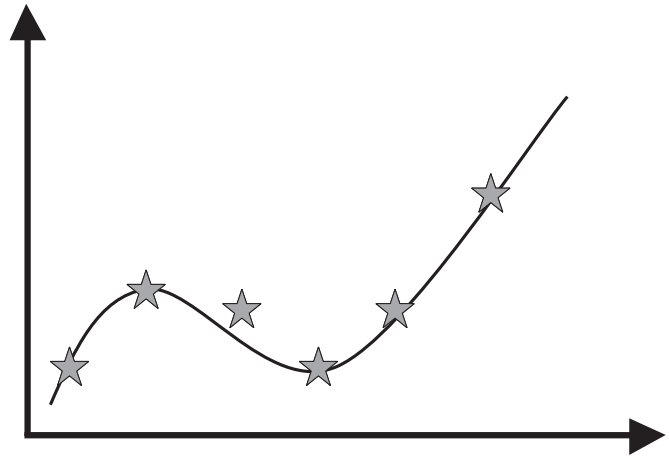


Models are abstractions of real world systems or implementations of hypothesis to investigate particular questions about, or to demonstrate particular features of, a system or hypothesis.

Is there a brain theory?

Marr's approach

1. **Computational theory: What is the goal of the computation, why is it appropriate, and what is the logic of the strategy by which it can be carried out?**
2. **Representation and algorithm: How can this computational theory be implemented? In particular, what is the representation for the input and output, and what is the algorithm for the transformation?**
3. **Hardware implementation: How can the representation and algorithm be realized physically?**

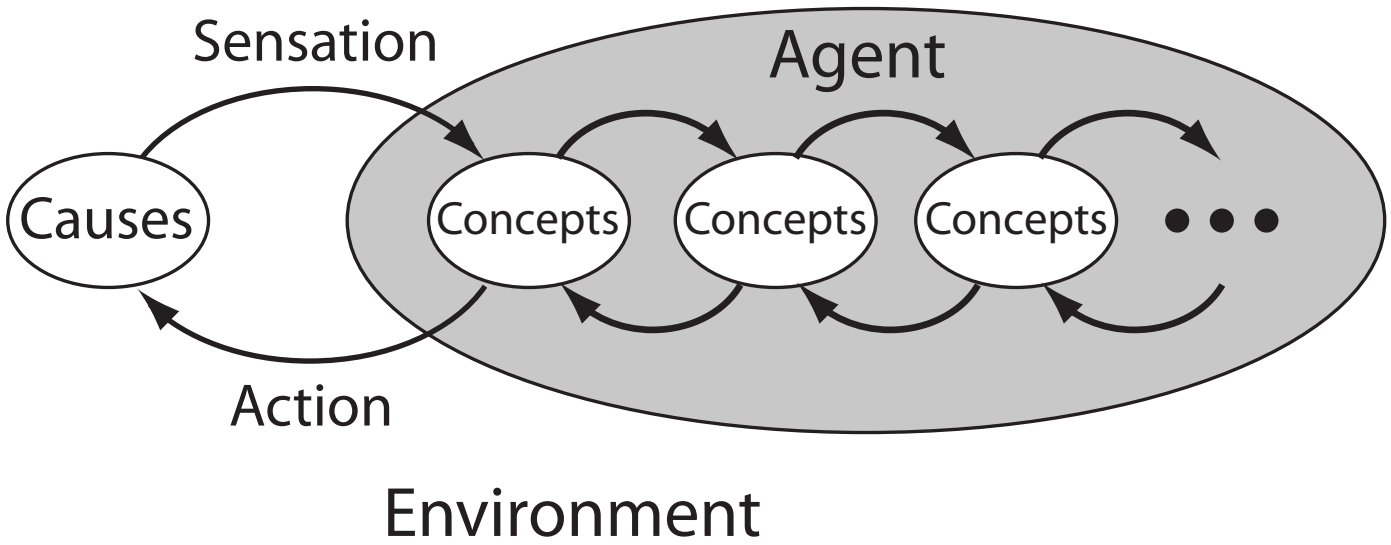
Marr puts great importance to the first level:

> *"To phrase the matter in another way, an algorithm is likely to be understood more readily by understanding the nature of the problem being solved than by examining the mechanism (and hardware) in which it is embodied."*

A computational theory of the brain:

The anticipating brain

The brain is an anticipating memory system. It learns to represent the world, or more specifically, expectations of the world, which can be used to generate goal directed behavior.



Overview of chapters

2 Neurons and conductance-based models

3 Simplied neuron and population models

4 Associators and synaptic plasticity

5 Cortical organizations and simple networks

6 Feed-forward mapping networks

7 Cortical maps and competitive population coding

8 Recurrent associative networks and episodic memory

9 Modular networks, motor control, and reinforcement learning

10 The cognitive brain

Further Readings

Patricia S. Churchland and Terrence J. Sejnowski, 1992, **The computational Brain**, MIT Press

Peter Dayan and Laurence F. Abbott 2001, **Theoretical Neuroscience**, MIT Press

Jeff Hawkins with Sandra Blakeslee 2004, **On Intelligence**, Henry Holt and Company

Norman Doidge 2007, **The Brain That Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science**, James H. Silberman Books

Paul W. Glimcher 2003, **Decisions, Uncertainty, and the Brain: The Science of Neuroeconomics**, Bradford Books

Questions

What is a model?

What are Marr's three levels of analysis?

What is a generative model?

Project 1

Suppose there is a simple world with a creature that can be in three distinct states, sleep (1), eat (2), and study (3). An agent is observing this creature with poor sensors, which add white (gaussian) noise to the true state.

Build a model of the behavior of the creature which can be use to observe the creature with some accuracy. Note: Use function `creature_state()` pull the state of the creature at one time step.