

Objectives

- Philosophy → models
- Models → Neuron Models
- Overview of Neuron Models
- Overview of Tutorials

Philosophy of Science

- Aims and Methods of Science → Knowledge
→ Prediction
→ Control
- We gain knowledge about the world
 - by using observations to generate theories
 - by using theories to generate theories
- Theories can take the form of models
- Models represent a target system
 - ↳ they are made up of parts and relations/structure
- What types of models are there?
 - Examples of Models?
 - Analogous models
 - ↳ when the model & target system are analogous
 - ↳ What does it mean to be analogous?
 - ↳ Analogy by:
 - Shared properties (sun + moon are spheres)
 - shared similarity of properties (light as waves and sound as waves)
 - shared similarity of structure e.g. formal analogy (oscillations in electrical circuit and pendulum)
 - Phenomenological Models
 - ↳ only represent observable properties of a target system and refraining from assuming/postulating hidden mechanisms
 - Idealized models
 - ↳ a deliberate distortion or simplification of something to make it more understandable or tractable
 - ↳ e.g. point masses, frictionless surface, spherical cow
 - Minimal models
 - ↳ a type of idealized model that is so simplified, it no longer represents a target system

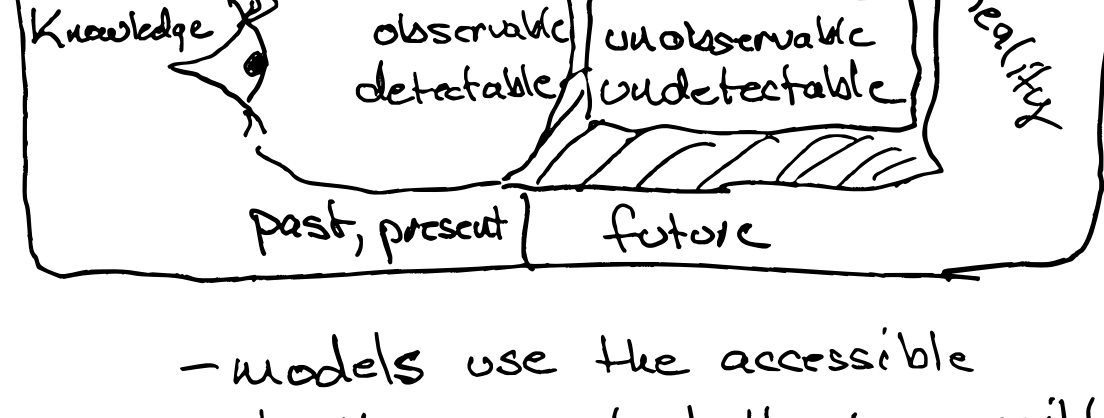
★ Discuss: What type of model is a HH model?

- Analogous (RC circuit)
- Phenomenological?
 - No → $I_{Na} + I_K + I_{Leak}$ corresponds to currents in membrane of s.g. axon.
 - Input/Output
 - ↑ current voltage
 - yes → what about the subunit representation?
 $I_K = N^p(V) (V - E_K)$ $p=4$
 - ↳ K^+ channel subunits were not known back in 1952!
- Idealized?
 - ↳ point neuron assumption
 - no dendrites!
 - ↳ intracellular signaling/mechanisms
 - ↳ many types of Na^+ & K^+ channels

- What makes a good model?

→ All models are wrong, some are useful

→ What are models good for?



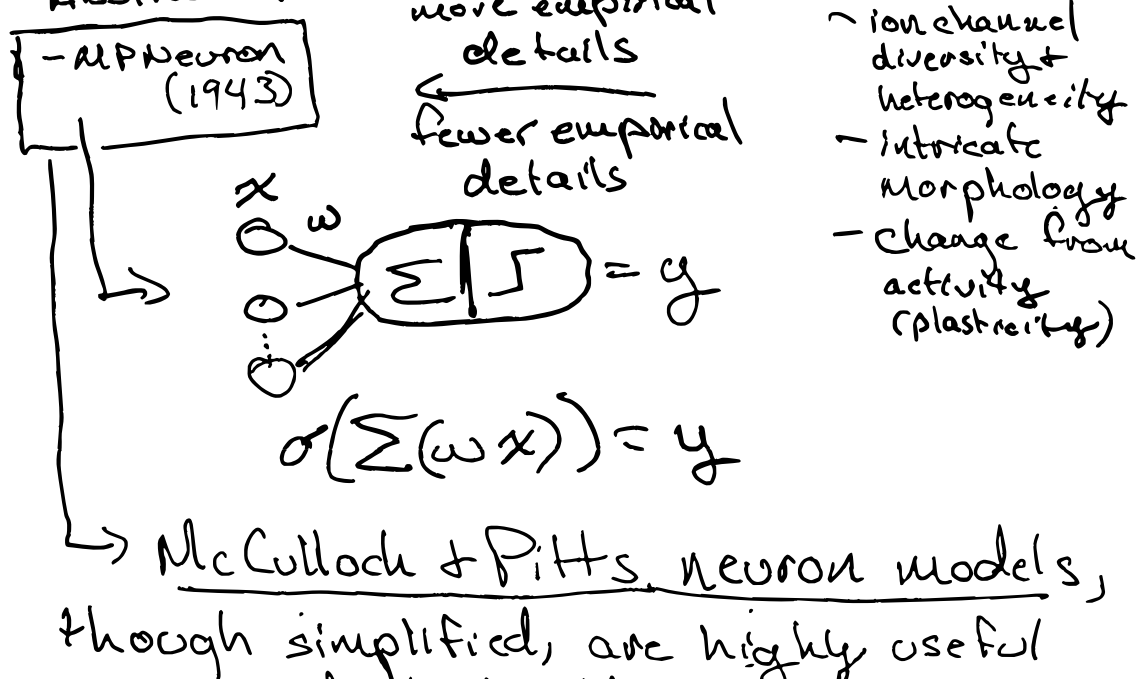
- models use the accessible to theorize about the inaccessible
- technology pushes the bounds of what is accessible over history
- all models are wrong, some are useful
 - ↳ can we look back on the history of science to see what modeling/reasoning strategies were most successful?

- How do we use models?

- ↳ Prediction (validation of past)
forecasting of future
- ↳ Representation of mechanisms
 - possible manipulations to test counterfactual hypotheses (Na^+ , HH)
- ↳ Building Blocks
 - HH out of RC circuit models
 - Neural Networks from neuron models

- What types of neuron models are there?

- Neurons have many empirical, observable details, and are quite complicated



→ McCulloch & Pitts neuron models, though simplified, are highly useful when used to build artificial neural network models

↓
However! These models are static. There are no time-varying processes.

★ Discuss: Do MP or NN neurons represent neurons in the real world to some degree?

- ↳ idealized models?
- ↳ are they minimal models?

Tutorials!

→ The tutorials we'll focus on today are on time-varying neuron models.

↳ Key to time-variation are the math concept of ODEs

① ↳ We will build an intuition behind 1-D ODEs

②a ↳ We will use ODEs to model LIF

②b ↳ We will study input/output relationship of LIF