Brief introduction to neurons

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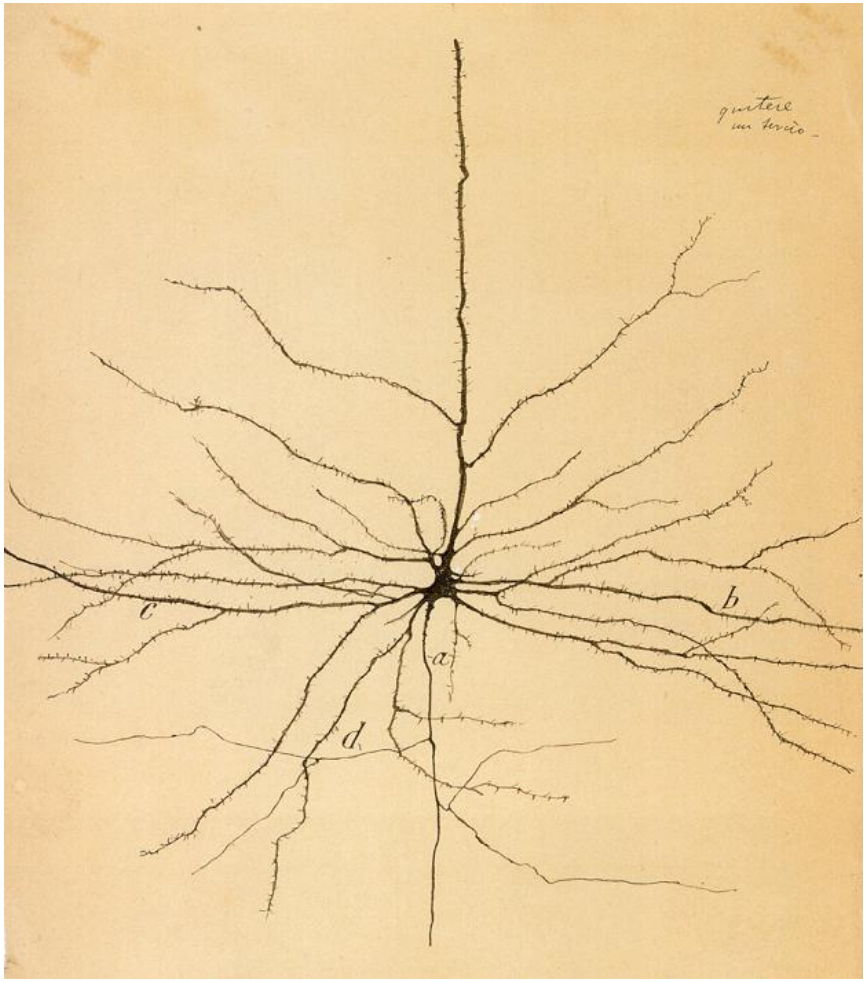
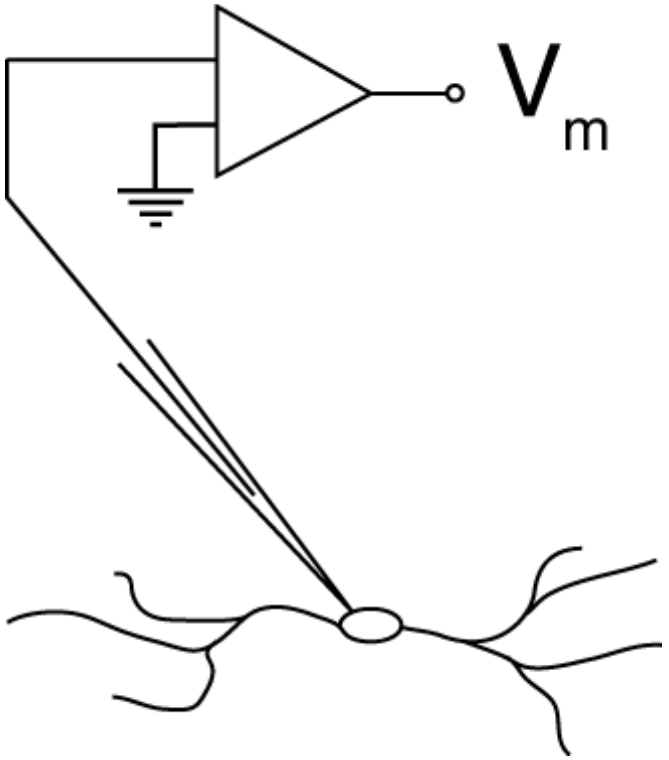
Neurons have branching shapes

- Cell body or soma
  - 10-100 μm
- The branches are called “neurites”
  - 100 μm - 1 m
- Neurites are like the “wires” of the brain.



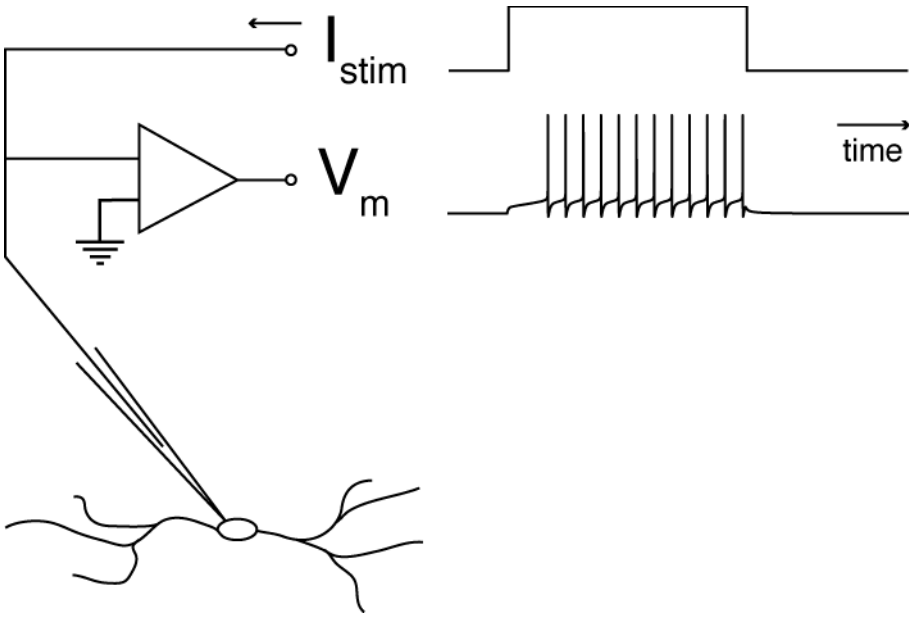
Neurons have a resting potential.

- Most of the time, the voltage of the inside of a neuron is negative relative to the outside.
- A typical value for this “resting potential” is –70 mV.



Neurons generate action potentials when stimulated

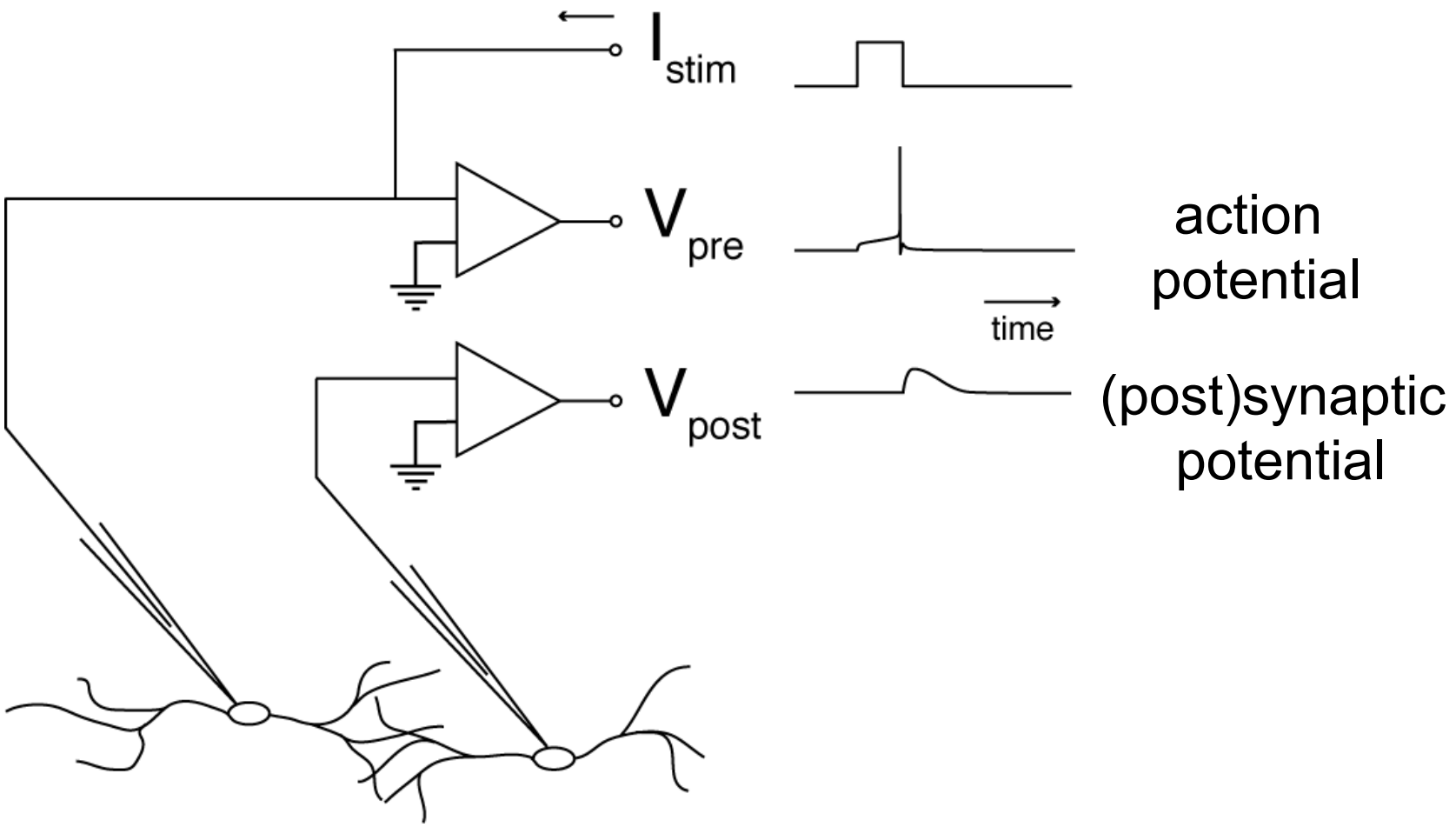
- Stimulation by current injection
- Response consisting of brief electrical pulses
  - “action potentials”
  - “spikes” or “spiking”



There is a threshold for spiking

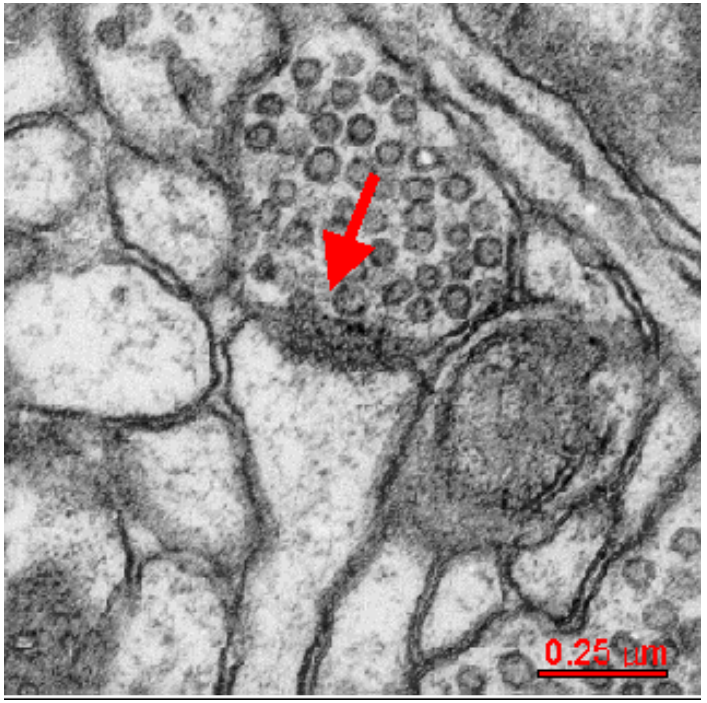
- Sufficiently large stimuli produce action potentials.
- Smaller stimuli do not.

One neuron can cause a potential change in another.



Neurons communicate via synapses.

- usually neurite-to-neurite junction
- visualized with EM
- presynaptic vesicles
- postsynaptic density



Kristen Harris, synapse-web.org

Most synapses transmit chemical messages

- An action potential stimulates secretion of neurotransmitter.
- Neurotransmitter binds to receptors.
- Binding triggers a synaptic potential.

Synapses are excitatory or inhibitory

- Excitatory
  - tends to cause spiking in the postsynaptic neuron
  - e.g. glutamate
- Inhibitory
  - tends to prevent spiking in the postsynaptic neuron
  - e.g. GABA

Neurons are excitatory or inhibitory (Dale's Law)

- Version 1: A neuron is either excitatory or inhibitory in its effects on other neurons.
- Version 2: A neuron secretes a single neurotransmitter at its synapses.
- There are exceptions to Dale's Law.

Synapses have strengths

- Amplitude of the postsynaptic potential
  - typically less than 1 mV.
- Duration of the postsynaptic potential
  - typically 1 to 1000 ms.
- Estimate of strength
  - amplitude $\times$ duration
  - amplitude

Dendrites and axons are types of neurites

- They can be distinguished in some types of neurons.
- Dendrites receive synaptic inputs.
- Axons make synapses on other neurons.

The axon is the output element.

- Thin and often long.
- A single axon leaves the soma, but may later branch, usually at right angles.
- Action potentials travel from the soma to the presynaptic terminals.

Dendrites are the input elements

- One or more dendrites attached to soma.
- Postsynaptic densities
- Hundreds of microns
- Graded potentials (a simplification)
- Spatial and temporal summation of synaptic inputs.

Functions of the action potential

- Computation
  - primitive form of decision-making
  - decision by comparison with a threshold
- Communication
  - transmission of signals over long distances through axons