BIOL3833

Week 11: Dendrites
Back when life was easy:

Dendrites → Soma → Axon → Synapse → Dendrites

Information flow through neurons

Dendrites: Collect electrical signals
Cell body: Integrates incoming signals and generates outgoing signal to axon
Axon: Passes electrical signals to dendrites of another cell or to an effector cell
What do dendrites do?
- Integrate subthreshold synaptic inputs
- Compartamentalize activity
- Determine how and when the neuron will fire

Integration

- Passive dendritic properties
- Active dendritic properties
The Passive Dendrite
Limitations of the Passive Dendrite

How to overcome the limitations?

- Decreasing $R_a$ allows more current to move toward the soma thus less signal loss with distance
- What are the limits on this strategy?
  - Diameter must increase by factor of 4 to double the distance efficiency (length constant)
Add more receptors to the distal dendrite
But – there is a limit on how big the distal EPSP can be.
Active Dendrites?
- Dendrites express voltage-gated Na$^+$, K$^+$ and Ca$^{2+}$ channels

Supralinear summation suggests the presence of dendritic ion channels

Add ion channels….

and get backpropagating action potentials!


Yes, those really are action potentials.

Hippocampus

Cerebellum
Add ion channels…. and get dendritic spikes!

Synaptic stim.

Dendritic Na spike
Dendritic Ca spike

100 µm

suprathreshold

subthreshold

20 mV

10 ms

Haüsser, et al. 2000, Science

- Dendrites express voltage-gated Na\(^+\), K\(^+\) and Ca\(^{2+}\) channels
- The location and densities of these channels is highly plastic (changes minute-to-minute)
- These ion currents can
  - enhance or suppress EPSPs
  - Produce nonlinear summation
  - Generate dendritic Na\(^+\) or Ca\(^{2+}\) spikes
  - Backpropagate somatic action potentials
What can dendritic spikes and backpropagated action potentials do?

- Help to activate NMDA receptors
- Increase calcium levels in dendrite
- Activate slow K+ channels in dendrite (this is where the IAHP and SK channels are!)

Compartmentalization

- Electrical events
- Biochemical events
Light microscope

Electron microscope (serial reconstruction)
Activation of CaMKII in single dendritic spines during long-term potentiation

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