Cogs 107B

Monday 4-5pm
A02

TA: Danielle Jacques
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OH: M 2-4pm Perks
Who’s in the class?

Aspiring researchers? Designers? Coders? Educators?
A bit about me

From Del Mar

Minor Music

2 years off to travel, work, figure out my career path (*highly recommend*)

UCSD 2019, Masters in Education Studies, Mathematics Teaching Credential
About this course

Midterm 1
  2/1, Thursday Week 4

Midterm 2
  2/22, Thursday Week 7

Final
  3/15, Thursday Week 10

~*The exams are not cumulative :)*
What do you want from section?

Open ended questions + class discussion

A summary of key points from lecture

Practice questions, followed by explanations

Images and YouTube videos

Other?
What we’ve covered

Neuron Doctrine & System Basics

Somatosensory (sense of touch)

Proprioceptive (sense of position and movement, egocentric)

Vestibular (coordinating movement with balance, allocentric)
systems neuroscience = structure dynamics

structure:
(micro) synapses → neurons → nuclei → regions (macro)

dynamics:
synaptic & action potentials (micro) → field potentials / EEG → fMRI (macro)
*ion selectivity*: Na+, Ca++, K+, Cl-

*gating*: by *voltage* (change in membrane potential), or *ligand* (neurotransmitter gated, glutamate receptors, etc.)

*kinetics*: open-time. (some ion channels are open for 1ms, some are open for 100s of ms and can vary)

*state*: activated, inactivated, deinactivated, persistent

*distribution*: in dendrites, at axon hillock
Question for you:

Explain the relationship between generator potentials (and where you find them):

- Action potentials
- Synaptic (Dendritic) potentials
- Neurotransmitter release
- Psychological response
### Table 1. Features of graded potentials and action potentials

<table>
<thead>
<tr>
<th><strong>Graded potentials</strong></th>
<th><strong>Action potentials</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depending on the stimulus, graded potentials can be depolarizing or hyperpolarizing.</td>
<td>Action potentials always lead to depolarization of membrane and reversal of the membrane potential.</td>
</tr>
<tr>
<td>Amplitude is proportional to the strength of the stimulus.</td>
<td>Amplitude is all-or-none; strength of the stimulus is coded in the frequency of all-or-none action potentials generated.</td>
</tr>
<tr>
<td>Amplitude is generally small (a few mV to tens of mV).</td>
<td>Large amplitude of ~100 mV.</td>
</tr>
<tr>
<td>Duration of graded potentials may be a few milliseconds to seconds.</td>
<td>Action potential duration is relatively short; 3-5 ms.</td>
</tr>
<tr>
<td>Ion channels responsible for graded potentials may be ligand-gated (extracellular ligands such as neurotransmitters), mechanosensitive, or temperature sensitive channels, or may be channels that are gated by cytoplasmic signaling molecules.</td>
<td>Voltage-gated Na⁺ and voltage-gated K⁺ channels are responsible for the neuronal action potential.</td>
</tr>
<tr>
<td>The ions involved are usually Na⁺, K⁺, or Cl⁻.</td>
<td>The ions involved are Na⁺ and K⁺ (for neuronal action potentials).</td>
</tr>
<tr>
<td>No refractory period is associated with graded potentials.</td>
<td>Absolute and relative refractory periods are important aspects of action potentials.</td>
</tr>
<tr>
<td>Graded potentials can be summed over time (temporal summation) and across space (spatial summation).</td>
<td>Summation is not possible with action potentials (due to the all-or-none nature, and the presence of refractory periods).</td>
</tr>
<tr>
<td>Graded potentials travel by passive spread (electrotonic spread) to neighboring membrane regions.</td>
<td>Action potential propagation to neighboring membrane regions is characterized by regeneration of a new action potential at every point along the way.</td>
</tr>
<tr>
<td>Amplitude diminishes as graded potentials travel away from the initial site (decremental).</td>
<td>Amplitude does not diminish as action potentials propagate along neuronal projections (non-decremental).</td>
</tr>
<tr>
<td>Graded potentials are brought about by external stimuli (in sensory neurons) or by neurotransmitters released in synapses, where they cause graded potentials in the post-synaptic cell.</td>
<td>Action potentials are triggered by membrane depolarization to threshold. Graded potentials are responsible for the initial membrane depolarization to threshold.</td>
</tr>
<tr>
<td>In principle, graded potentials can occur in any region of the cell plasma membrane, however, in neurons, graded potentials occur in specialized regions of synaptic contact with other cells (post-synaptic plasma membrane in dendrites or soma), or membrane regions involved in receiving sensory stimuli.</td>
<td>Occur in plasma membrane regions where voltage-gated Na⁺ and K⁺ channels are highly concentrated.</td>
</tr>
</tbody>
</table>

**Note:** The details of action potentials noted here refer to those of neuronal action potentials. As we will see throughout our study of physiology, other action potentials (for example, in skeletal, cardiac, and smooth myocytes, and in some endocrine cells) exhibit different features than those mentioned here.
Week 1 Review

What do all the somatosensory & proprioceptive receptor cells have in common?

What differences do they have?

How could you classify them?

Meissner’s Corpuscles
Pacinian Corpuscles
Merkel Discs
Hair Receptor (NOT Aud./Vest. hair cell)
Golgi Tendon Organ
Muscle Spindle Cell
Otolith Organs (Utricle/Sacule)
Semicircular Canals
# Week 1 Review

## Mechanoreceptors

<table>
<thead>
<tr>
<th>Type</th>
<th>RA / SA</th>
<th>Depth</th>
<th>Response Field</th>
<th>Sensitivity</th>
<th>Info. Processed/Best Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacinian</td>
<td>RA</td>
<td>deep</td>
<td>very large (hand)</td>
<td>very high (10 nm)</td>
<td>high-freq. vibration</td>
</tr>
<tr>
<td>Meissner</td>
<td>RA</td>
<td>shallow</td>
<td>3-5 mm</td>
<td></td>
<td>slip / low-freq. vibration</td>
</tr>
<tr>
<td>Merkl</td>
<td>SA</td>
<td>shallow</td>
<td>spotty 2-3 mm</td>
<td>broad depth range</td>
<td>form, texture / points, edges</td>
</tr>
<tr>
<td>SA2</td>
<td>SA</td>
<td>deep</td>
<td>12-25 mm</td>
<td></td>
<td>hand shape / stretch</td>
</tr>
<tr>
<td>Hair</td>
<td>RA</td>
<td>deep</td>
<td>10 mm</td>
<td>1 micron</td>
<td>hair displacement</td>
</tr>
</tbody>
</table>
### Week 1 Review

<table>
<thead>
<tr>
<th>Receptive Fields</th>
<th>Transient</th>
<th>Persistent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Somatosensory</strong></td>
<td>Meissner, Pacinian</td>
<td>Merkl Disks</td>
</tr>
<tr>
<td><strong>Proprioceptive</strong></td>
<td>Muscle Spindle</td>
<td>Golgi Tendon Organ</td>
</tr>
<tr>
<td><strong>Vestibular</strong></td>
<td>Semicircular Canals</td>
<td>Otolith Organs</td>
</tr>
</tbody>
</table>

...  

...
Which system provides the primary basis for bodily sense of self?
Week 2 Review

[Diagram of the human leg and spinal cord with labels:
- Quadriceps muscle
- Hamstring muscle
- Cell body of sensory neuron in dorsal root ganglion
- Gray matter
- White matter
- Spinal cord (cross section)
- Sensory neuron
- Motor neuron
- Interneuron]
Vestibular System: Stereocilia
Hair cells on the right side will therefore be like \( || || \). Moving left will cause inhibition on the right side.

It's the exact opposite on the left side.

Transient because while you're turning, the cupula is still lagging, but once you stop, then it catches up, returning to its baseline polarization. They detect radial motion relative to the trunk.
Question: How can we explain the sensation of dizziness?
Head Direction Cells: Head relative to the **world** (rather than the body)