February 13, 2012
AP generation and conduction
Extra credit opportunities this Weds, Thurs, Fri afternoons (1:45-3:00)

Initiation of AP?
threshold?
Rising phase?
Falling phase?
Undershoot?
All happening in 1 msec!

Other contributions to RP?

Application of RP Principal

Pump 1

Dynamic RP
Changes in "RP" by changing ionic conductances:

Action Potential Generation

Initiation of AP
Examples of passive voltages
Initiating AP??
- AP voltage spread ahead
- Receptor potentials
- Synaptic potentials

Measurements of membrane voltage after cold block

Why is AP getting smaller with distance?
- AP is a voltage booster

Spread of AP voltage ahead depends on space constant

Experimental measurement of space constant

Typical values 0.01 to 1.0 mm.
The longer the space constant, the less often the AP has to be initiated
Evolution of fast signal conduction
How to make the space constant longer.

Lambda and tau interact to determine speed and amplitude of voltage change ahead of AP

Lambda 1-20 ms

Initiation Na vs K
Na wins
Threshold- dynamic
Peak- high gNa
Fall- high gK- Why does AP fall below RP?

Traveling AP- unmyelinated nerve
Local current flowing ahead of AP initiates next AP
What happens first?- Spreading charge by K+ depolarizes Cm ahead.

1 ms!
Also: Cms in series add reciprocally

Repolarization at Nodes of Ranvier by fast tau for repolarization unmyelinated nerve resting $g = 0.2-1 \text{ mS/cm}^2$, $\tau = 1-20 \text{ ms}$
myelinated nodes resting $g = 40 \text{ mS/cm}$, $\tau = 100\mu\text{s}$!
Why doesn’t the AP go backwards?

Refractory periods: Why are the APs getting smaller and then fail?

Note changing AP threshold too.

I/V curve explanation for AP

V, stable
V, unstable
Vpeak could be stable but conductances are time and V sensitive

Refractory periods

D: gK >> gNa
C: gNa recovering, but no AP
B: smaller AP
A: full AP

Notice threshold change.
Calcium APs

Ca\textsuperscript{2+} works entirely for APs in muscles of:
1) arthropods
2) molluscs
3) nematodes
4) adult tunicates
5) smooth muscles of verts.

Ca\textsuperscript{2+} works with Na\textsuperscript{+} for APs in:
1) cardiac muscle of verts
2) nerve cell bodies of
   a) molluscs
   b) annelids
   c) arthropods
   d) amphibians
   e) birds
   f) mammals

Examples of calcium APs

(A) CARDIAC PACEMAKER
(B) CARDIAC VENTRICLE
(C) VASCULAR SMOOTH MUSCLE
(D) CENTRAL NEURON

Na vs. Ca AP

Na AP vs. Heart AP
## Cardiac AP currents

<table>
<thead>
<tr>
<th>Principal Ion</th>
<th>Response to depolarization</th>
<th>Speed of recovery</th>
<th>Inactivation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>Open</td>
<td>Fast</td>
<td>Fast, but incomplete</td>
<td>Initial depolarization</td>
</tr>
<tr>
<td>K</td>
<td>Close</td>
<td>Slow</td>
<td>None</td>
<td>Maintenance of plateau</td>
</tr>
<tr>
<td>K</td>
<td>Open</td>
<td>Slow</td>
<td>Little</td>
<td>Repolarization</td>
</tr>
<tr>
<td>K</td>
<td>Open due to Ca influx</td>
<td>Slow</td>
<td>Close at internal Ca levels</td>
<td>Repolarization</td>
</tr>
<tr>
<td>Ca</td>
<td>Open</td>
<td>Slow</td>
<td>Slow</td>
<td>Maintains plateau and prolongs contraction</td>
</tr>
</tbody>
</table>