February 4, 2015

AP generation and conduction

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

Lab 1 due tomorrow

Measurements of membrane voltage after cold block

Why is AP getting smaller with distance
Why “smooshed”??
AP is a voltage booster

Evolution of fast signal conduction
How can the space constant be longer?

Reduce internal resistance to current flow
Increase membrane resistance to leak current flow
Lambda and tau interact to determine speed and amplitude of voltage change ahead of AP

Action Potential Generation

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

Initiation of AP

Initiating AP??

Examples of passive voltages

AP Summary

Traveling AP
Local current flowing ahead of AP initiates next AP

What happens first?: Spreading charge by K+ depolarizes Cm ahead.

Depolarizing voltage Na vs K
- Na wins
- Threshold: dynamic
- Peak: high gNa
- Fall: high gK- Why does AP fall below RP?
Traveling AP

Comparison of traveling AP

Relatively “uniform” channel distribution

Unmyelinated nerve
“continuous” conduction”

More precisely distributed channels

Myelinated nerve
“saltatory conduction”

Repolarization at Nodes of Ranvier by fast tau for repolarization unmyelinated nerve resting g=0.2-1 mS/cm², tau 1-20 ms
myelinated nodes resting g= 40 mS/cm, tau= 100µS!

Effects of demyelination

Cms in series add reciprocally

Frassen and Straver, 2013

Frassen and Straver, 2013
AP conduction velocity: Squid giant axon vs. myelinated axons

Alpha motor neuron: 120 m/s = 268 mph
8.6 microns
Unmyelinated C pain fibers: 2 m/s = 4 mph
1.5 micron

19 m/s = 43 mph
500 micron

Same as 10 micron
Frog myelinated fiber!!

Comparison of conduction velocities

<table>
<thead>
<tr>
<th>Axon</th>
<th>Diameter (micron)</th>
<th>Myelated</th>
<th>CV (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha motor neurons</td>
<td>13-20</td>
<td>yes</td>
<td>80-120 (268 mph)</td>
</tr>
<tr>
<td>Gamma motor neurons</td>
<td>5-8</td>
<td>yes</td>
<td>4-24</td>
</tr>
<tr>
<td>Muscle spindle receptor</td>
<td>13-20</td>
<td>yes</td>
<td>50-120</td>
</tr>
<tr>
<td>Skin mechanoreceptors</td>
<td>6-12</td>
<td>yes</td>
<td>35-75</td>
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<tr>
<td>Fast pain</td>
<td>1-5</td>
<td>yes</td>
<td>3-30</td>
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<tr>
<td>Slow pain (C fiber)</td>
<td>0.2-1.5</td>
<td>no</td>
<td>0.5-2</td>
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<tr>
<td>Squid giant axon</td>
<td>500</td>
<td>no</td>
<td>19</td>
</tr>
<tr>
<td>Chorda (plant)</td>
<td>1000</td>
<td>no</td>
<td>0.4</td>
</tr>
</tbody>
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Fastest conduction- shrimp motor neurons- 200 m/s