February 24, 2016

MRO Analysis
Sim 3
AP conduction
Refractory period
Intracellular Recording
Electrical “noise”

Lab 2 due tomorrow

Simulation 3 highlights: a. unmyelinated axon

Why do you see more of the AP with smaller diameter axon?

Why less stimulus current with smaller axon? V = IR, Gm down

Effect of stimulus current on delay?

Simulation 3b: myelinated axon: How does myelin increase conduction speed?

Effect of Myelin Wrap on Velocity

Velocity versus Axon Size

AP conduction velocity: Squid giant axon vs. myelinated axons

Alpha motorneuron: 120 m/s = 268 mph
8.6 microns
Unmyelinated C pain fibers: 2 m/s = 4 mph
3.5 micron

Same as 10 micron
Frog myelinated fiber!!
Comparison of conduction velocities

<table>
<thead>
<tr>
<th>Axon</th>
<th>Diameter (micron)</th>
<th>Myelin</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</td>
</tr>
<tr>
<td>Gamma motor neurons</td>
<td>5-8</td>
<td>yes</td>
<td>4-24</td>
</tr>
<tr>
<td>Muscle spindle</td>
<td>13-20</td>
<td>yes</td>
<td>80-120</td>
</tr>
<tr>
<td>Skin mechanoreceptors</td>
<td>6-12</td>
<td>yes</td>
<td>35-75</td>
</tr>
<tr>
<td>Fast pain (C fiber)</td>
<td>1-5</td>
<td>yes</td>
<td>3-30</td>
</tr>
<tr>
<td>Slow pain (C fiber)</td>
<td>0.2-1.5</td>
<td>no</td>
<td>0.5-2</td>
</tr>
<tr>
<td>Squid giantaxon</td>
<td>500</td>
<td>no</td>
<td>19</td>
</tr>
<tr>
<td>Chara (plant)</td>
<td>1000</td>
<td>no</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Fastest conduction- shrimp motor neurons - 200 m/s (~450 mph) 1 Meter = 0.00062137119 Miles

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

Note changing AP threshold too

AP refractory periods

<table>
<thead>
<tr>
<th>Amplitude of action potential</th>
<th>Absolute refractory phase</th>
<th>Relative refractory phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensity</td>
<td></td>
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</table>

Why doesn't the AP go backwards?
2 reasons:
- Can it go backwards?

Intracellular potentials

Action Potentials

Synaptic Potentials

Receptor Potentials

MRD stretch in TTX
Motor Network Example

Intracellular

Extracellular

Comparison of needle tips

Intracellular microelectrode

Intracellular microelectrode filled with 3M KCl (conducting fluid)

Electrical Property 1:
Electrode resistance (10 to 30 Mohms with 3M KCl)

How do we get KCl to the tip?
Replacing air with KCl in electrodes

RC response of electrode to current injection

Electrical Property 2: Electrode Capacitance

Electrode capacitance

How do we get the biological signal to the electronics?

Extracellular capacitative charge transfer
Intracellular direct charge transfer
DC charge transfer on electrode wire
Conduction in saline solution
Very low solubility
Conduction in metal