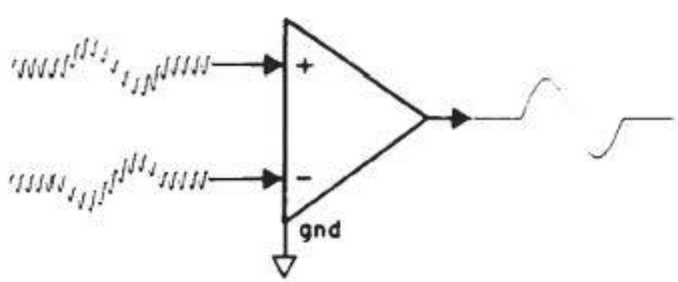
BE172 Week 4: The Compound Action Potential

- Classic experiment using frog sciatic nerve
- Use a general bio-amplifier to examine the biopotential produced by the nerve cells

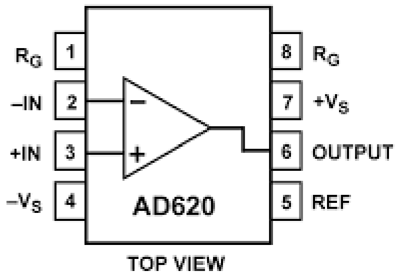
Amplifying Biopotentials

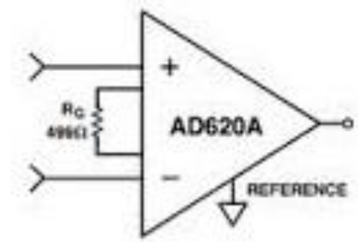
- Use a differential amplifier for biopotentials like ECG, EEG, action potentials
- Differential (instrumentation) amplifier: amplifies the voltage difference between 2 points. Filters or rejects "noise" that is common to both inputs.



Noisy sine waves, each relative to ground. Difference will cancel common noise

Characterize the differential amplifier





Common mode gain (A_{cm}): Gain when $V_{in}(1) = V_{in}(2)$

$V_{out} = A_{cm} V_{in}(1) = A_{cm} V_{in}(2)$

Differential mode gain (A_d): Gain when $V_{in}(1) \neq V_{in}(2)$

$V_{out} = A_d (V_{in}(2) – V_{in}(1))$

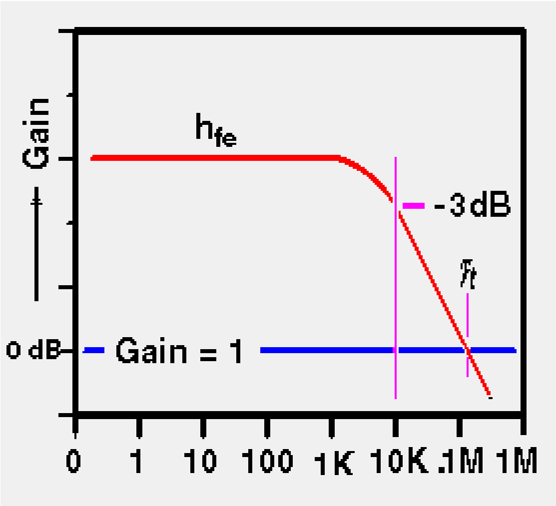
Common mode rejection ratio (in dB):

$$CMRR = 20 \log_{10} \left(\frac{A_{\rm d}}{|A_{\rm cm}|} \right)$$

CMRR is around 80 dB for the AD620
(voltage ratio of 10,000)

Characterize the differential amplifier (con't)

Can find these gains and CMMR as functions of frequency

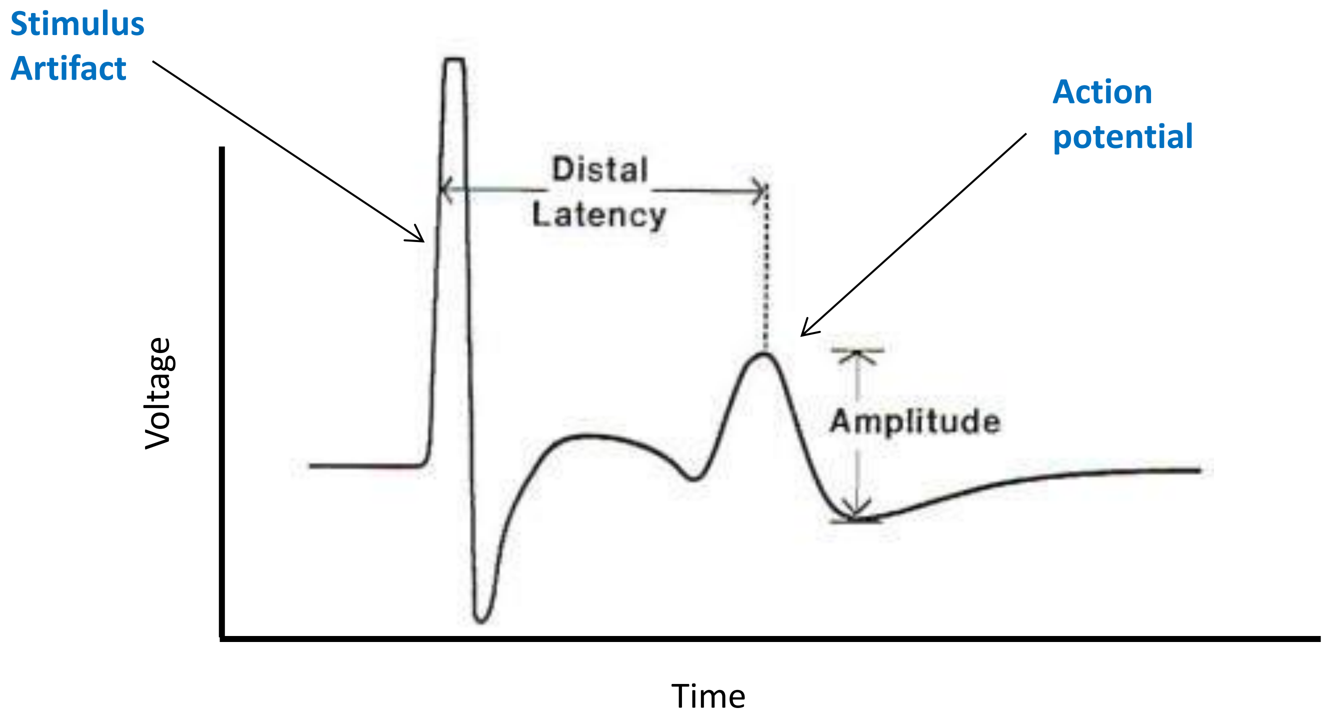


Can also find gain-bandwidth product from above plot of differential gain vs. frequency. Characterizes the overall gain potential.

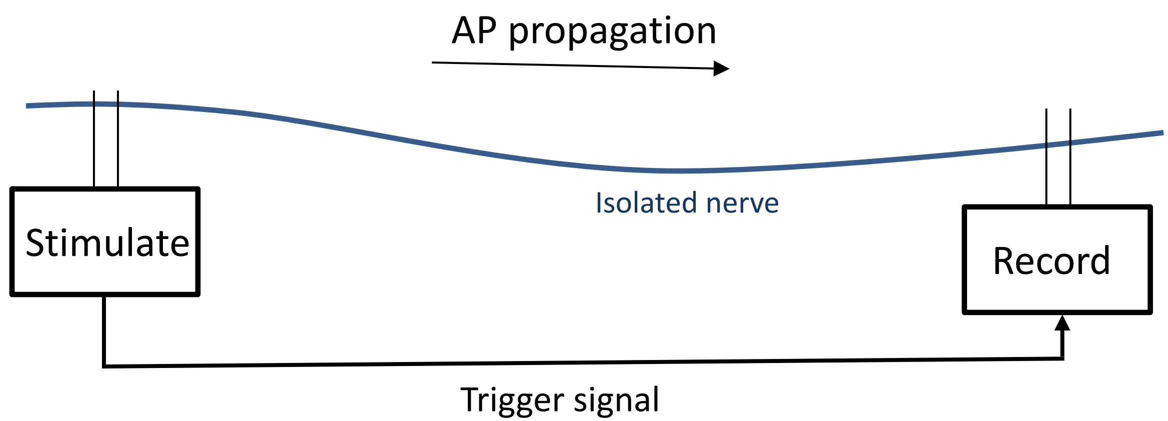
Nerve conduction and action potentials

Nerves propagate an action potential to transmit information

Action potential is a local depolarization of the resting membrane potential.
Stimulate nerve and measure membrane voltage vs. time:

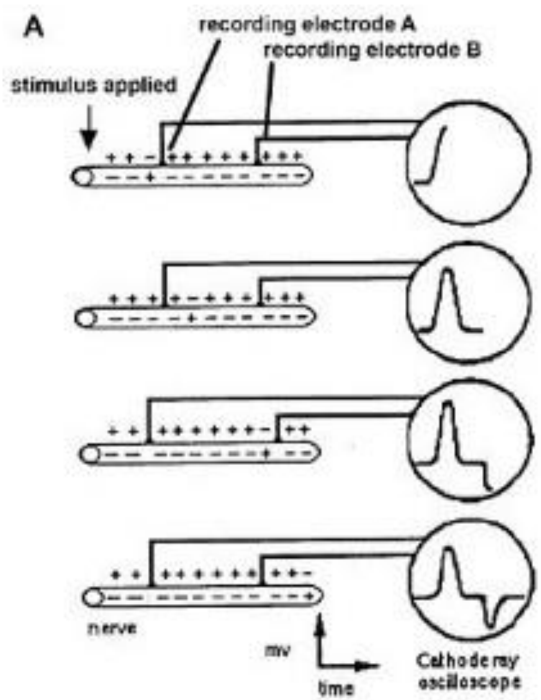


How do we measure the action potential and conduction velocity?

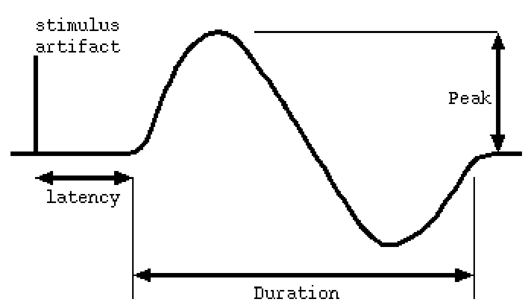


- Measure change in membrane voltage external to the cells
- Critical to trigger recording from stimulus

Biphasic action potential



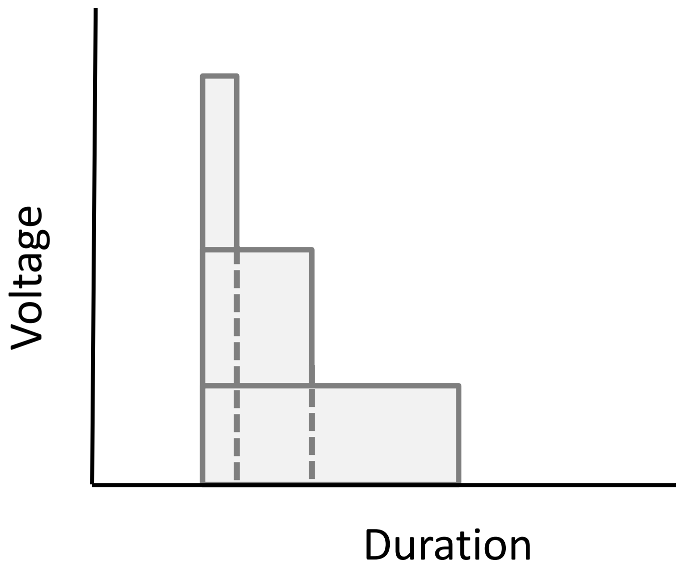
Actual recording:



or

Strength-duration curve

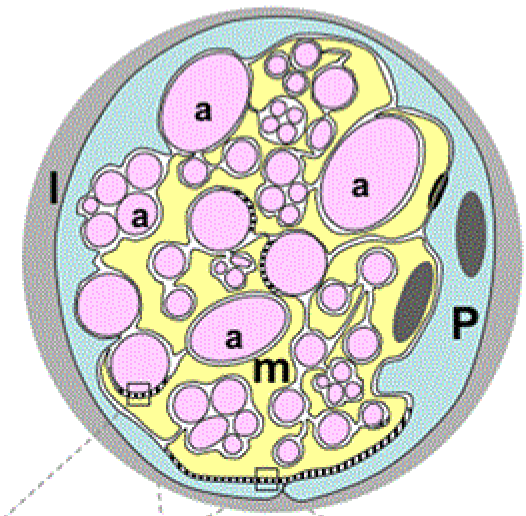
- Action potential is all or none
- Need to reach stimulus threshold to start an AP
- Can reach threshold of energy delivered by increasing strength or duration of stimulus

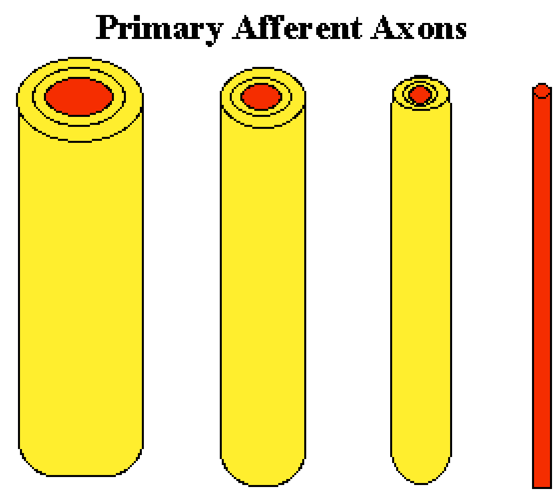


- Different square wave stimuli can reach threshold

- Area under pulses is roughly equal

Frog sciatic nerve

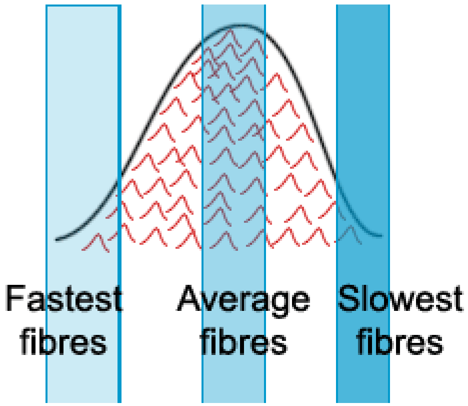


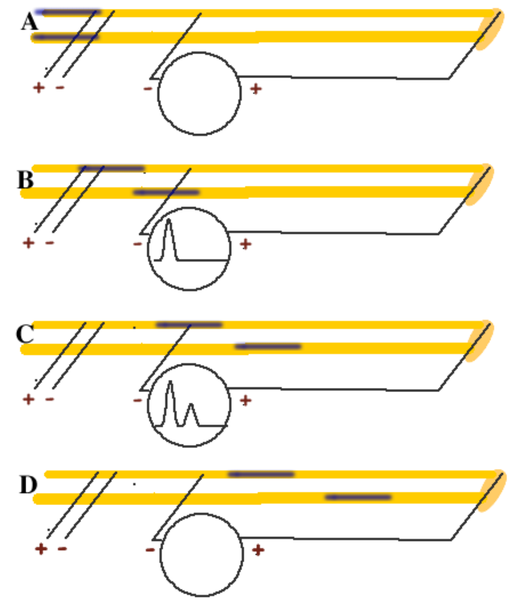


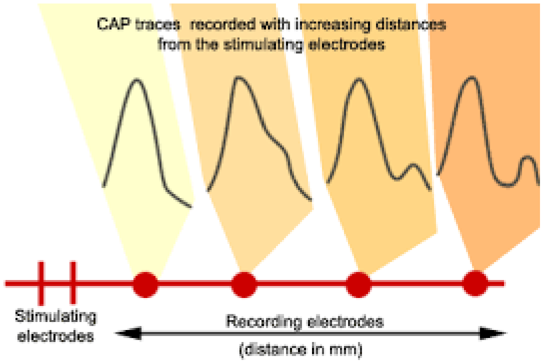
Axon Type	Aα	Aβ	Aδ	C
Diameter (μm)	13-20	6-12	1-5	.2-1.5
Speed (m/s)	80-120	35-75	5-35	.5-2.0

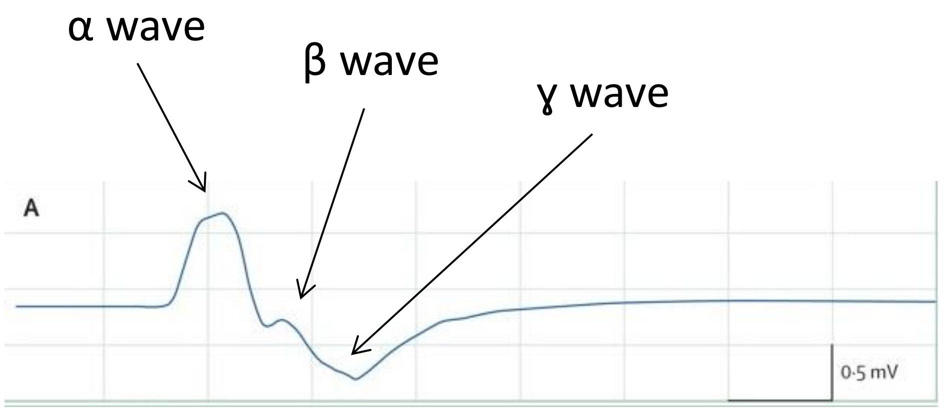
- Hundreds of fibers (cells) with different diameters
- Classified by diameter/propagation speed

Compound Action Potential



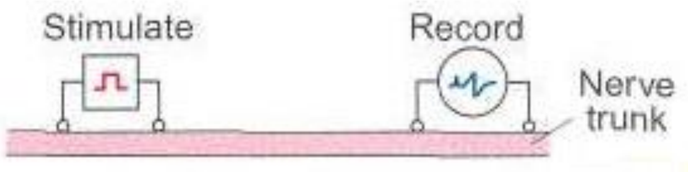


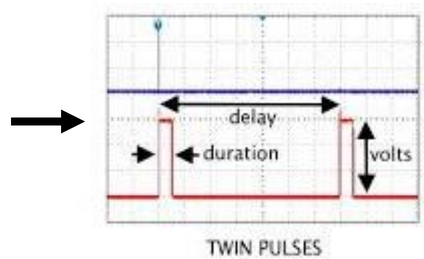


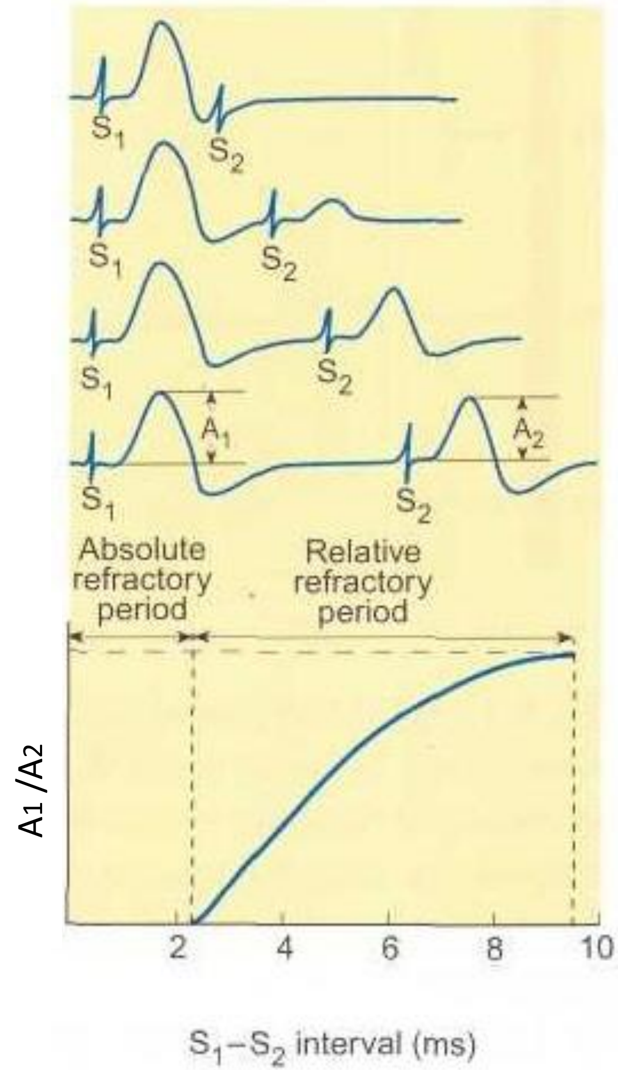


- Separation of waves will be greater further down the nerve
- Bi-phasic α waves can mask later, slower waves

Refractory period



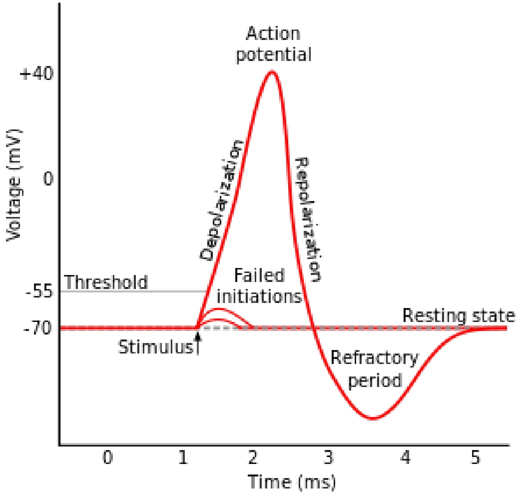




Second stimulus (sometime called S_2) may not elicit an AP depending on timing relative to S_1

Goals of the lab

- Characterize differential amplifier, use it to record extracellular action potential in an isolated sciatic nerve
- Create a strength-duration curve
- Find propagation velocity, if possible, for α, β and γ waves
- Measure refractory periods
- Examine repeatability of experimental measurement



Hints for a successful experiment

- Nerve dissection will take 30-40 minutes after demo
- Keep nerve moist, maximize excised length
- Avoid metal instruments touching nerve….use glass or cotton
- Take data on o-scope, use Labview for “sample” plot, similar to lab 2
- Use external trigger for more stable waveforms
- Use electrode “wand” for recording APs….more control.
- Watch out for stimulus artifact….can look like an Action Potential!