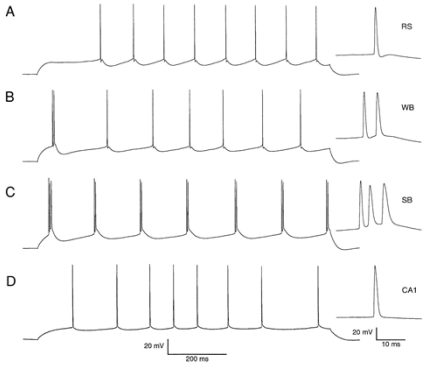
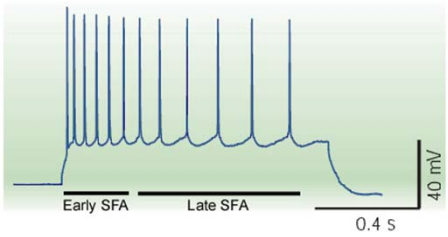
BIOL3833

Week 3a: Ion gradients and equilibrium potentials

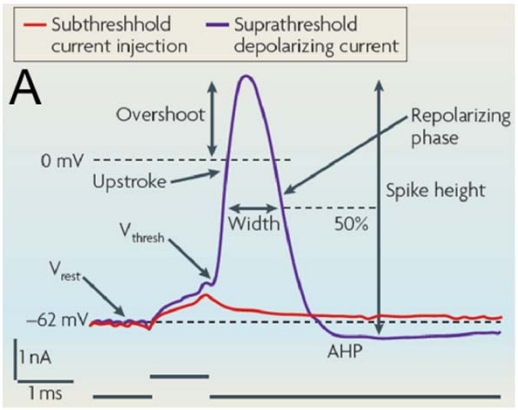
Preview: Where are we headed?

Action potentials carry information in the nervous system:





Understanding the single Action Potential



Ohm's Law . . . . again

These two expressions of Ohms Law govern *all neural function*:

$V = I*R$ $I = G*V$

Driving force (Voltage): Separation of Charge Across the Membrane

- Two forces at work: Diffusion and Electromotive
  - Particles of same identity diffuse to areas of lower concentration
  - Different charges attract, similar charges repel
- Neural membranes maintain different concentrations of ions inside vs. outside
- What are the consequences of these events?

Now the Inside/Outside Game!

- Reeses = +1 Kisses = -1 (This is their relative charge)
- *You can only move Reeses*
- Chem Teams: Score = 30–abs(#reeses$_{[inside]}$ – #reeses$_{[outside]}$)
- Electrical Teams: Score = 30 - abs(sum$_{[inside]}$ - sum$_{[outside]}$)
- Record your starting reeses$_{[inside]}$ and reeses$_{[outside]}$
- Record your starting sum$_{[inside]}$ - sum$_{[outside]}$
- Try to find the compromise that is best for both teams
- Record the final sum$_{[inside]}$ - sum$_{[outside]}$
  - This is your equilibrium potential

Exploring the consequences:

Nernst Equation for Equilibrium Potentials

$$E_x = \frac{RT}{z_x F} ln \frac{[X]_o}{[X]_i}$$

Nernst Equation for Equilibrium Potentials

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TABLE 1.2 Values of *RT/F*

Temperature (°C)	*RT/F* (mV)
0	23.54
5	23.97
10	24.40
15	24.83
20	25.26
25	25.69
30	26.12
35	26.55
37	26.73

Example: Calculate E_K

$$E_x = \frac{RT}{z_x F} ln \frac{[X]_o}{[X]_i}$$

K_o = 3 mM

K_i = 130 mM

Example: Calculate E_{Na}

$$E_x = \frac{RT}{z_x F} ln \frac{[X]_o}{[X]_i}$$

Na_o = 144 mM

Na_i = 22 mM

Significance of equilibrium potentials

If the membrane potential is at E_{ion} there will be no net movement of that ion species across the membrane

If the membrane is exclusively permeable to one type of ion, the membrane potential will move to E_{ion}

The concept of driving force

The electromotive force on an ion species is a function of the membrane voltage and E_{ion}

$$I_{ion} = (V_m - E_{ion}) * G_{ion}$$

What happens when the membrane is permeable to more than one ion?

The Goldman Hodgkin Katz (GHK) Equation

Membrane potential is determined by the relative membrane permeability of each ion species and its Equilibrium potential.

$$V_m = \frac{RT}{F} \ln \frac{P_K[\mathrm{K^+}]_\mathrm{o} + P_{Na}[\mathrm{Na^+}]_\mathrm{o} + P_{Cl}[\mathrm{Cl^-}]_\mathrm{i}}{P_K[\mathrm{K^+}]_\mathrm{i} + P_{Na}[\mathrm{Na^+}]_\mathrm{i} + P_{Cl}[\mathrm{Cl^-}]_\mathrm{o}}$$

The Goldman Hodgkin Katz (GHK) Equation

Simplified by ignoring chloride

$$V_m = \frac{RT}{F} \ln \frac{P_K[\mathrm{K^+}]_\mathrm{o} + P_{Na}[\mathrm{Na^+}]_\mathrm{o}}{P_K[\mathrm{K^+}]_\mathrm{i} + P_{Na}[\mathrm{Na^+}]_\mathrm{i}}$$

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Provider: Craig Rice
Lab Reference ID: 401458
Reference Number: XO636818U

Patient ID: 9975 **Chart #:** Available
DOB: 11/14/1968 **Sex:** M

Result Statuses: *F* Final *P* Pending *C* Corrected

Test Name	Res Date	In Range	Out of Range	Ref. Range	Units	Status	Location
F 10165 - BASIC METABOLIC PANEL		Col. Date 6/5/14 12:23 pm		Speci. Date: 6/5/14 12:28 pm		Res Date 6/6/14 1:34 am	
GLUCOSE		94		65-99	mg/dL	Final results	DLO
		Fasting reference interval					
UREA NITROGEN (BUN)		17		7-25	mg/dL	Final results	DLO
CREATININE		0.89		0.60-1.35	mg/dL	Final results	DLO
eGFR NON-AFR. AMERICAN		103		> OR = 60	mL/min/1.73m2	Final results	DLO
eGFR AFRICAN AMERICAN		120		> OR = 60	mL/min/1.73m2	Final results	DLO
BUN/CREATININE RATIO		NOT APPLICABLE		6-22	(calc)	Final results	DLO
SODIUM		139		135-146	mmol/L	Final results	DLO
POTASSIUM		4.4		3.5-5.3	mmol/L	Final results	DLO
CHLORIDE		102		98-110	mmol/L	Final results	DLO
CARBON DIOXIDE		24		19-30	mmol/L	Final results	DLO