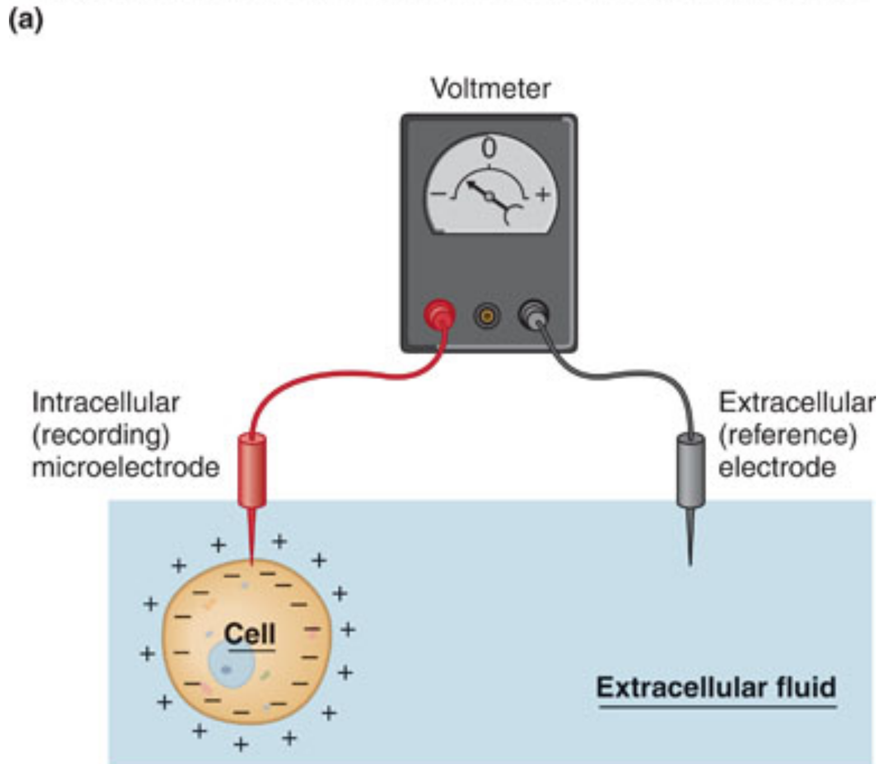
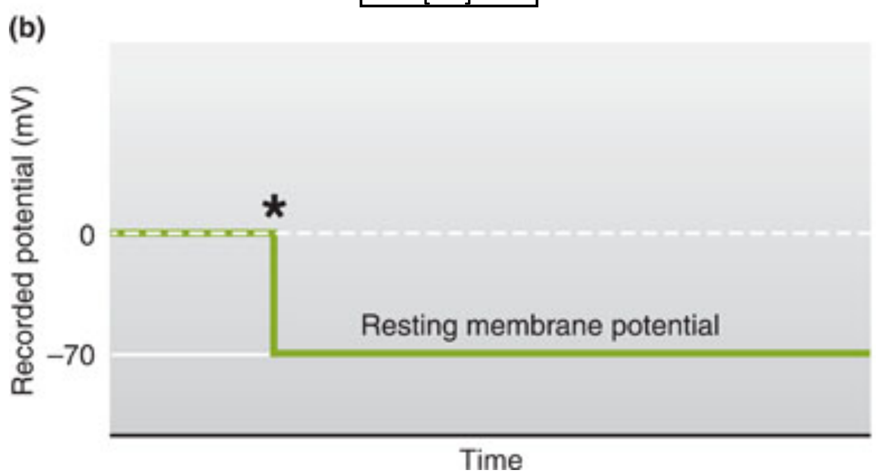
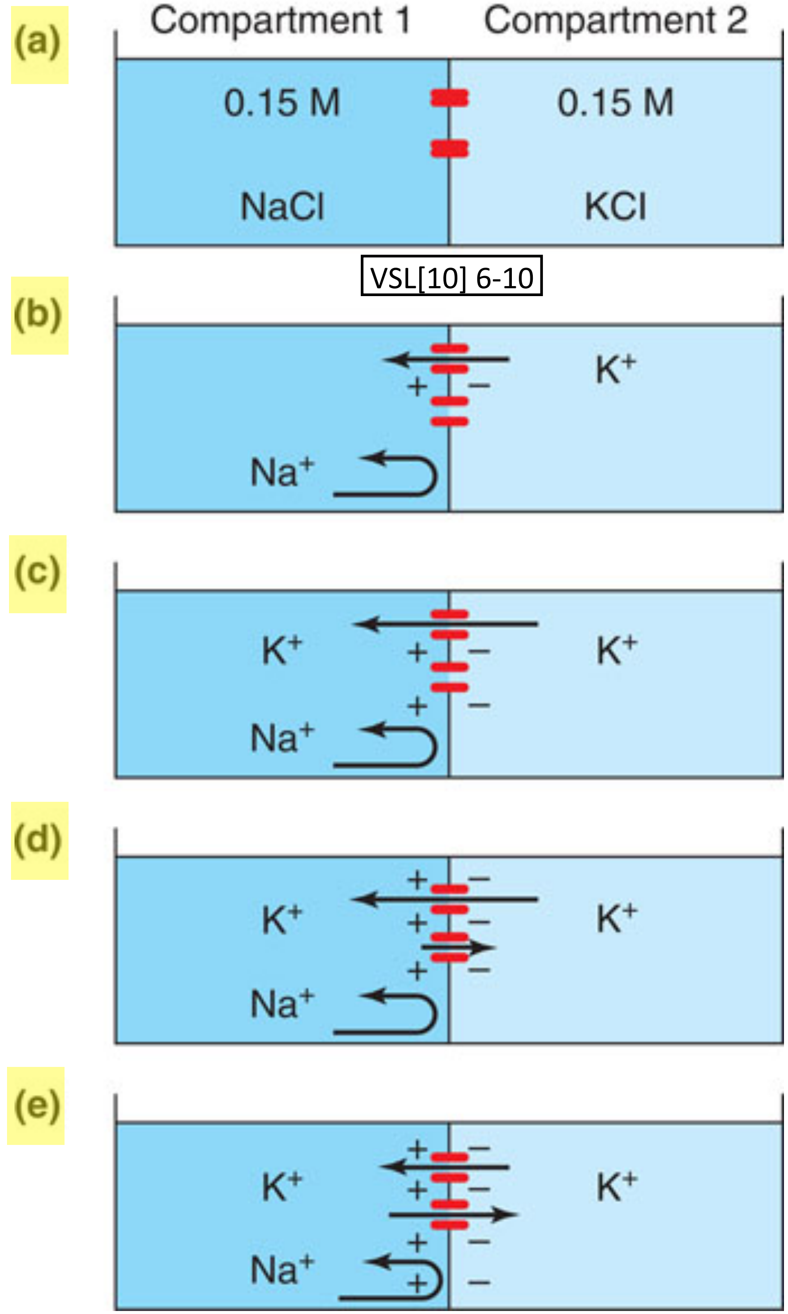
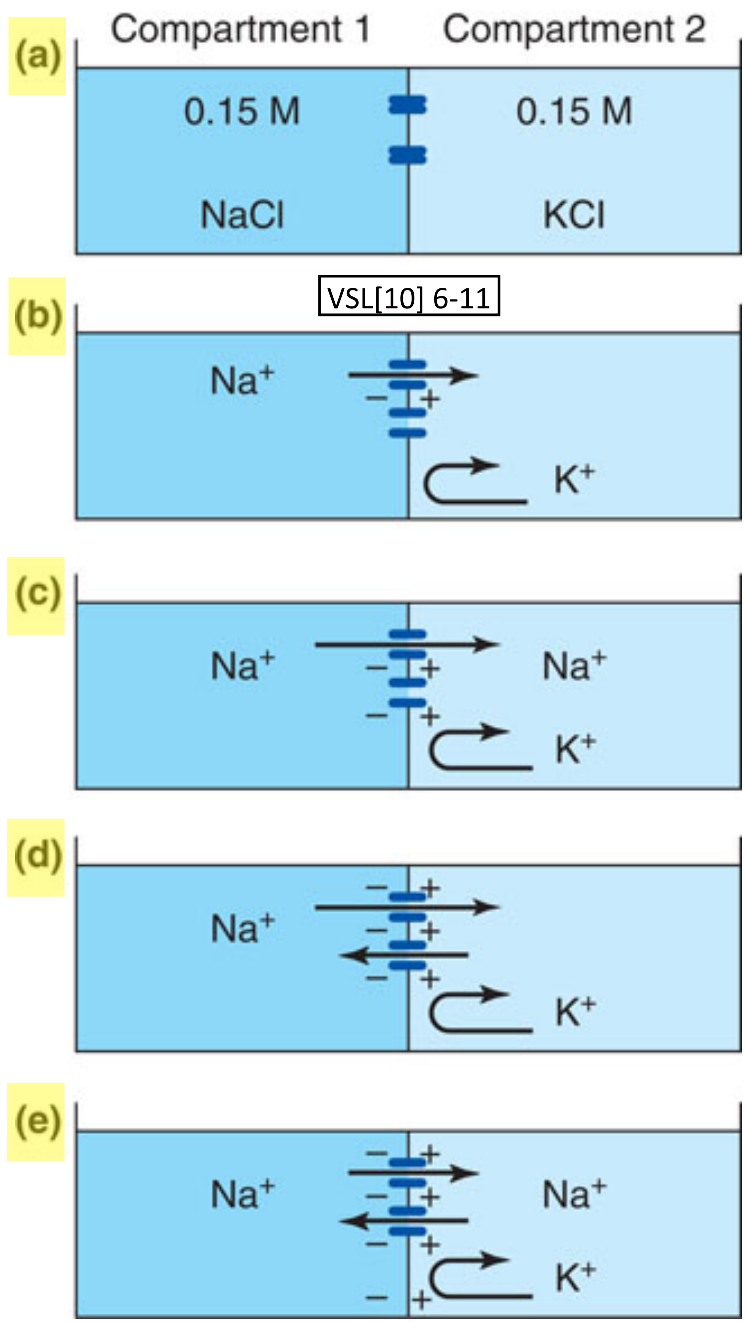

(a)
Voltmeter
0
−
+
Intracellular
(recording)
microelectrode
Extracellular
(reference)
electrode
Cell
Extracellular fluid

VSL[10] 6-8


(b)
Recorded potential (mV)
*
0
−70
Resting membrane potential
Time

	EXTRACELLULAR FLUID	INTRACELLULAR FLUID
Na^+	142 mEq/L	10 mEq/L
K^+	4 mEq/L	140 mEq/L
Ca^{++}	2.4 mEq/L	0.0001 mEq/L
Mg^{++}	1.2 mEq/L	58 mEq/L
Cl^-	103 mEq/L	4 mEq/L
HCO_3^-	28 mEq/L	10 mEq/L
Phosphates	4 mEq/L	75 mEq/L
SO_4^{-}	1 mEq/L	2 mEq/L
Glucose	90 mg/dl	0 to 20 mg/dl
Amino acids	30 mg/dl	200 mg/dl ?
Cholesterol, Phospholipids, Neutral fat	0.5 g/dl	2 to 95 g/dl
PO_2	35 mm Hg	20 mm Hg ?
PCO_2	46 mm Hg	50 mm Hg ?
pH	7.4	7.0
Proteins	2 g/dl (5 mEq/L)	16 g/dl (40 mEq/L)


(a)
Compartment 1
Compartment 2
0.15 M
NaCl
0.15 M
KCl
VSL[10] 6-10
(b)
K+
Na+
(c)
K+
K+
Na+
(d)
K+
K+
Na+
(e)
K+
K+
Na+


(a)
Compartment 1
Compartment 2
0.15 M
0.15 M
NaCl
KCl
VSL[10] 6-11
(b)
Na+
K+
(c)
Na+
Na+
K+
(d)
Na+
K+
(e)
Na+
Na+
K+

Resting Cell Membrane Potential

- Property of all (living) cells
- Measured inside WRT outside
- Ranges between ≈ -40 mv to ≈ -90 mv
  - Depends on cell type
- Energy required to maintain cell membrane resting potential

Diffusion Potential – Nernst Equation Approach to Derivation

- $[X]_i \neq [X]_o$
- Permeant ion moves down its chemical concentration gradient (diffusion)
- Movement of ion sets up an electrical gradient across membrane
- Equilibrium achieved when chemical and electrical forces are of equal magnitude and opposite direction

Diffusion Potential – Nernst Equation Assumptions

- Membrane
  - Constant thickness
  - Homogeneous
  - Infinite extent in transverse plane
    - Allows one dimensional solution
- Solutions
  - Well mixed (uniform in space, temperature, etc.)
  - Concentrations do not change as problem moves forward

Diffusion Potential – Nernst Equation Assumptions, continued

- Ionic mobility and activity coefficient are constant
  - Over time (as problem goes forward)
  - Same in both solutions and in membrane
- No net flow of solvent through membrane
  - Osmotic pressure gradient negligible
  - Hydrostatic pressure gradient negligible

1) $\mu = \mu_0 + R \cdot T \cdot \ln[S]$

2) $\vec{F} = -\vec{\nabla} U$

3) $\vec{F}_{chem} = -\vec{\nabla}\mu = -\vec{\nabla}\left(\mu_0 + R \cdot T \cdot \ln[S]\right)$

4) $= -\frac{d}{dx}\left(\mu_0 + R \cdot T \cdot \ln[S]\right) = -R \cdot T \cdot \frac{d}{dx}\left(\ln[S]\right)$

$$5)\quad F_{chem,\,net,\,1\rightarrow 2} = F_{chem,\,1\rightarrow 2} - F_{chem,\,2\rightarrow 1}$$

$$6) = -R \cdot T \cdot \frac{d}{dx} \ln[S]_1 + R \cdot T \frac{d}{dx} \cdot \ln[S]_2$$

$$7)\quad F_{chem,net,1\rightarrow 2} = R \cdot T \cdot \frac{d}{dx} \ln\left(\frac{[S]_2}{[S]_1}\right)$$

8) $$F_{electric} = -Q \cdot \frac{dV}{dx}$$

9) $$F_{electric} = -z \cdot q \cdot N_A \cdot \frac{dV}{dx}$$

10) $$F_{electric,net,1\rightarrow 2} = -z \cdot F \cdot \left(\frac{dV_1}{dx} - \frac{dV_2}{dx} \right)$$

11) $$= -z \cdot F \cdot \frac{d}{dx}\left(V_1 - V_2\right)$$

$$12)\quad F_{chem,net,1\to 2} + F_{electric,net,1\to 2} = 0$$

$$13)\quad R \cdot T \cdot \frac{d}{dx}\left\{\ln\left(\frac{[S]_2}{[S]_1}\right)\right\} - z \cdot F \cdot \frac{d}{dx}\left(V_1 - V_2\right) = 0$$

$$14)\quad R \cdot T \cdot \frac{d}{dx}\left\{\ln\left(\frac{[S]_2}{[S]_1}\right)\right\} = z \cdot F \cdot \frac{d}{dx}\left(V_1 - V_2\right)$$

15) $$\frac{R \cdot T}{z \cdot F} \cdot \ln\left(\frac{[S]_2}{[S]_1}\right) = V_1 - V_2$$

16) $$\boxed{V_{membrane} = V_{1 \to 2} = \frac{R \cdot T}{z \cdot F} \cdot \ln\left(\frac{[S]_{out}}{[S]_{in}}\right)}$$

17) $$V_{membrane,\,mV} = \pm 61.56 \cdot \log_{10}\left(\frac{[S]_{out}}{[S]_{in}}\right)$$

END

Video 6, Module 1