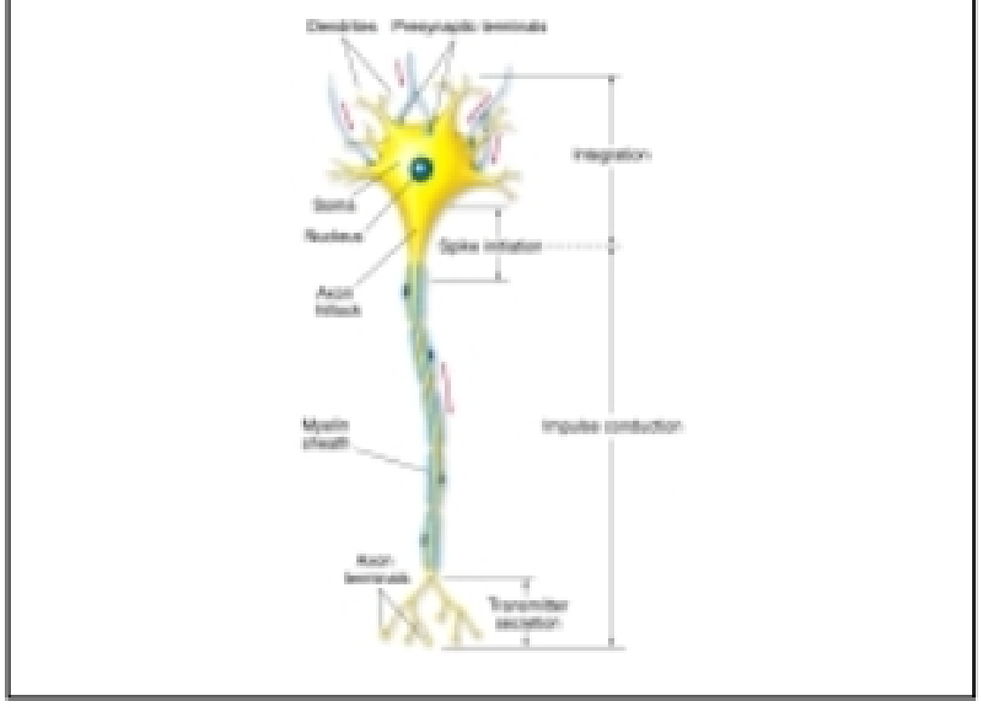
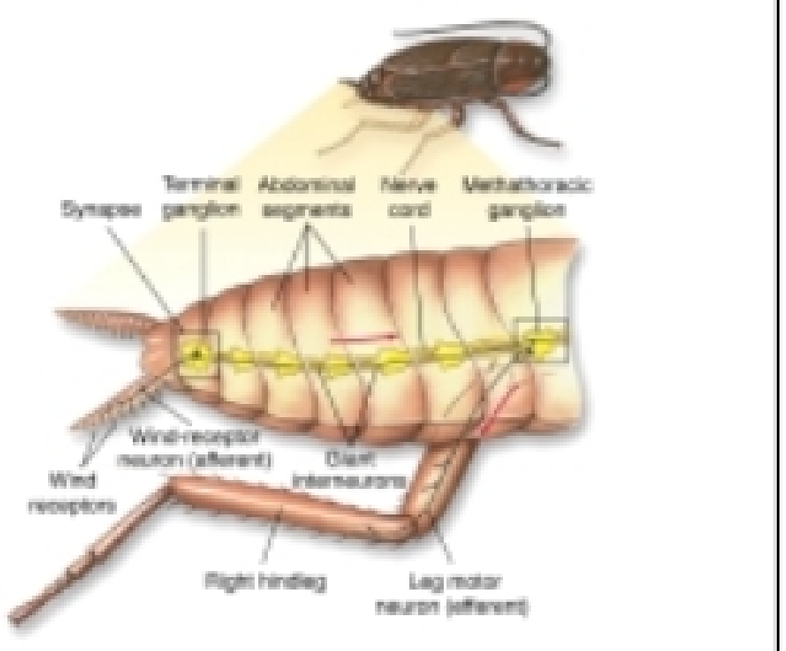
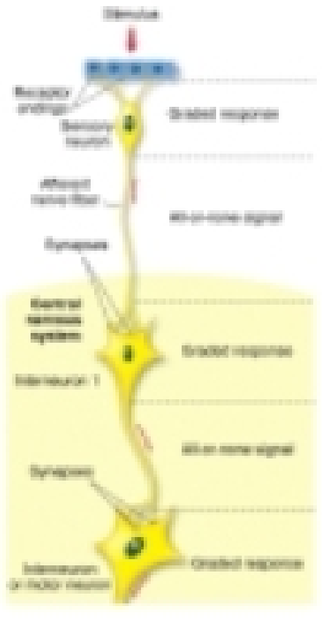
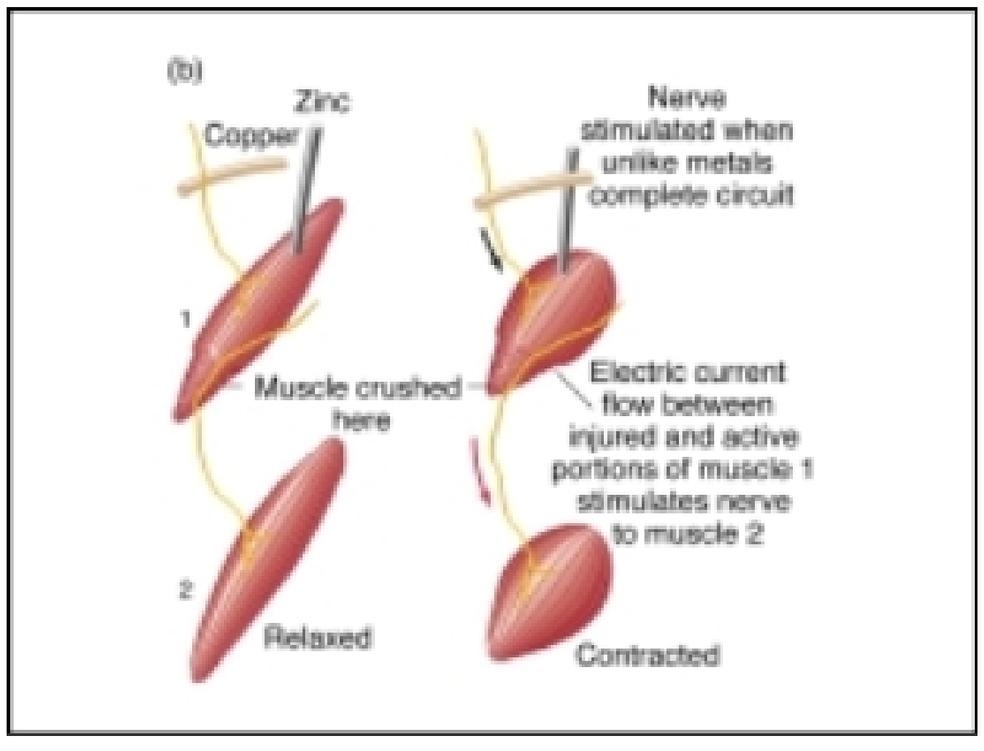
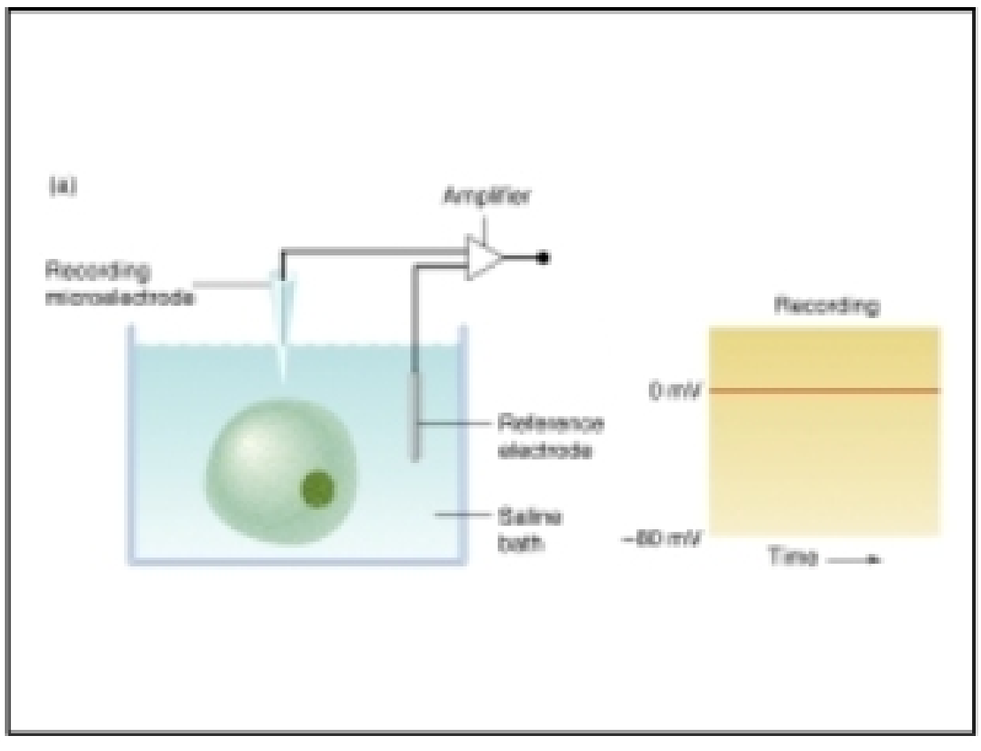
Chapter 5: Neuronal function

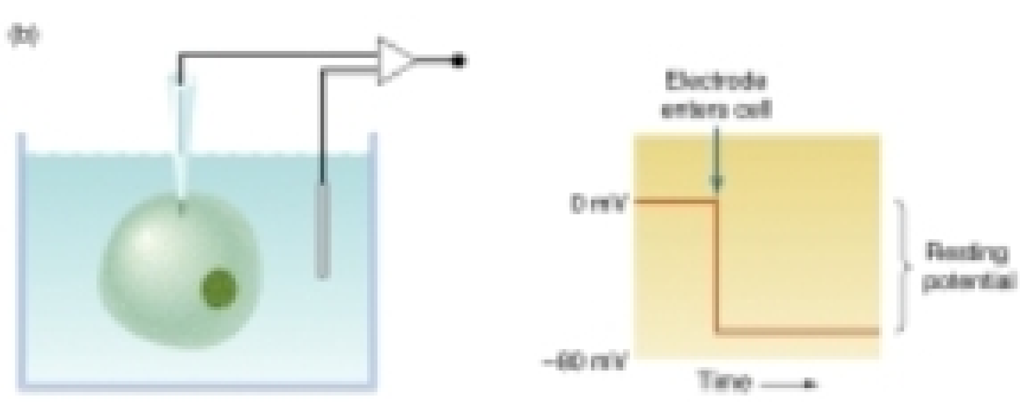












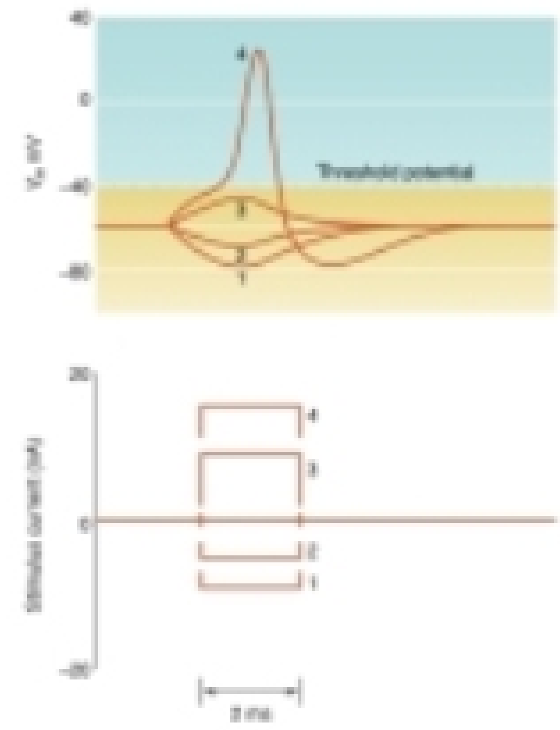
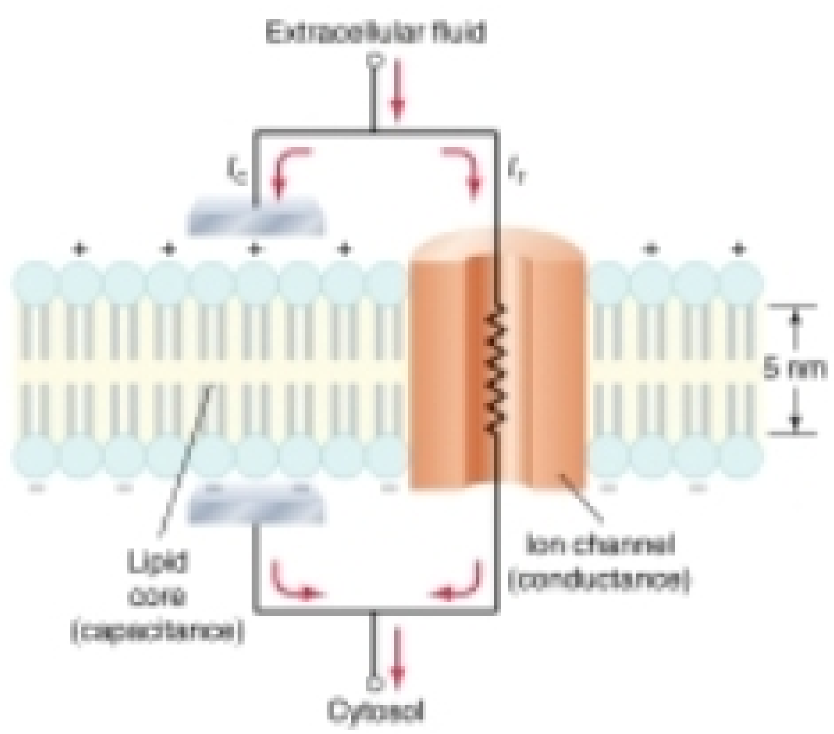
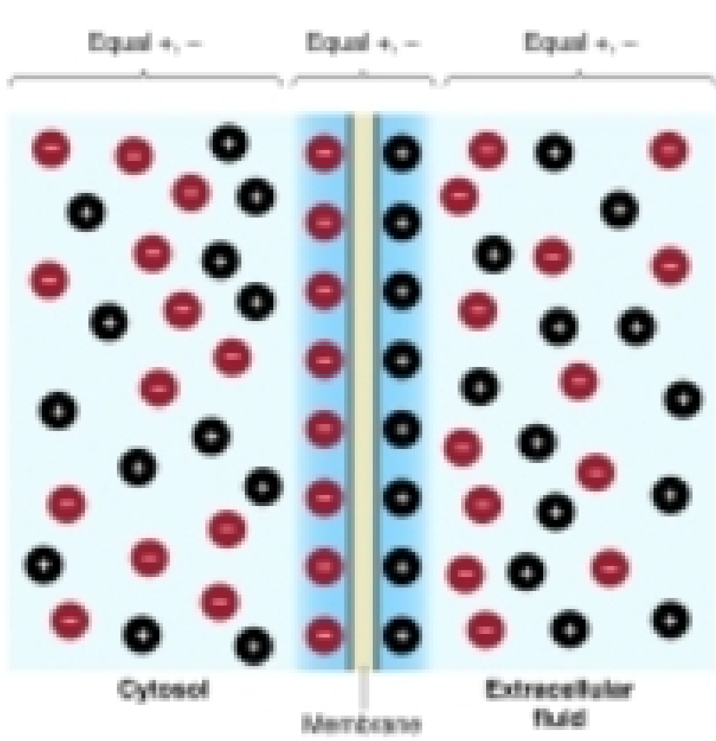
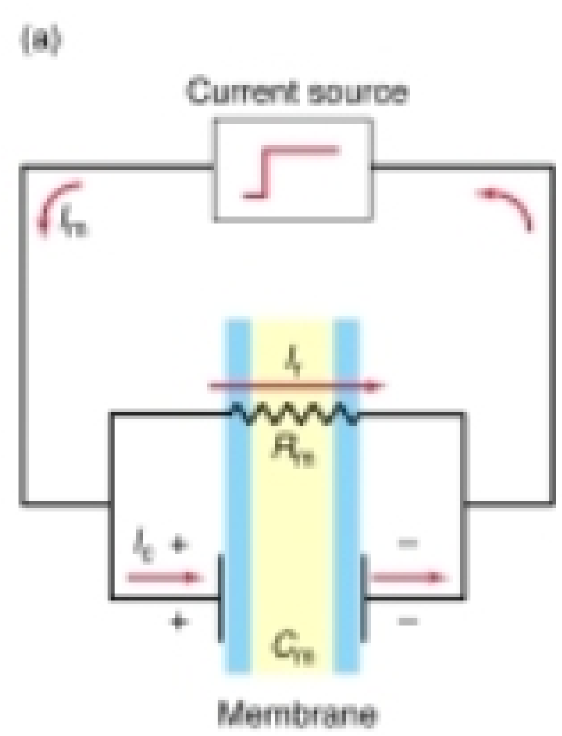


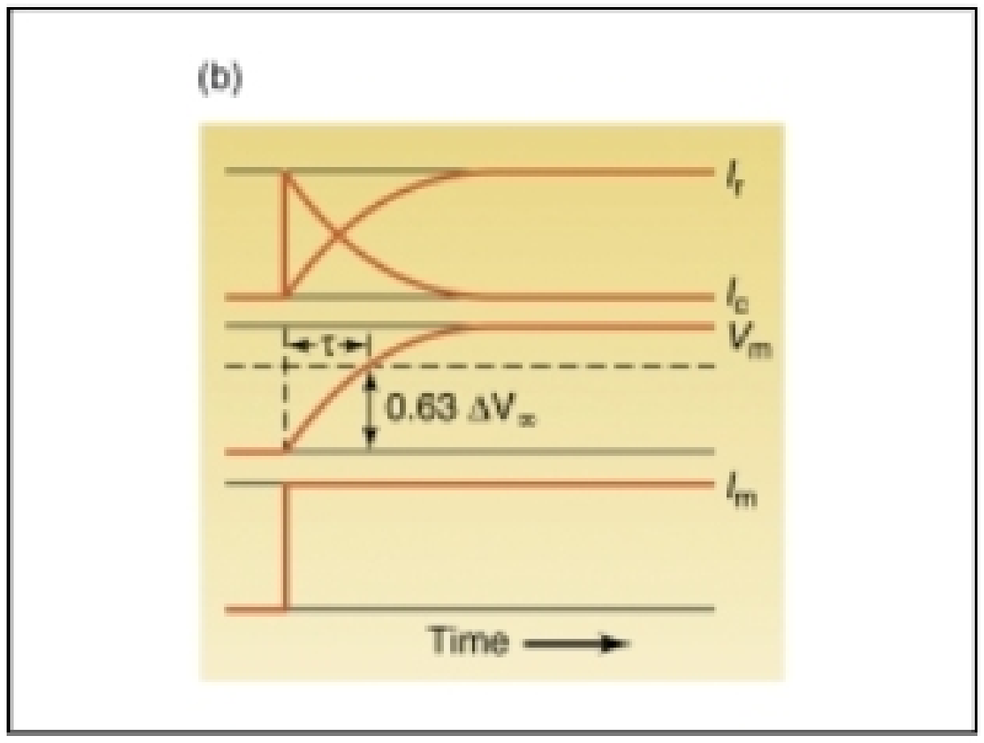
Table 2-1 Examples of ion channels found in axons

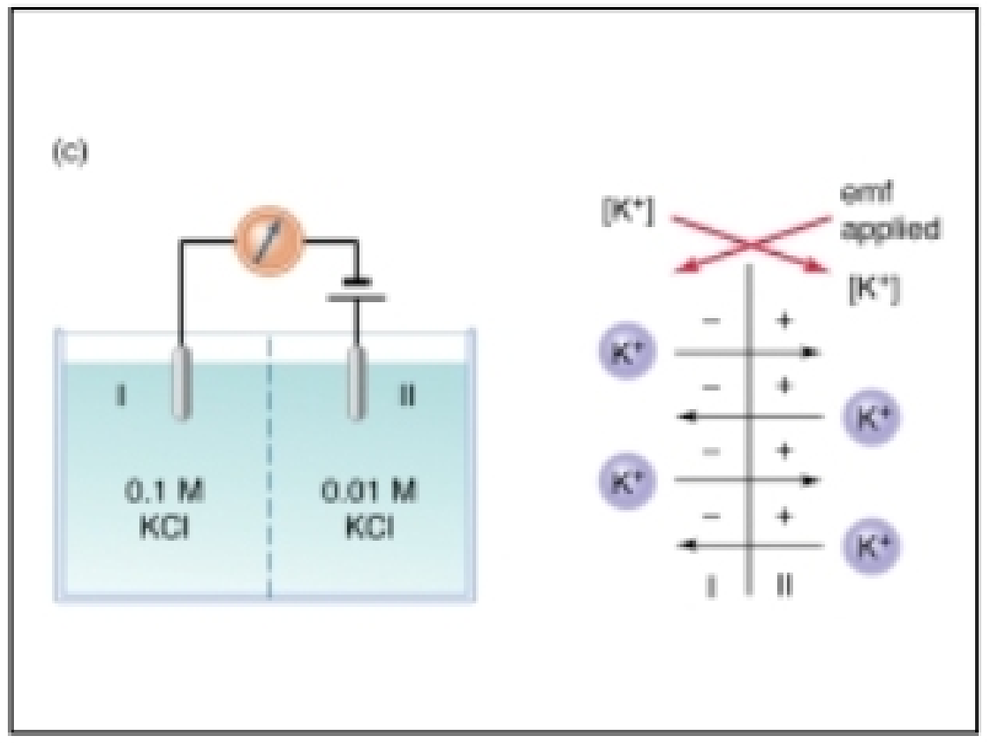
Channel	Current through channel	Characteristics	Selected blockers	Function
Leak channel (open in resting axon)	$i_{K(leak)}$	Produces relatively high g_K of resting cell	Partially blocked by tetraethylammonium (TEA)	Largely responsible for V_{rest}
Voltage-gated Na^+ channel	i_{Na}	Rapidly activated by depolarization; becomes inactivated even if V_m remains depolarized	Tetrodotoxin (TTX)	Produces rising phase of AP
Voltage-gated Ca^{2+} channel	i_{Ca}	Activated by depolarization, but less slowly than Na^+ channel; inactivated as function of cytoplasmic $[Ca^{2+}]$ or V_m	Verapamil, D600, Co^{2+}, Cd^{2+}, Mn^{2+}, Ni^{2+}, La^{3+}	Produces slow depolarization; allows Ca^{2+} to enter cell where it can act as second messenger
Voltage-gated K^+ channel ("delayed rectifier")	$i_{K(V)}$	Activated by depolarization, but more slowly than Na^+ channel; inactivated slowly and not completely if V_m remains depolarized	Intra- and extracellular TEA, amino-pyridines	Carries current that rapidly repolarizes the membrane to terminate an AP
Ca^{2+}-dependent K^+ channel	$i_{K(Ca)}$	Activated by depolarization, but needs elevated cytoplasmic $[Ca^{2+}]$; remains open as long as cytoplasmic $[Ca^{2+}]$ is higher than normal	Extracellular TEA	Carries current that repolarizes the cell following APs based on either Na^+ or Ca^{2+} and that balances i_{Ca}, thus limiting depolarization by i_{Ca}

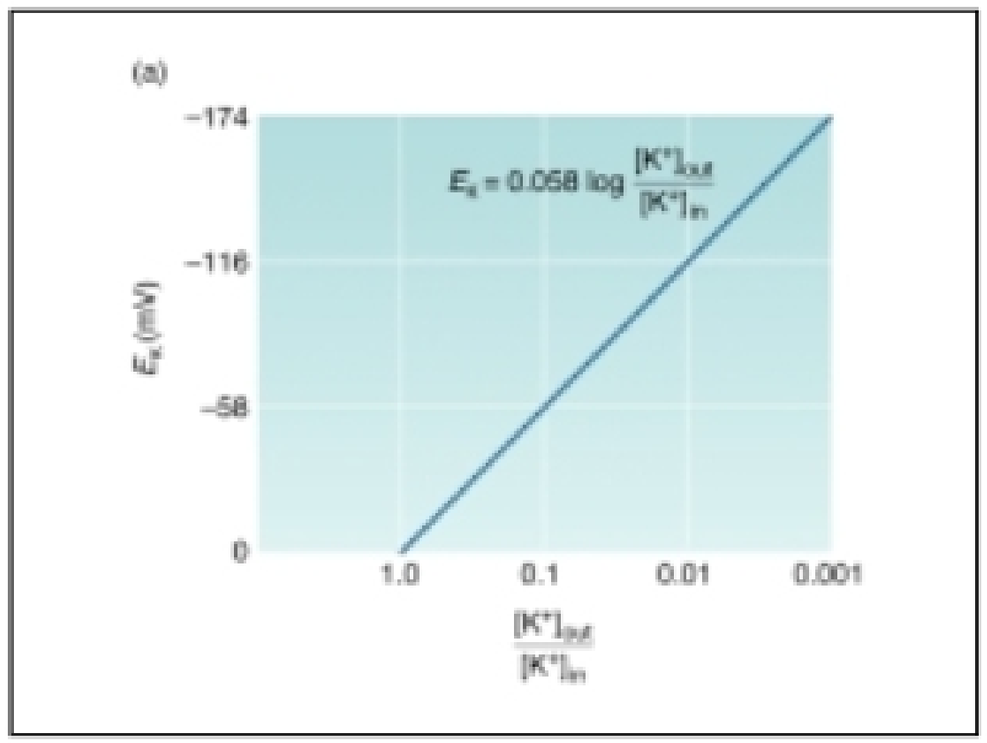


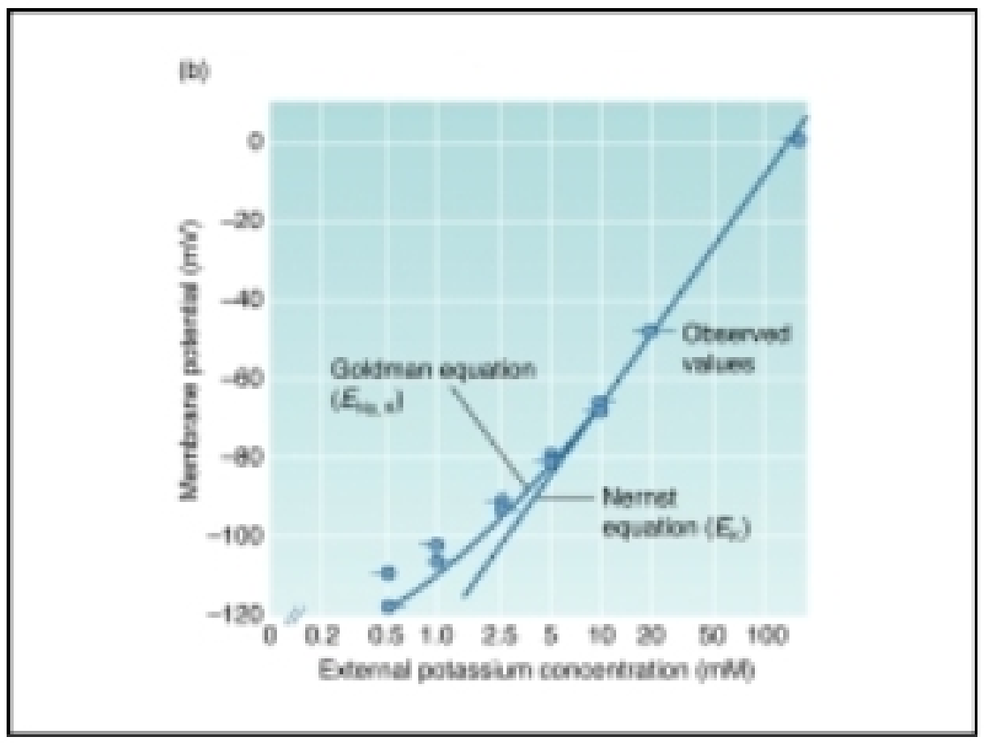


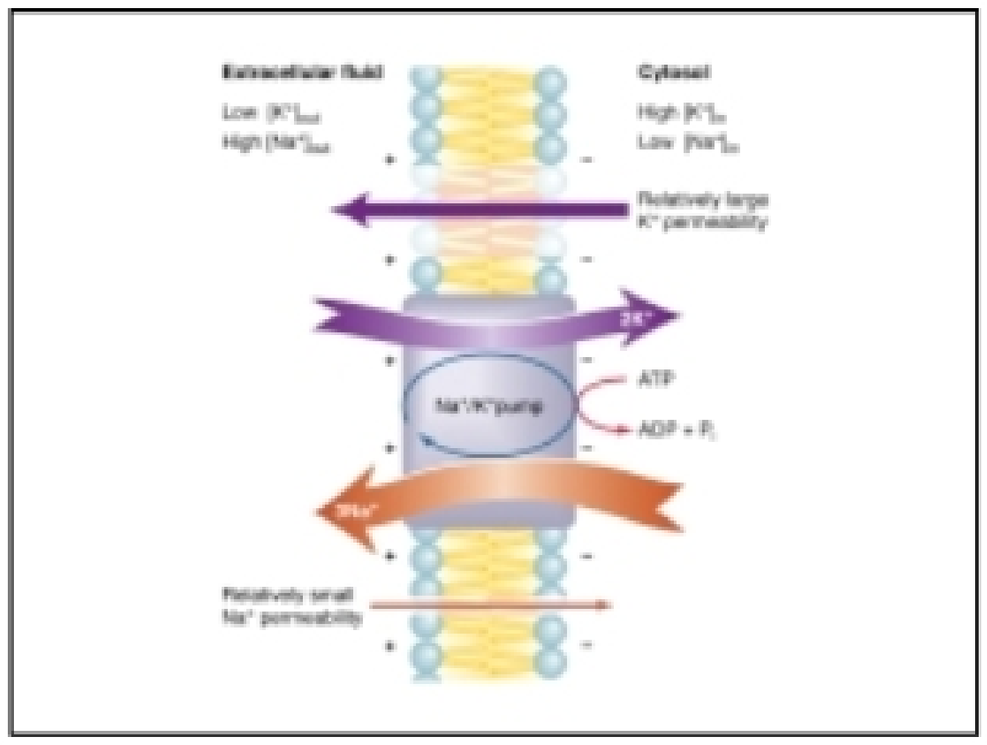



(b)
I_r
I_c
V_m
τ
0.63 ΔV_∞
I_m
Time


(c)
I
II
0.1 M KCl
0.01 M KCl
[K+]
emf applied
[K+]
K+
K+
K+
K+
I
II


(a)
−174
−116
−58
0
E_K (mV)
$E_K = 0.058 \log \frac{[K^+]_{out}}{[K^+]_{in}}$
1.0
0.1
0.01
0.001
$\frac{[K^+]_{out}}{[K^+]_{in}}$


(b)
Membrane potential (mV)
0
−20
−40
−60
−80
−100
−120
Goldman equation ($E_{m,K}$)
Observed values
Nernst equation (E_K)
0
0.2
0.5
1.0
2.5
5
10
20
50
100
External potassium concentration (mM)


Extracellular fluid
Low $[K^+]_{out}$
High $[Na^+]_{out}$
Cytosol
High $[K^+]_{in}$
Low $[Na^+]_{in}$
Relatively large K^+ permeability
2K+
ATP
Na+/K+ pump
ADP + P_i
3Na+
Relatively small Na^+ permeability