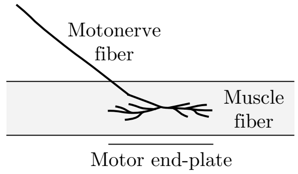
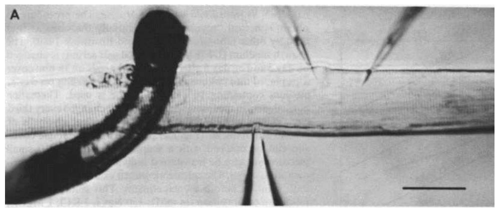
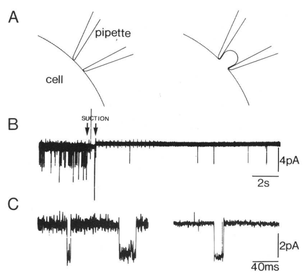


Figure 3.32





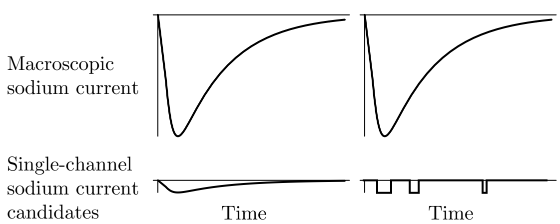
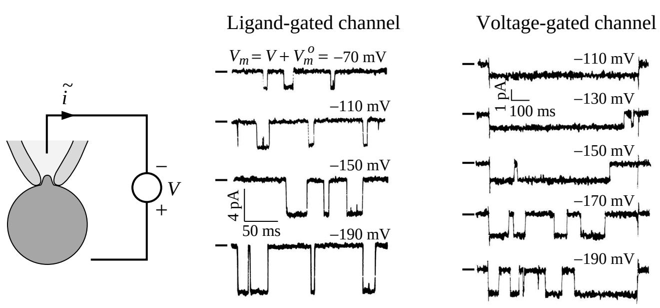


Figure 6.27



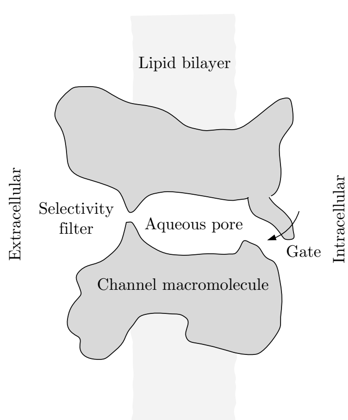
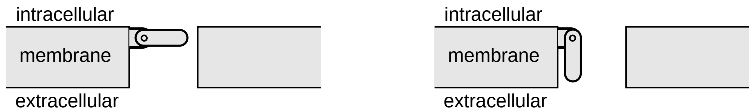


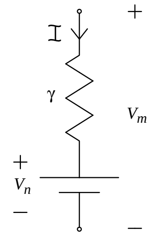
Figure 6.3

Model of ion channel has two parts

1. Two-state gate model of kinetics



2. Passive electrodiffusive model of permeation



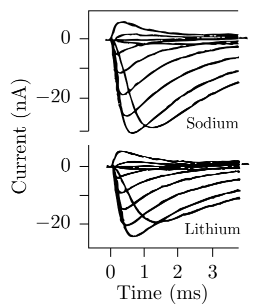


Figure 6.8

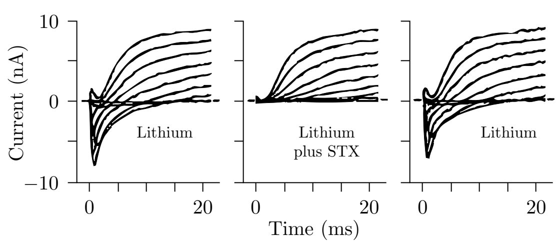


Figure 6.9

Na^+ channel Frog node		K^+ channel Frog node	
Ion n	P_n/P_{Na^+}	Ion n	P_n/P_{K^+}
Na^+	1.0	Tl^+	2.3
Li^+	0.93	K^+	1.0
Tl^+	0.33	Rb^+	0.91
NH_4^+	0.16	NH_4^+	0.13
K^+	0.086	Cs^+	< 0.077
Rb^+	< 0.012	Li^+	< 0.018
Cs^+	< 0.013	Na^+	< 0.10

State occupancy

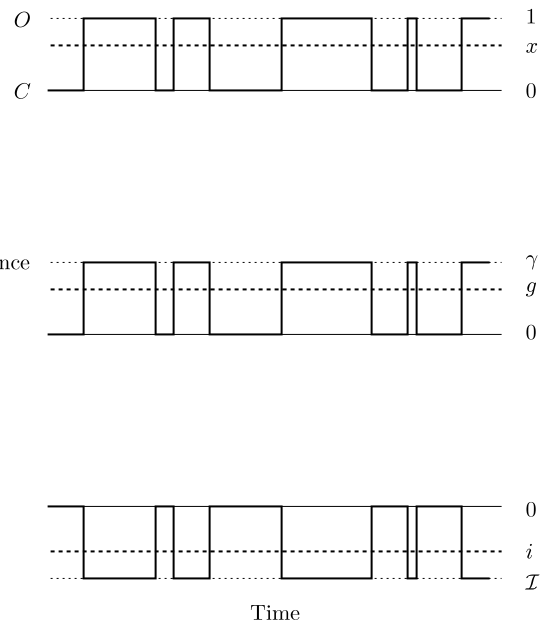
$\tilde{s} = \begin{cases} 0 \text{ if closed} \\ 1 \text{ if open} \end{cases}$

Single-channel conductance

$\tilde{g} = \begin{cases} 0 \text{ if closed} \\ \gamma \text{ if open} \end{cases}$

Single-channel current

$\tilde{i} = \begin{cases} 0 \text{ if closed} \\ \mathcal{I} \text{ if open} \end{cases}$



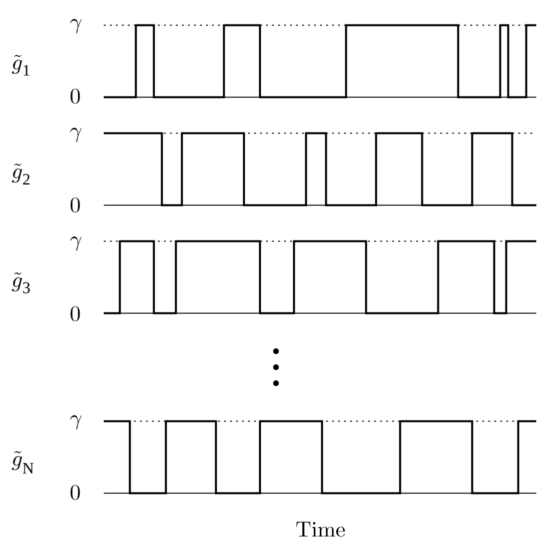
probability of open $= x$
x = average state occupancy
(many statistically independent channels)

g = average channel conductance
$= \mathrm{E}[\ \tilde{g}\ ] = 0 \times \Pr[\text{closed}] + \gamma \times \Pr[\text{open}]$
$= 0(1-x) + \gamma x = \gamma x$

i = average channel current
$= \mathrm{E}[\ \tilde{i}\ ] = 0 \times \Pr[\text{closed}] + \mathcal{I} \times \Pr[\text{open}]$
$= 0(1-x) + \mathcal{I}x = \mathcal{I}x$
$= \gamma(V_m - V_n)x = g(V_m - V_n)$
deterministic

random variables (˜)

Relation between microscopic and macroscopic variables is statistical.
Assume cell has N identical channels that are statistically independent.



$$\tilde{\mathcal{G}} = \sum_{n=1}^{N} \tilde{g}_n$$

$$\approx \mathcal{G} = N\mathrm{E}[\ \tilde{g}\ ] = Ng$$

$$G = \frac{\mathcal{G}}{A} = \frac{N}{A} g$$

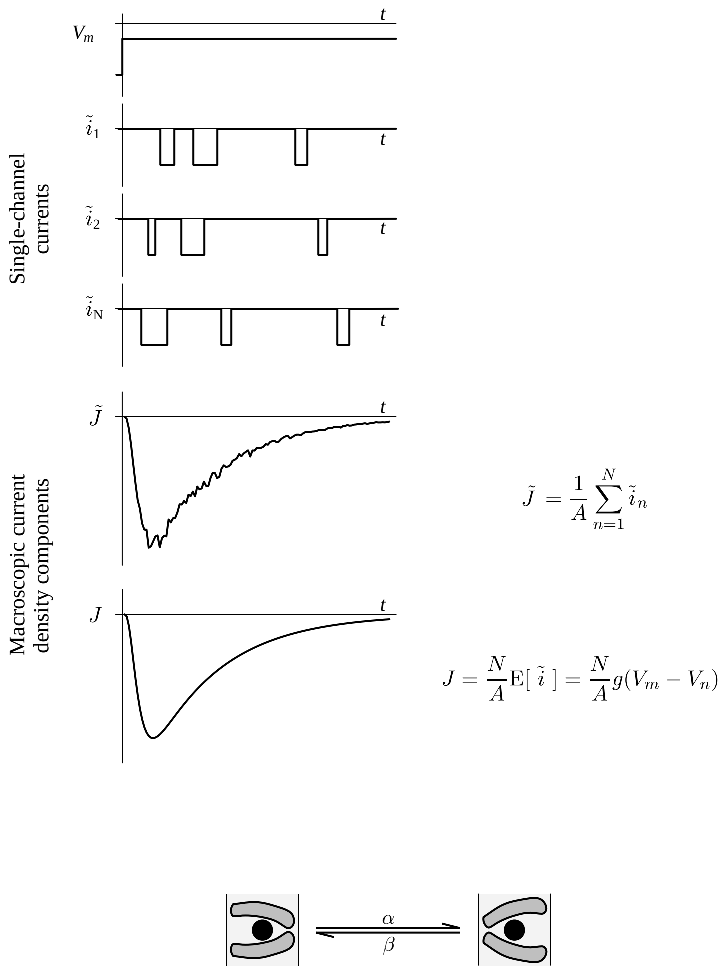
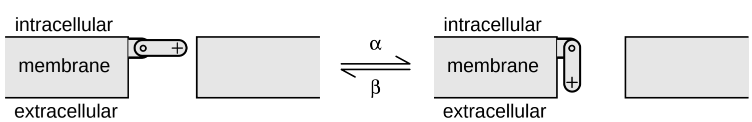


Figure 6.19

First-order reversible reaction



Assume $\mathcal{N}$ channels per unit area, of which $n(t)$ are open.

$$\frac{dn(t)}{dt} = \alpha(\mathcal{N} - n(t)) - \beta n(t)$$

$$n(t) = n_\infty + (n(0) - n_\infty)\, e^{-t/\tau_x}\ ; \qquad n_\infty = \frac{\alpha}{\alpha+\beta}\ \mathcal{N}\ , \quad \tau_x = \frac{1}{\alpha+\beta}$$

Assume $\mathcal{N}$ is large.

$$x(t) = \text{probability gate is open} \approx \frac{n(t)}{\mathcal{N}}$$

$$x(t) = x_\infty + (x(0) - x_\infty)\, e^{-t/\tau_x}\ ; \qquad x_\infty = \frac{\alpha}{\alpha+\beta}\ , \quad \tau_x = \frac{1}{\alpha+\beta}$$