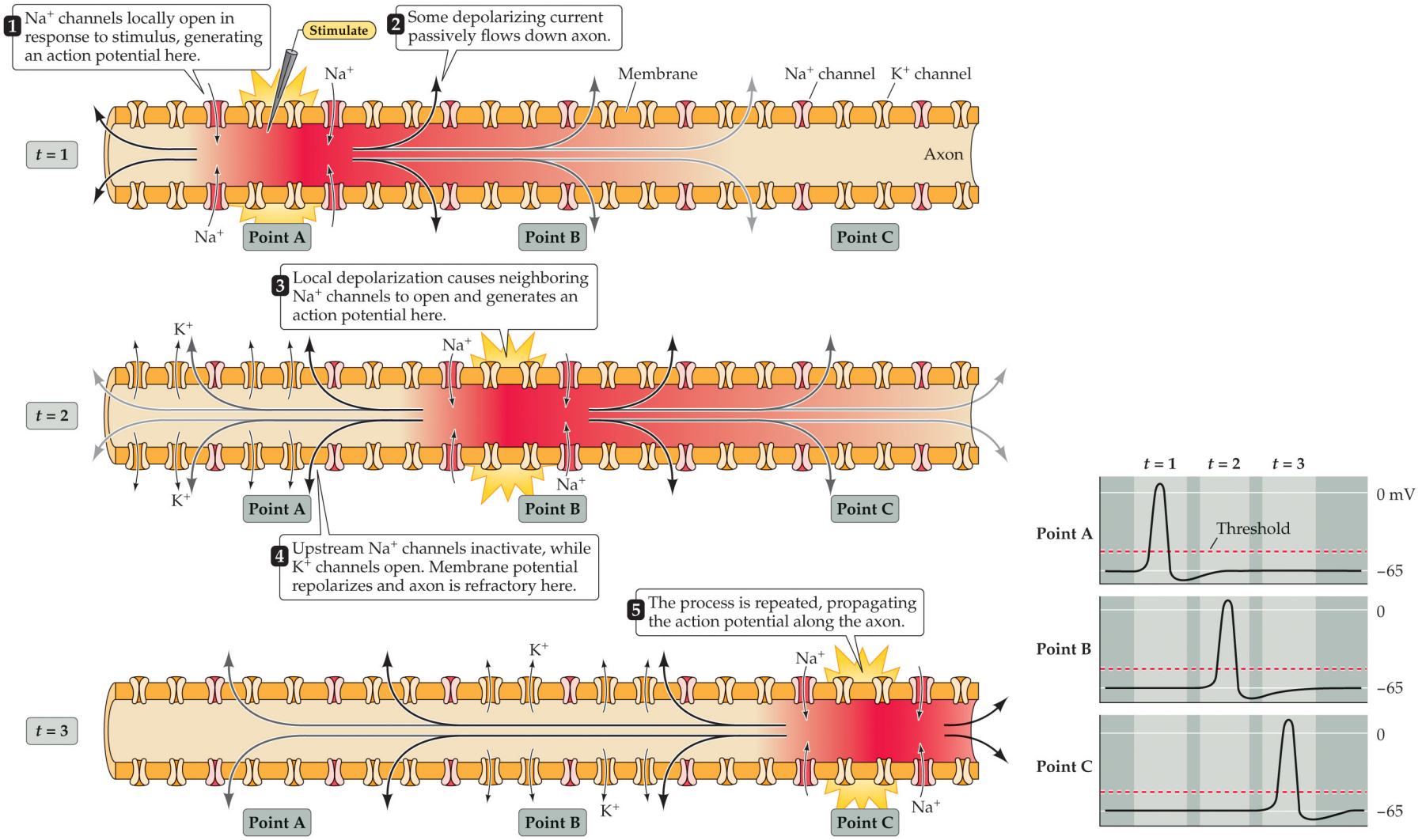
BMD ENG 301
Quantitative Systems Physiology
(Nervous System)

Lecture 8: Action Potential (Ion Channels)

2022_v1

Professor Malcolm MacIver

Action potential conduction requires both



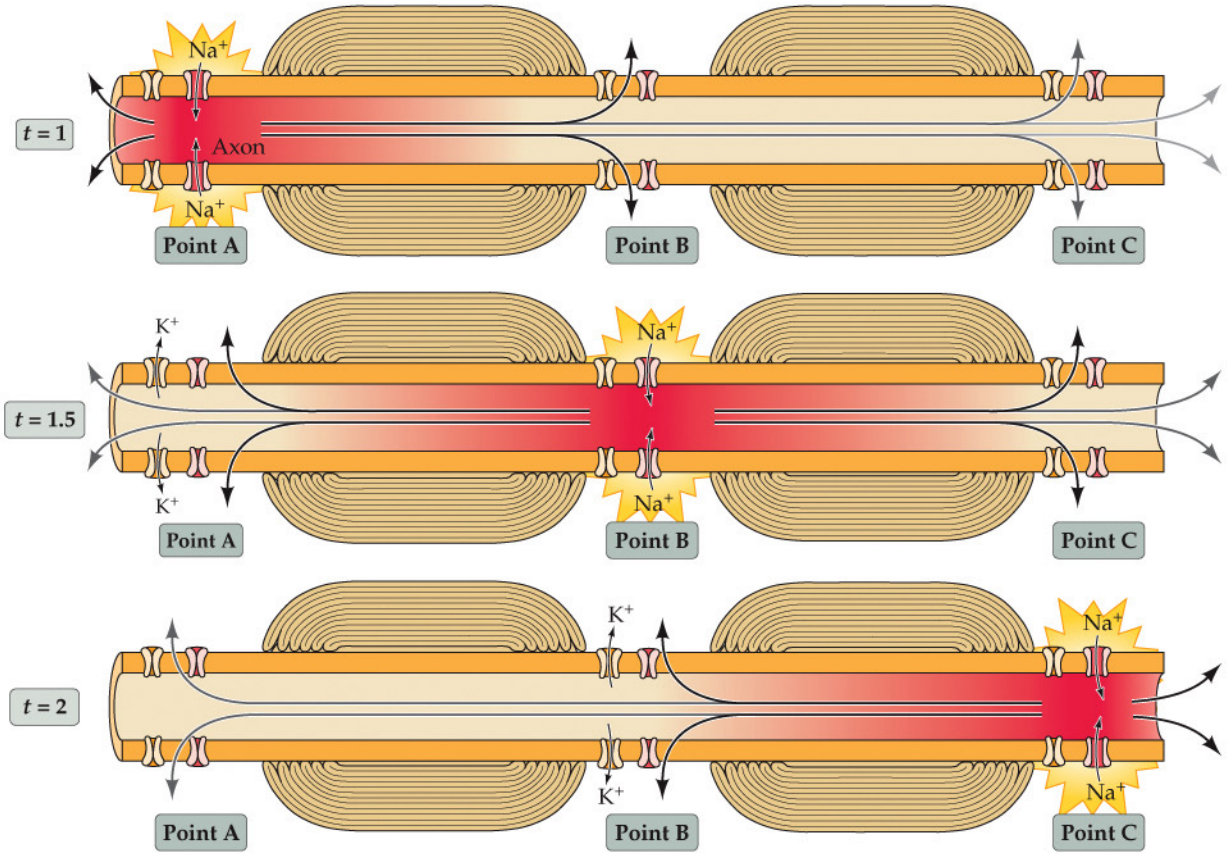
NEUROSCIENCE 6e, Figure 3.10

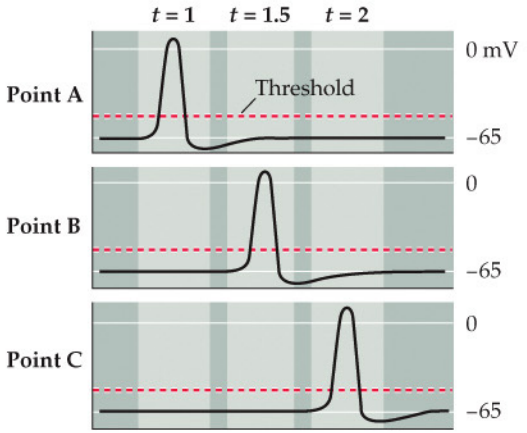
TABLE 3.1 ■ Axon Conduction Velocities

Axon	Conduction velocity (m/s)	Diameter (μm)	Myelination
Squid giant axon	25	500	No
Human			
Motor axons			
Aα type	80–120	13–20	Yes
Aγ type	4–24	5–8	Yes
Sensory axons			
Aα type	80–120	13–20	Yes
Aβ type	35–75	6–12	Yes
Aδ type	3–35	1–5	Thin
C type	0.5–2.0	0.2–1.5	No
Autonomic			
preganglionic B type	3–15	1–5	Yes
postganglionic C type	0.5–2.0	0.2–1.5	No

NEUROSCIENCE 6e, Table 3.1

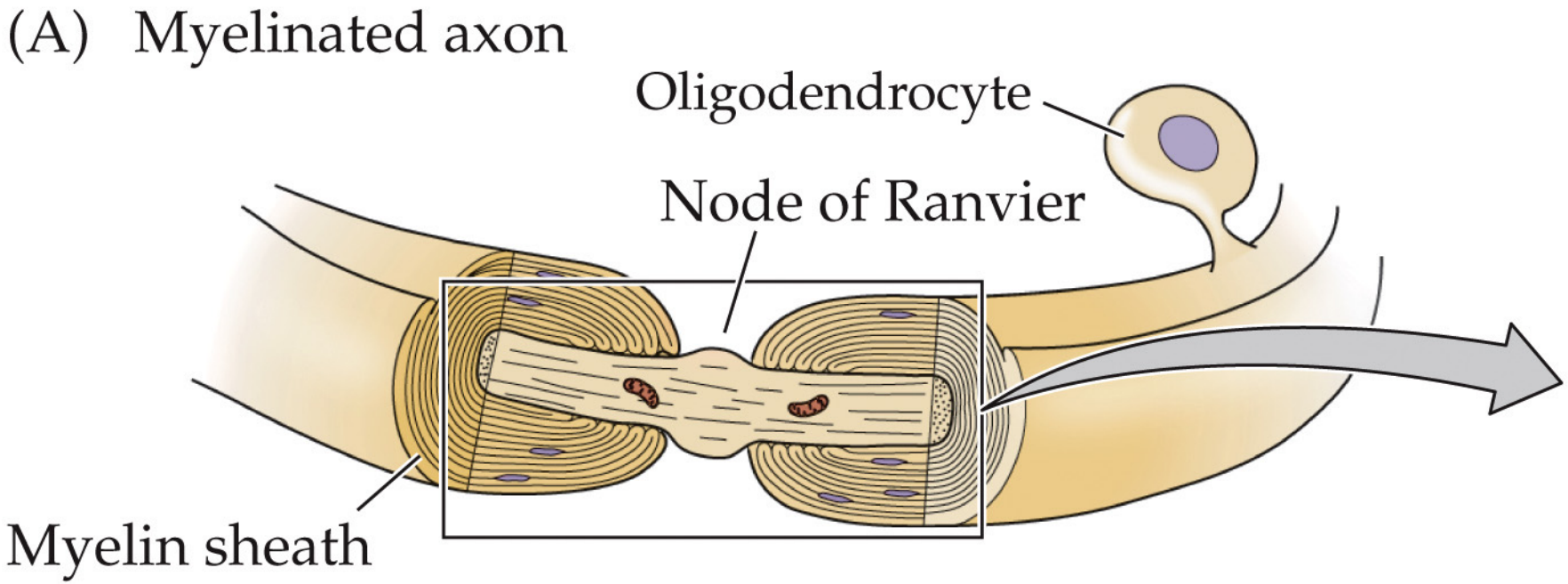
(C) Action potential propagation





NEUROSCIENCE 6e, Figure 3.11 (Part 3)

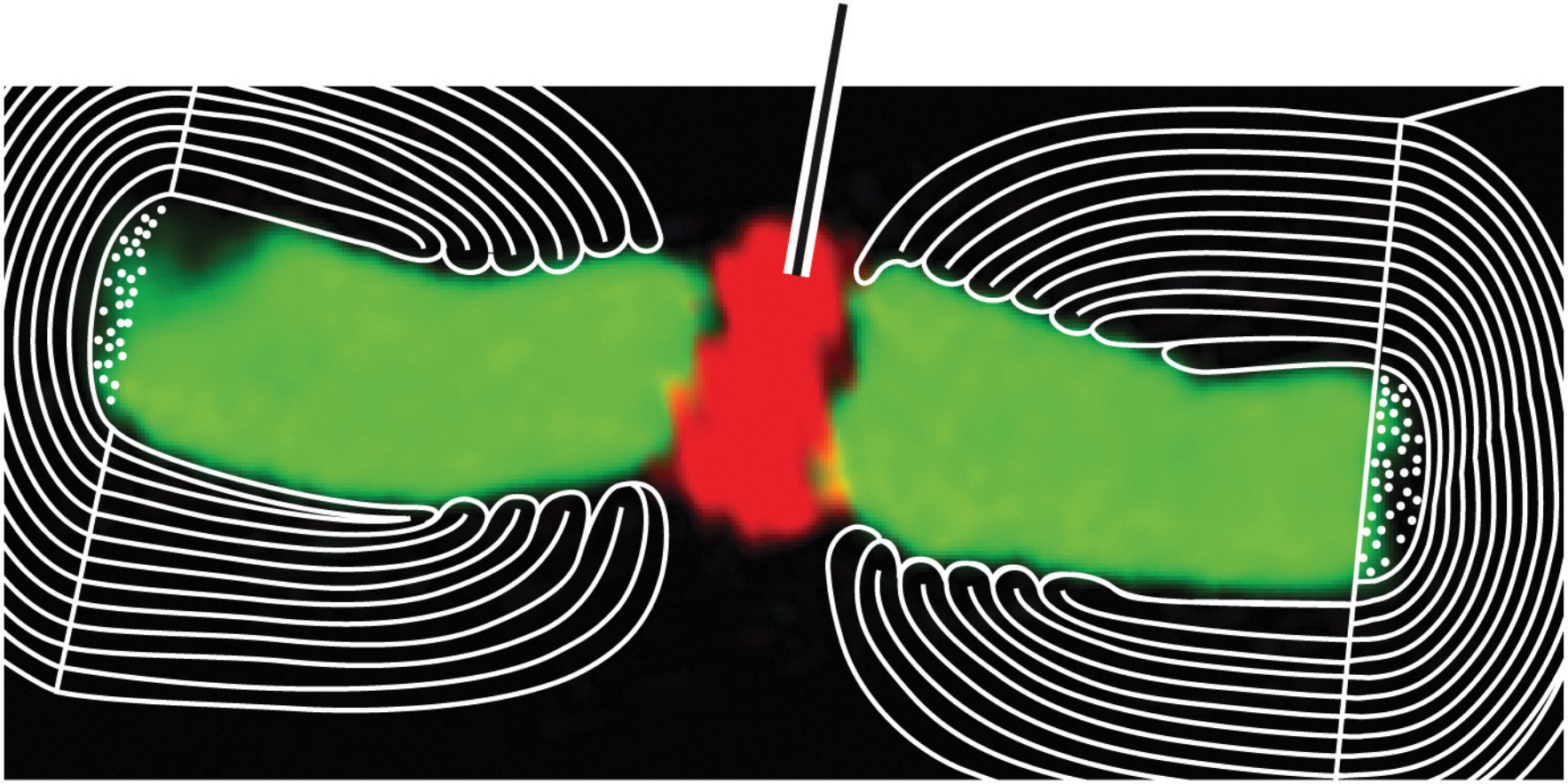
Saltatory action potential conduction



NEUROSCIENCE 6e, Figure 3.11 (Part 1)

(B)

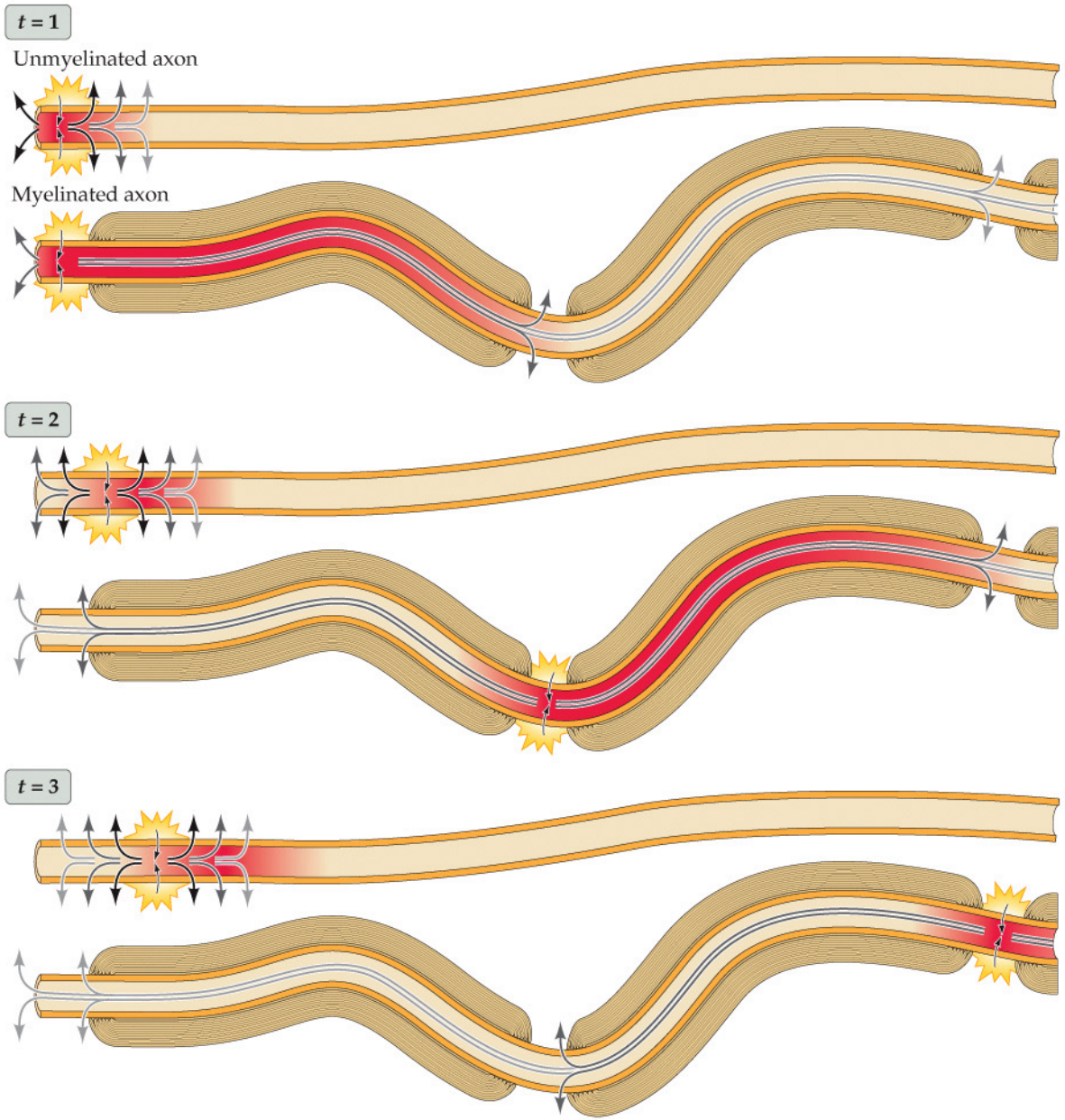
Na^+ channels



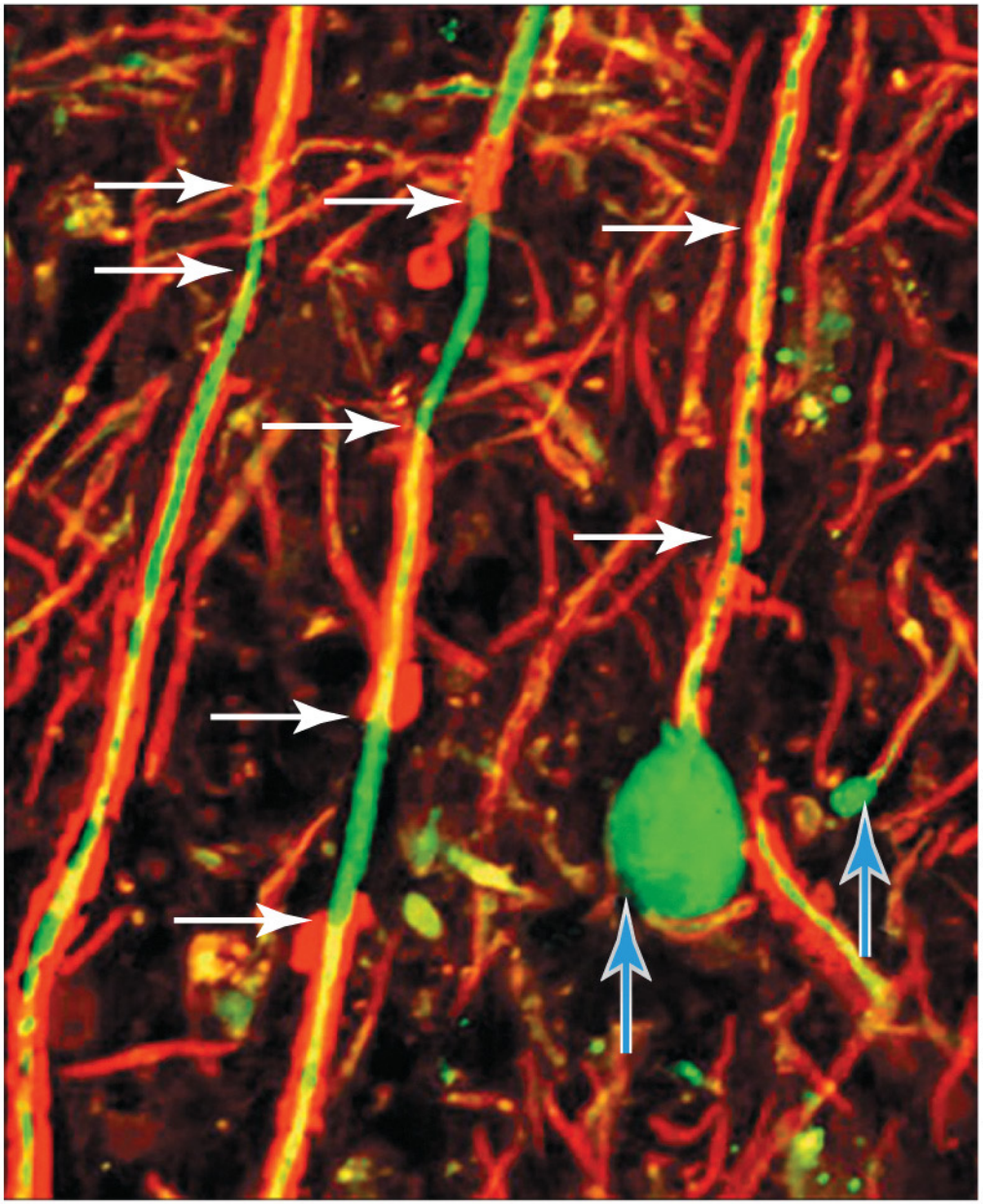
From Chen et al. (2004) *J. Neurosci.* 24: 4030–4042.

NEUROSCIENCE 6e, Figure 3.11 (Part 2)

Myelin increases conduction speed



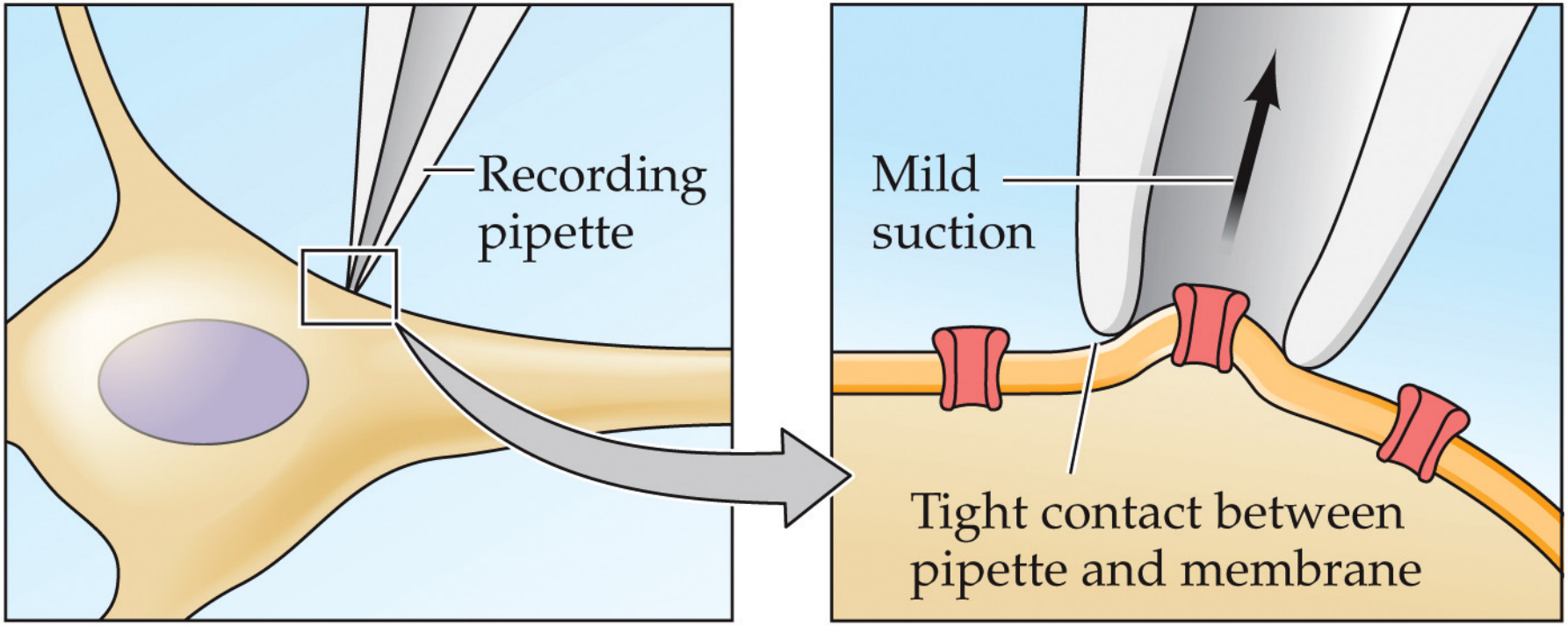
NEUROSCIENCE 6e, Figure 3.12



From Trapp, B. D and P.K. Stys (2009) *Lancet Neurol.* 8: 280–291.

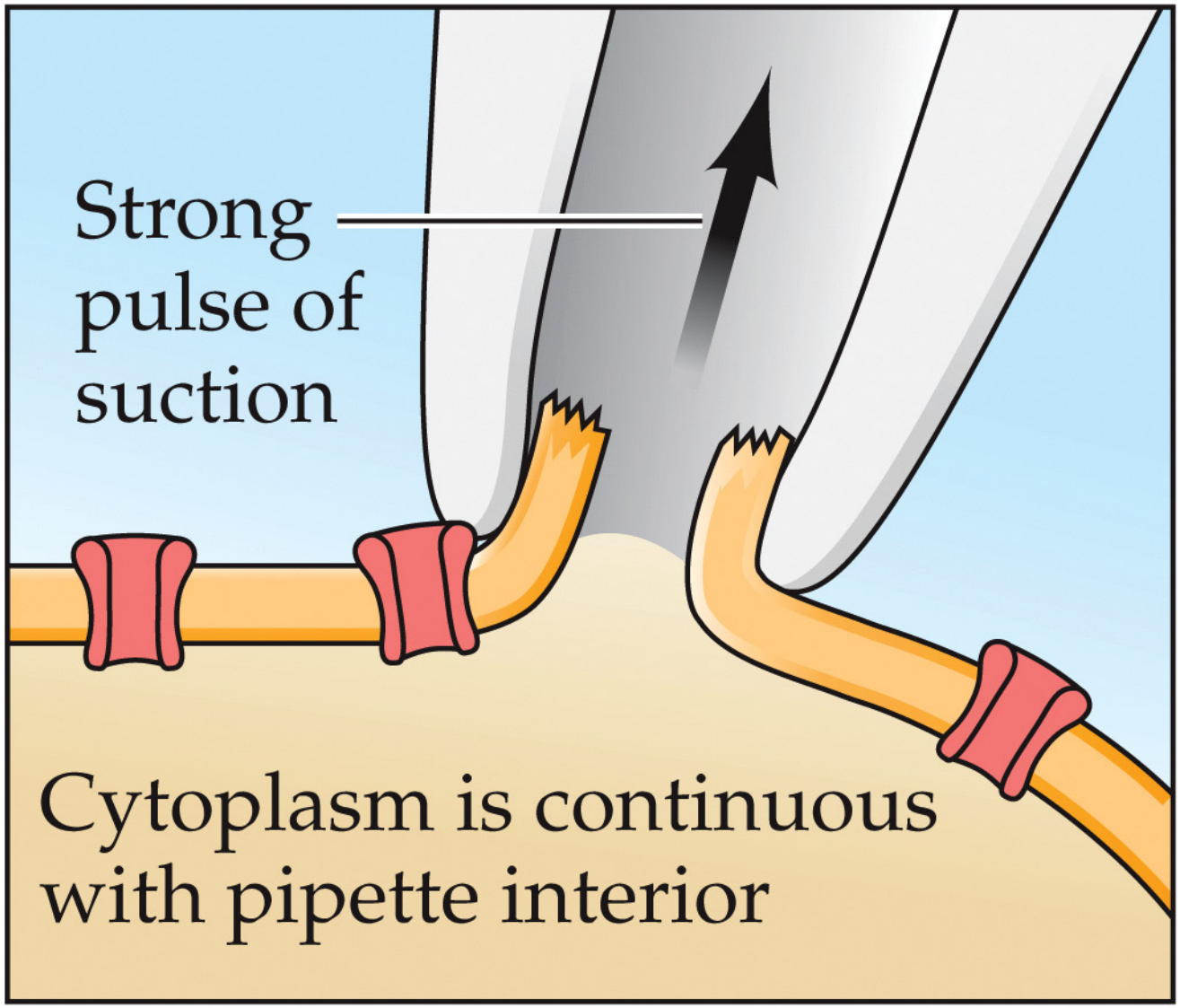
NEUROSCIENCE 6e, Clinical Applications 3

Cell-attached recording



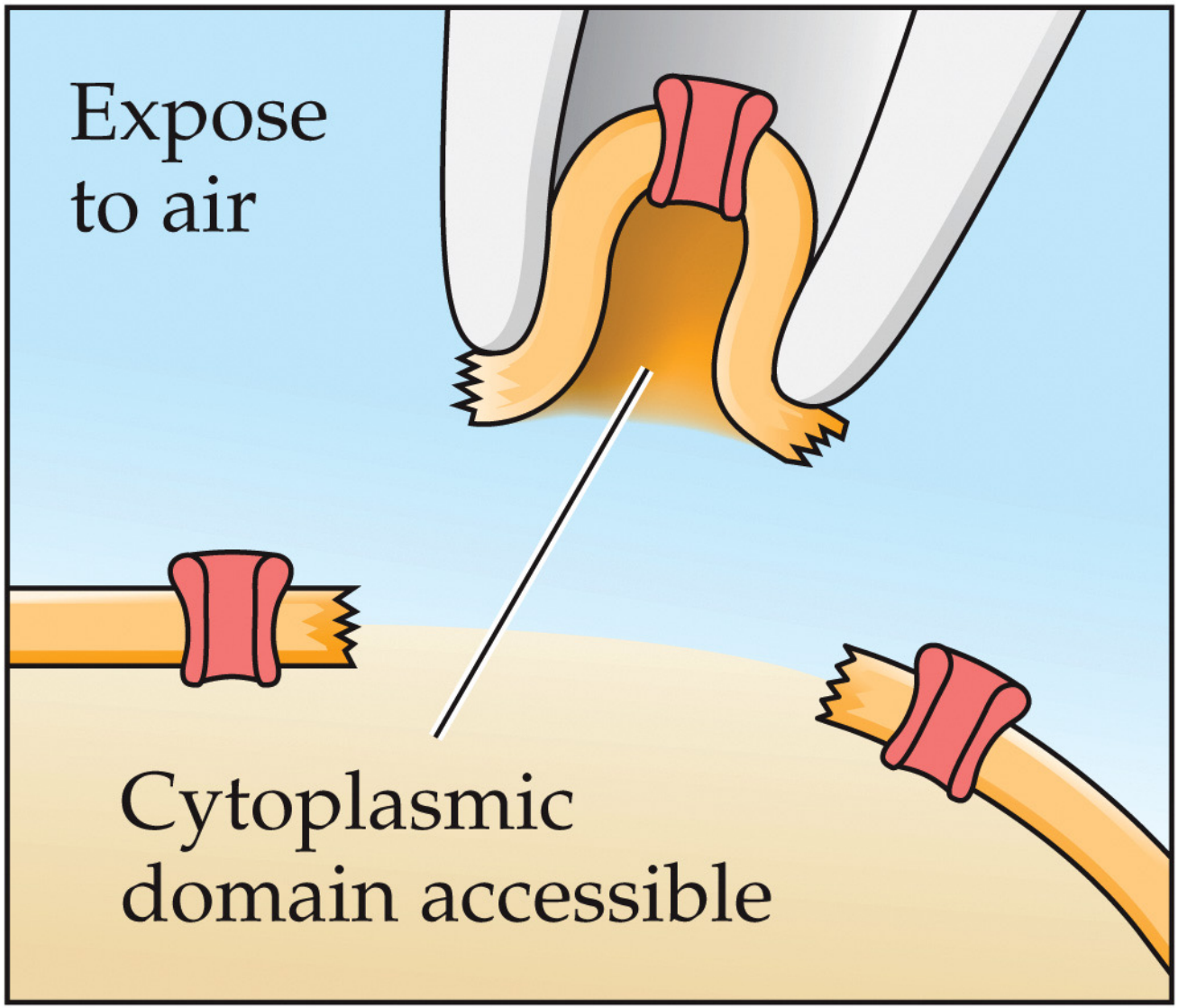
NEUROSCIENCE 6e, Box 4A (Part 1)

Whole-cell recording



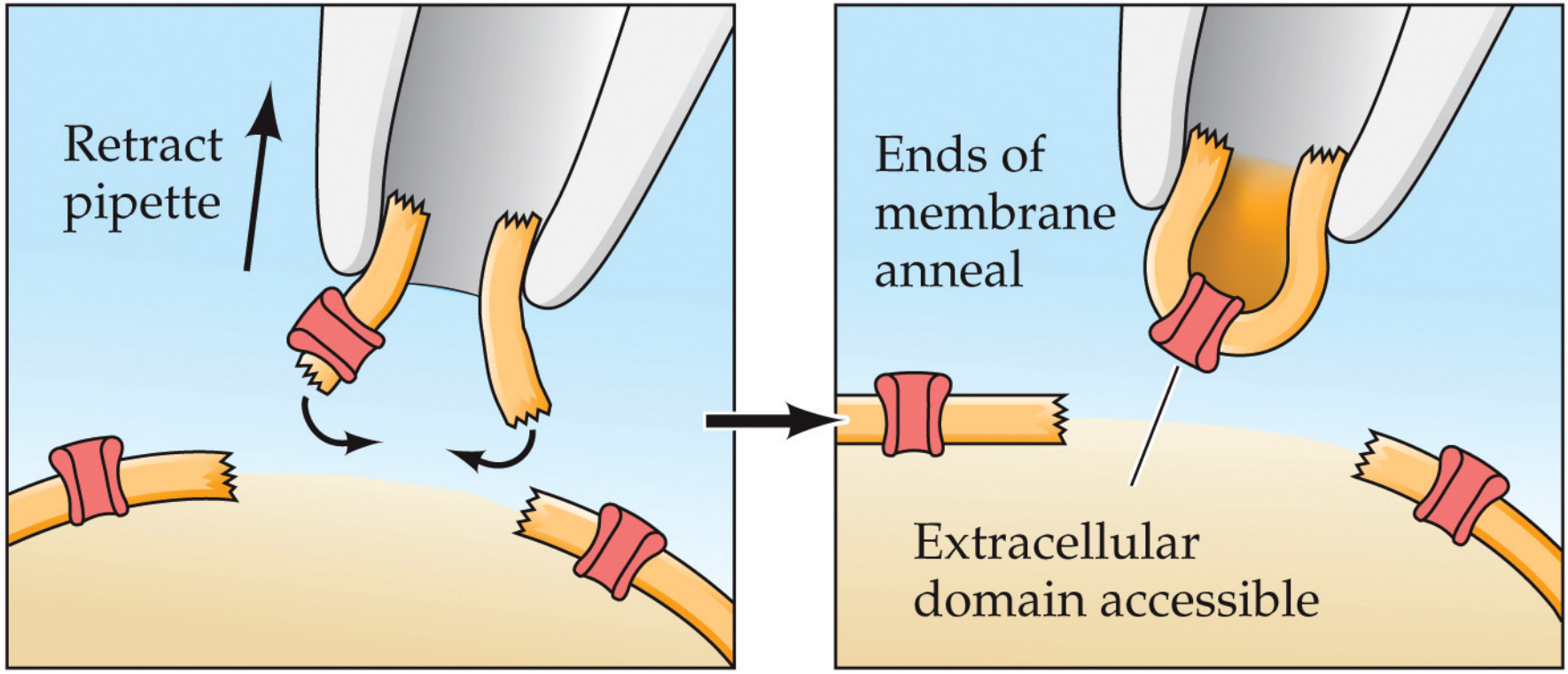
NEUROSCIENCE 6e, Box 4A (Part 2)

Inside-out recording

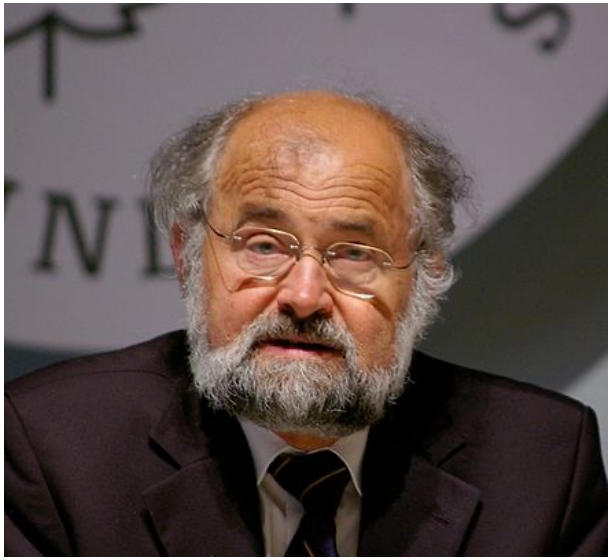


NEUROSCIENCE 6e, Box 4A (Part 3)

Outside-out recording

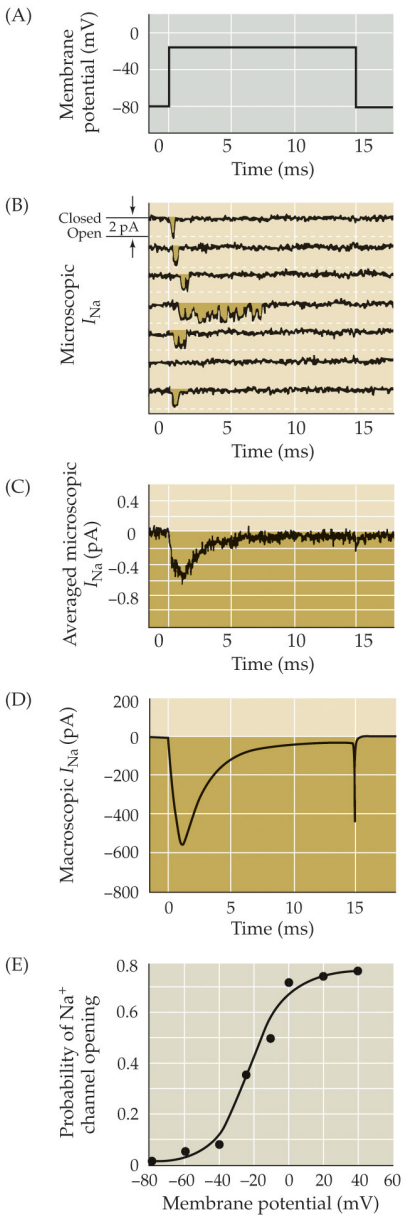


NEUROSCIENCE 6e, Box 4A (Part 4)



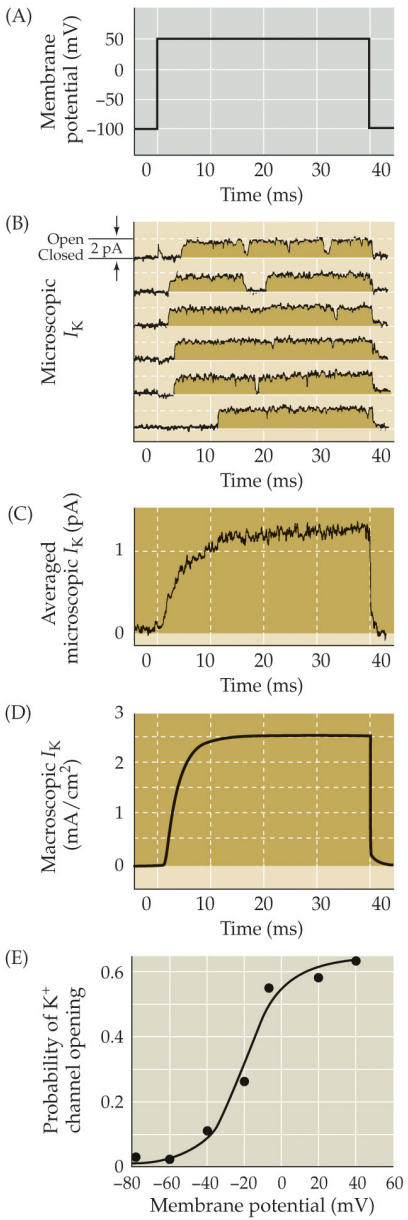
Erwin Neher and
Bert Sakmann
Nobel Prize for
Physiology or Medicine,
1991

Patch clamp measurements of ion currents flowing through single Na^+ channels in a squid giant



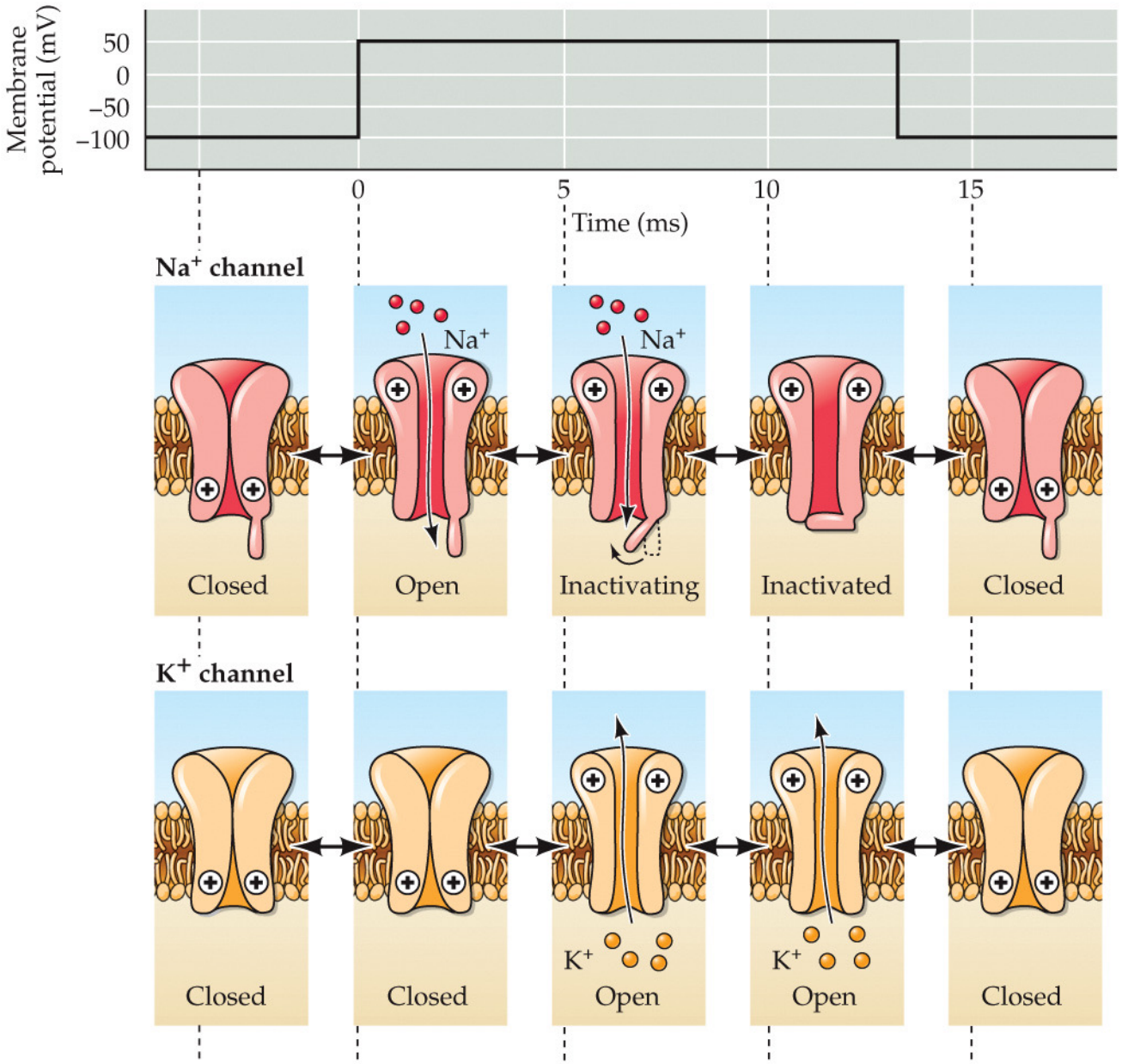
***NEUROSCIENCE 6e*, Figure 4.1**

Patch clamp measurements of ion currents flowing through single K+ channels in a squid giant



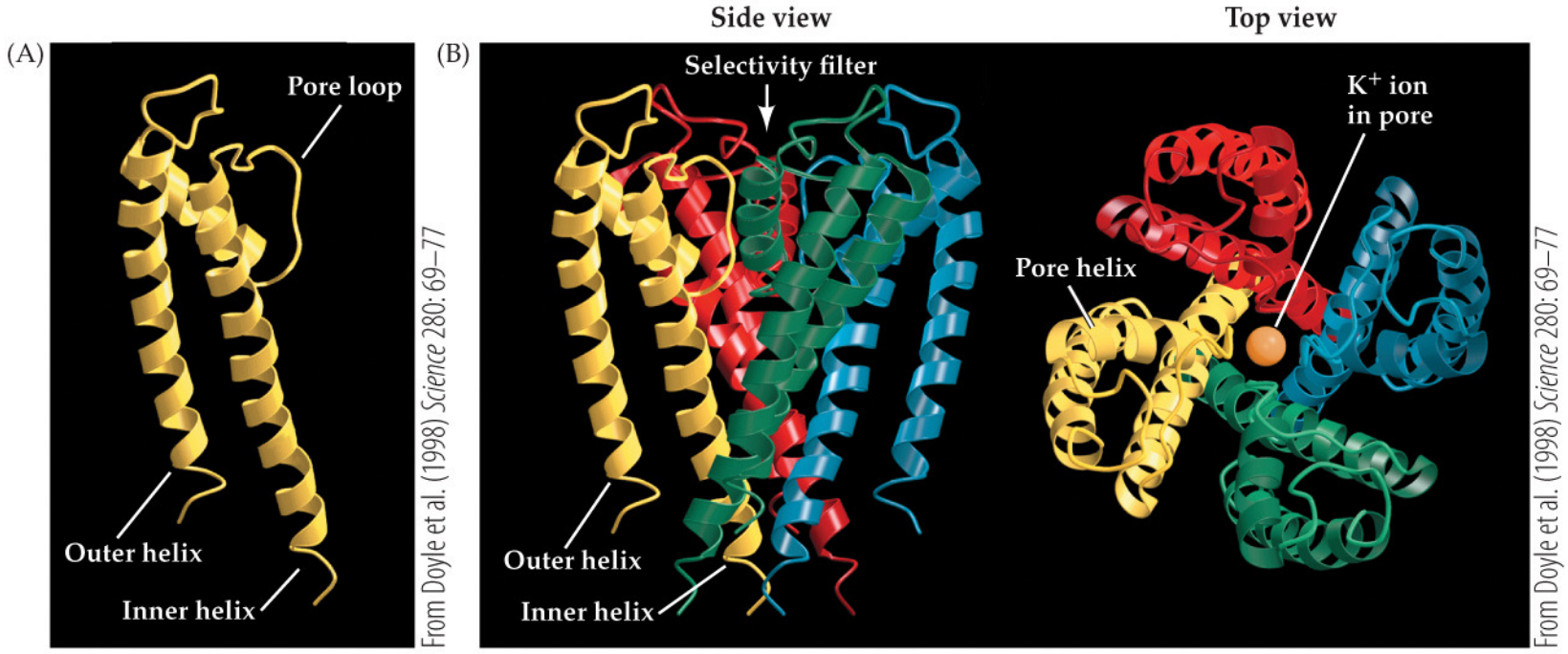
***NEUROSCIENCE 6e*, Figure 4.2**

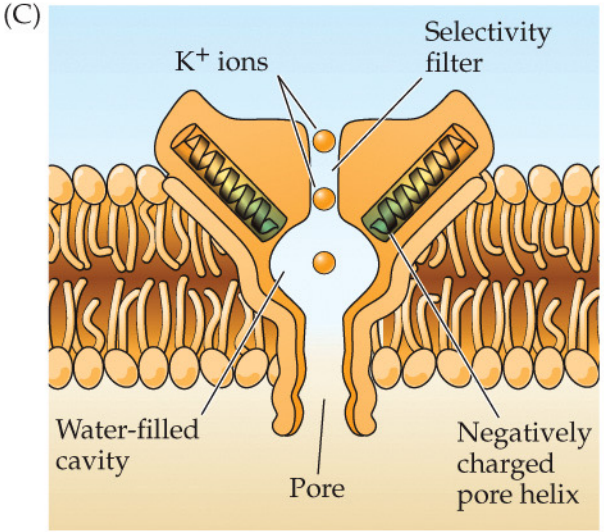
Functional states of voltage-gated Na^+ and K^+ channels



NEUROSCIENCE 6e, Figure 4.3

Structure of a simple bacterial K^+ channel determined by crystallography

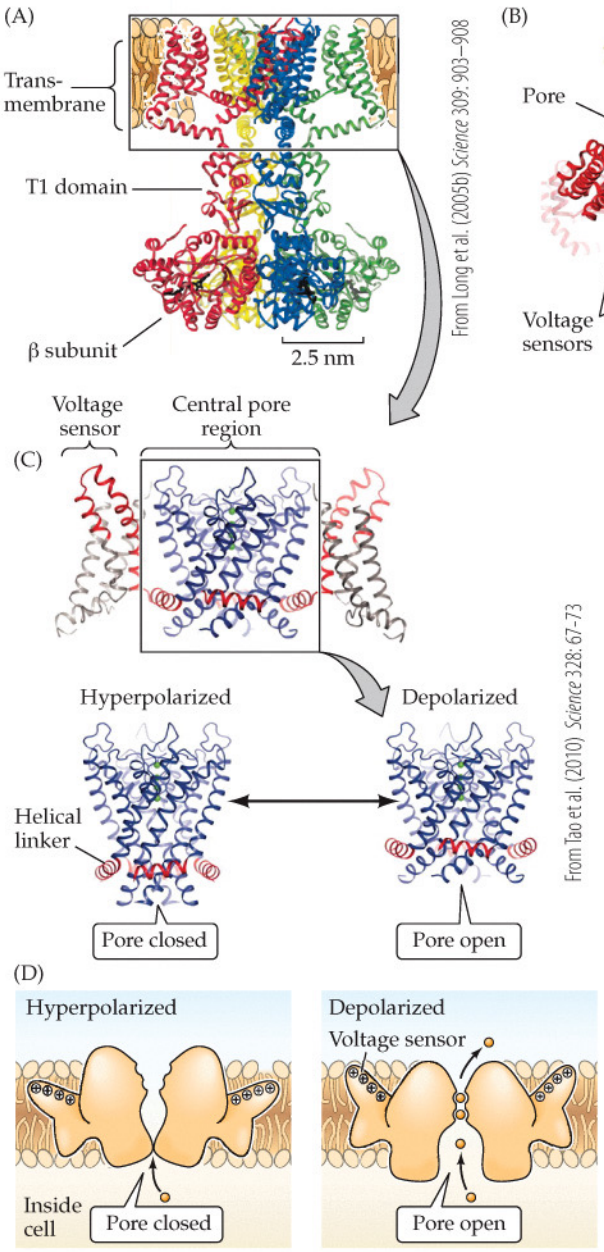




Roderick MacKinnon
Nobel Prize in Chemistry 2003

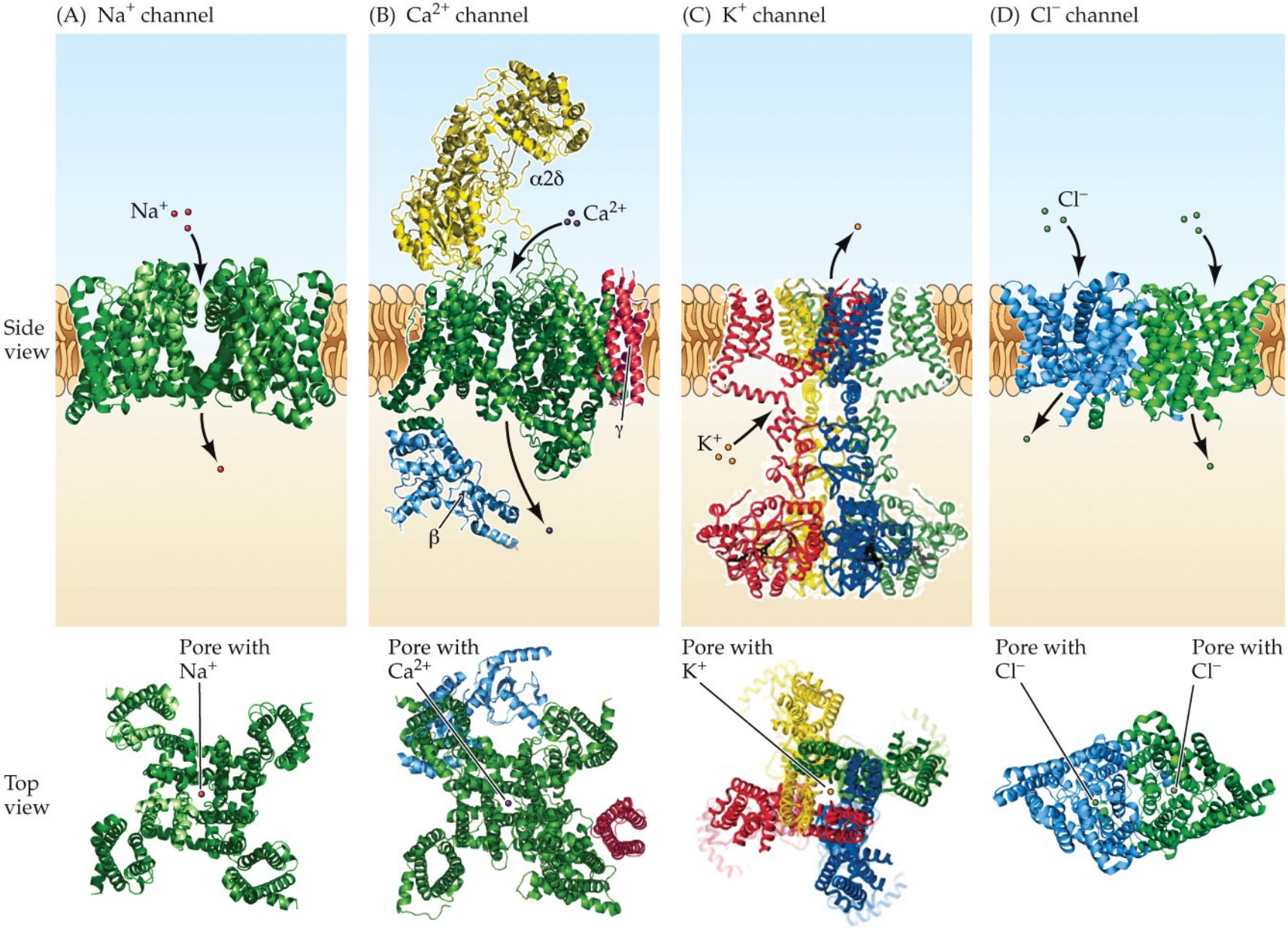
NEUROSCIENCE 6e, Figure 4.4

Structure of a mammalian voltage-gated K^+ channel



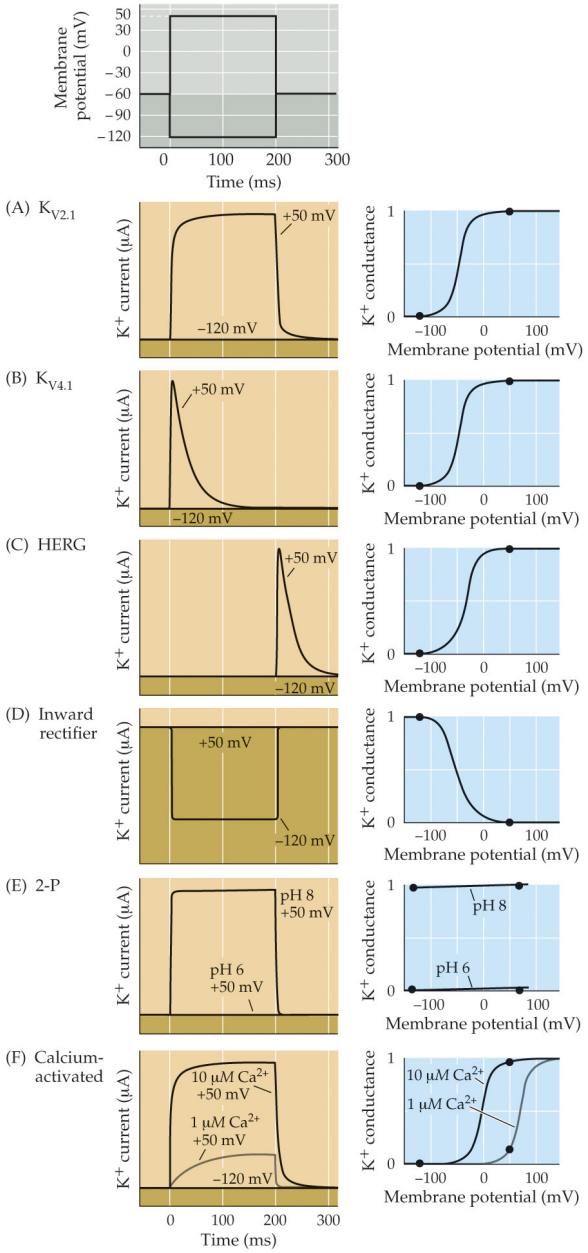
NEUROSCIENCE 6e, Figure 4.5

Types of voltage-gated ion channels



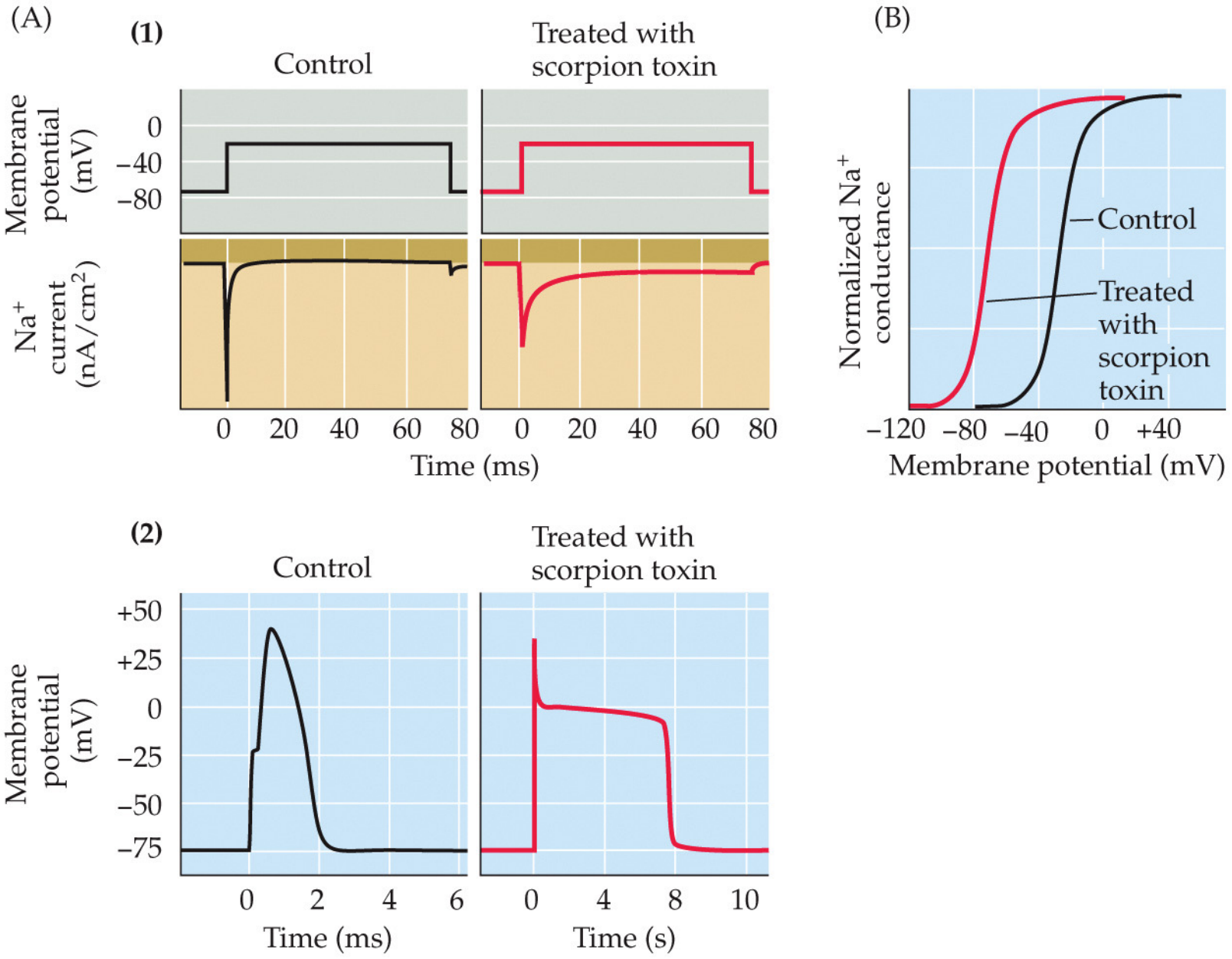
NEUROSCIENCE 6e, Figure 4.6

Diverse properties of K^+ channels



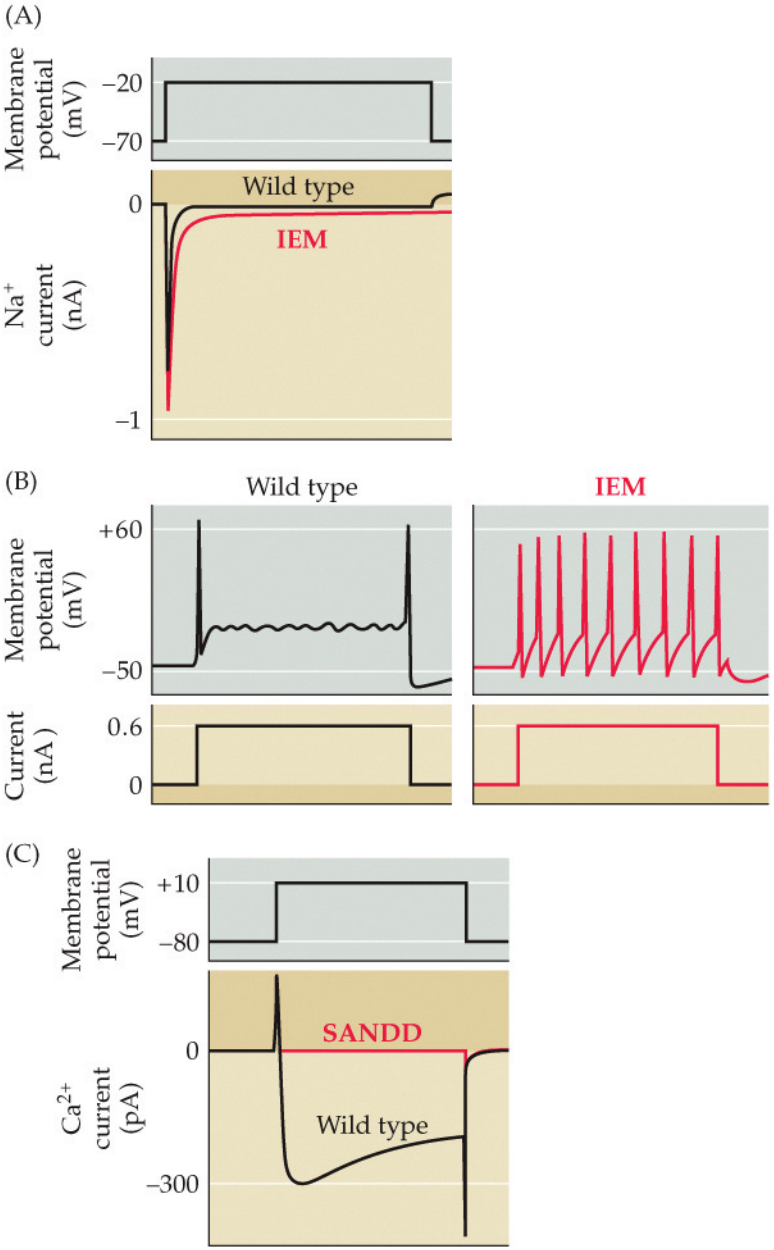
NEUROSCIENCE 6e, Figure 4.7

Toxins That Poison Ion Channels



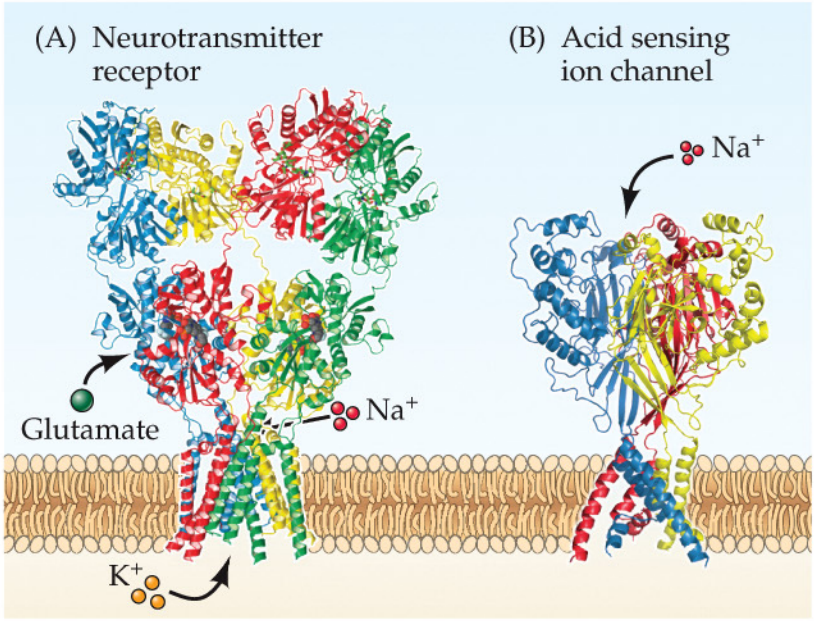
NEUROSCIENCE 6e, Box 4B

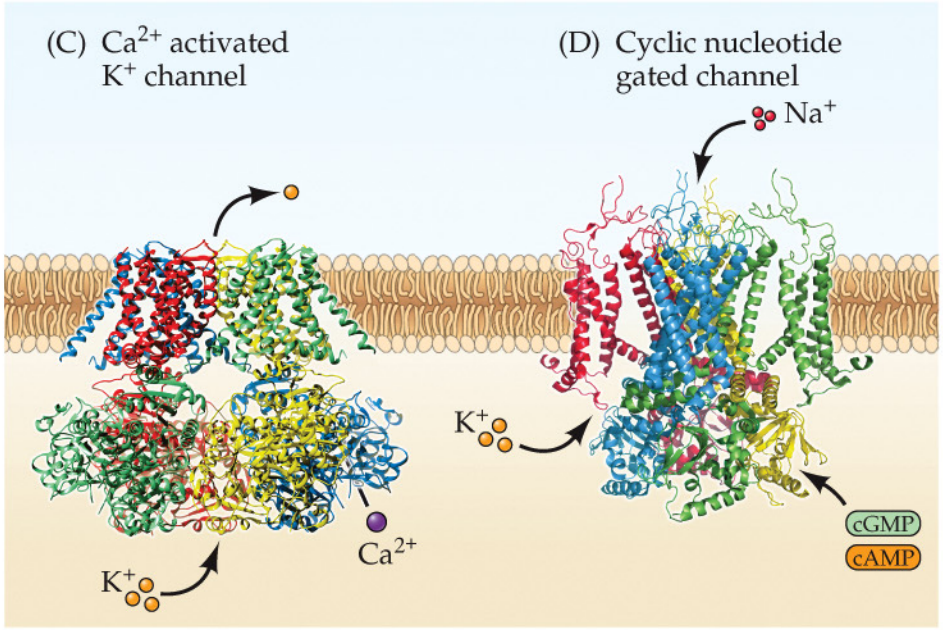
CLINICAL APPLICATIONS Neurological Diseases Caused by Altered Ion Channels



NEUROSCIENCE 6e, Clinical Applications 4

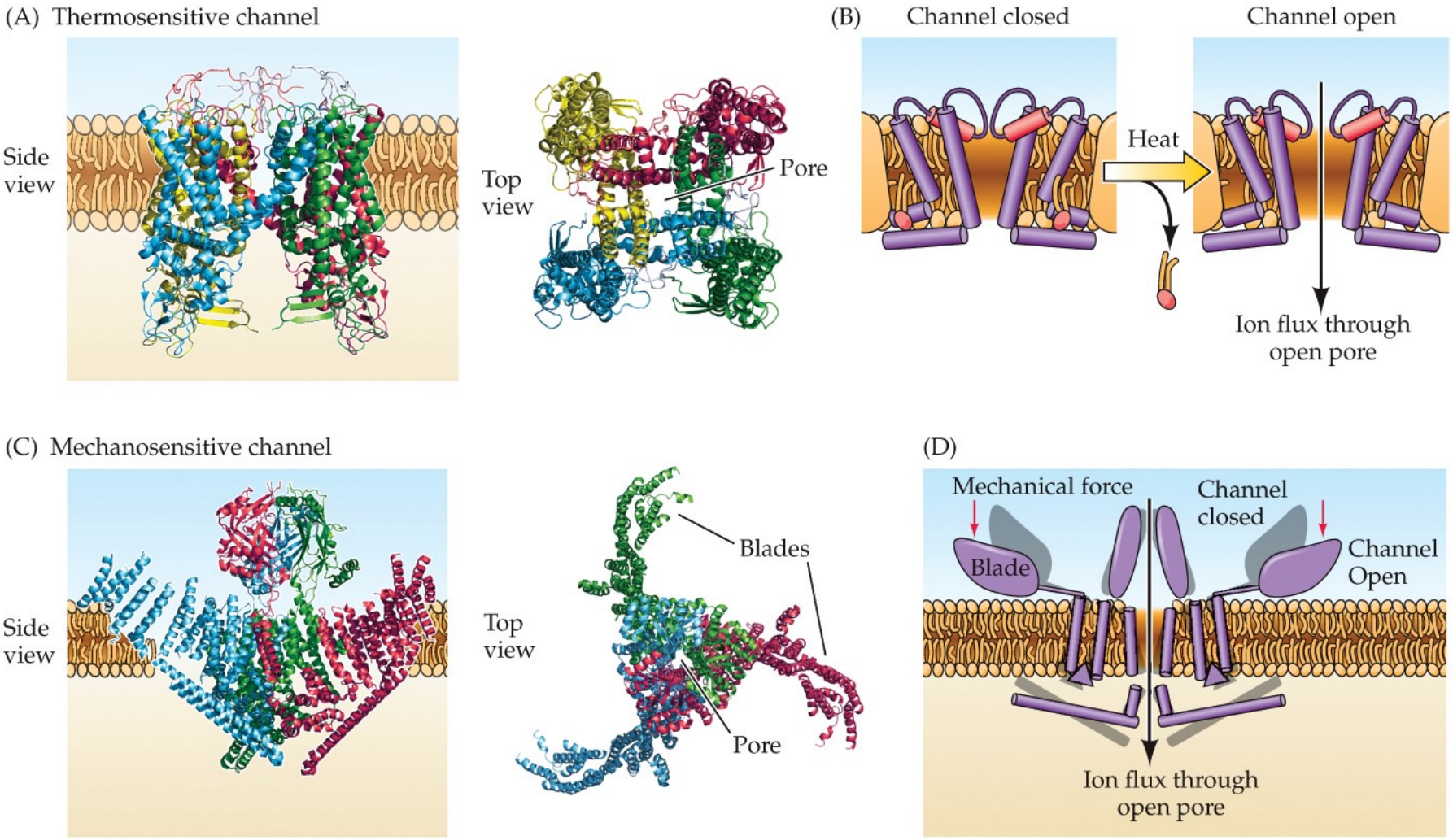
Ligand-gated ion channels





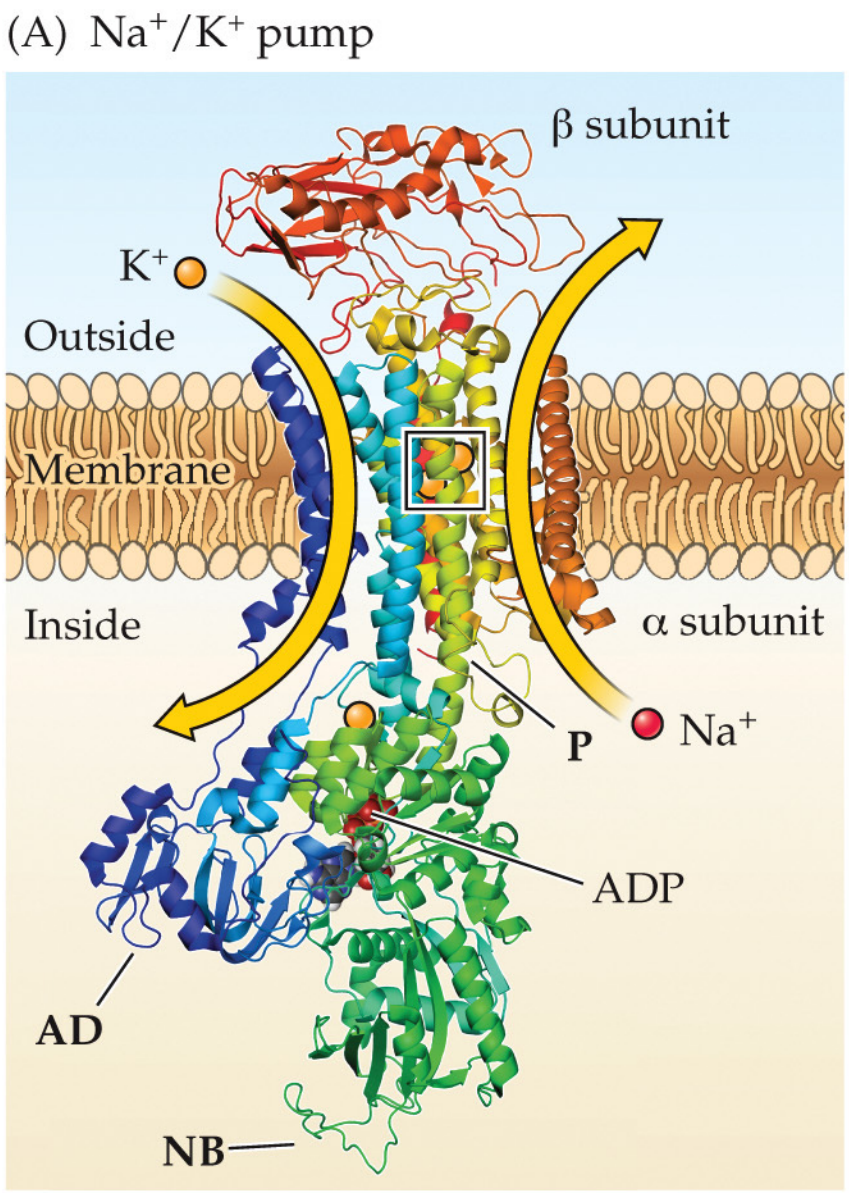
NEUROSCIENCE 6e, Figure 4.8

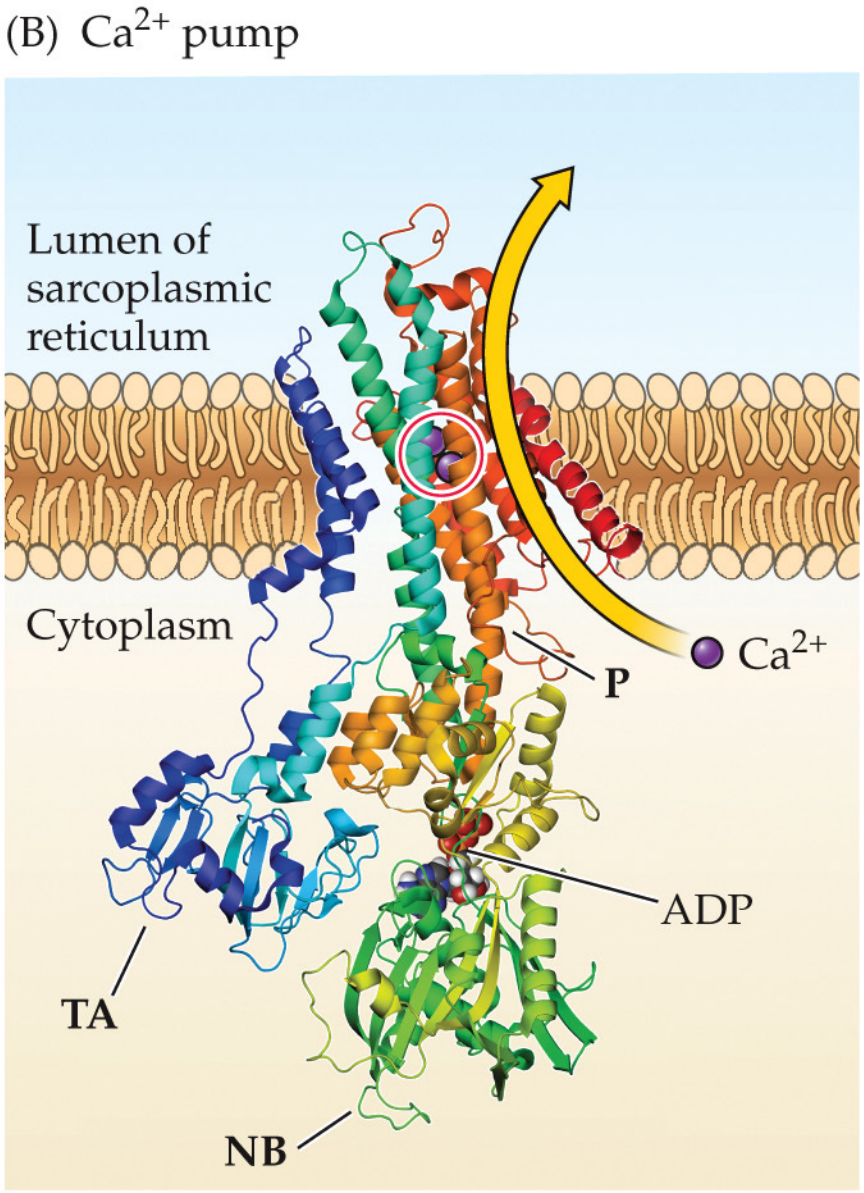
Thermosensitive and mechanosensitive channels



NEUROSCIENCE 6e, Figure 4.9

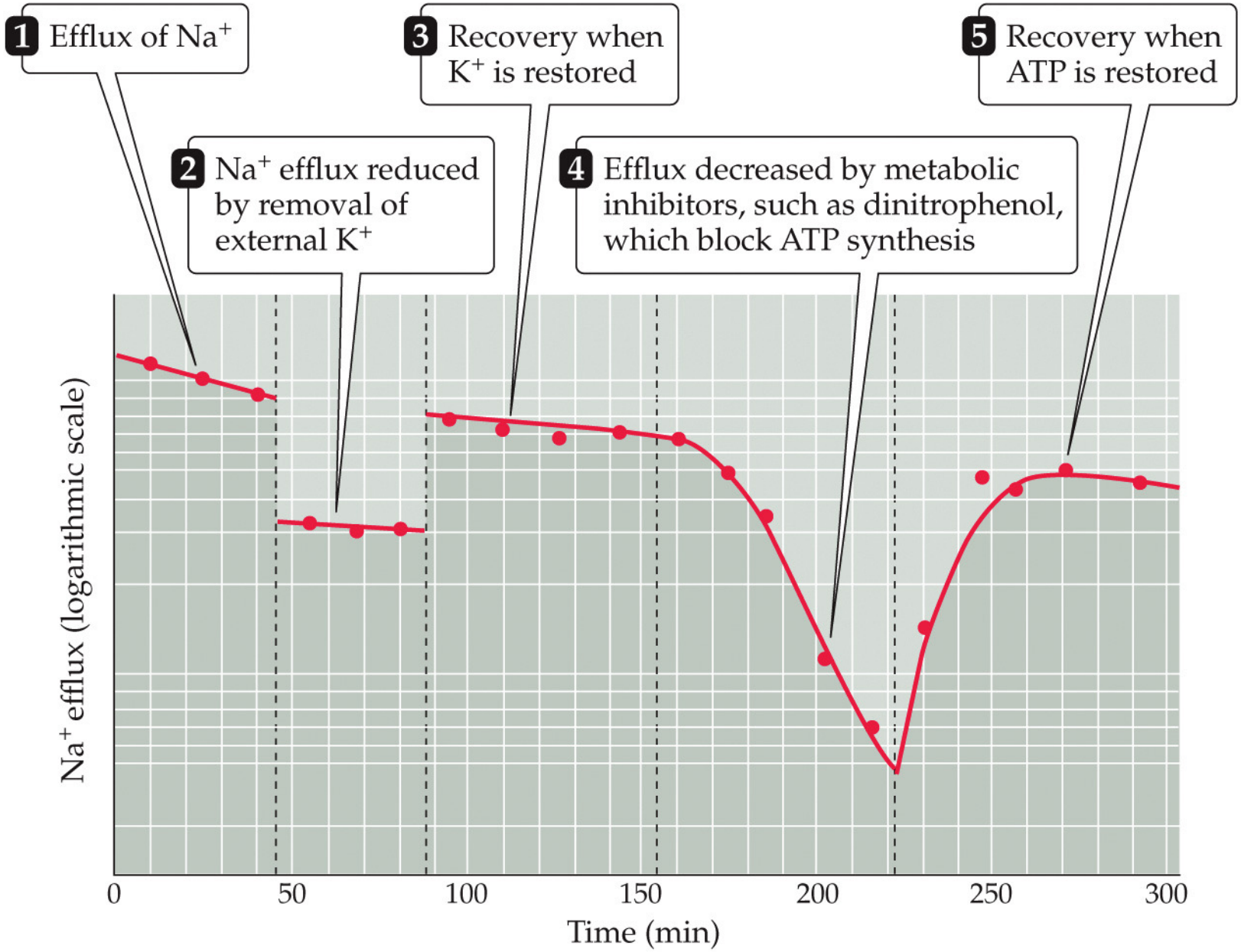
Examples of ATPase pumps





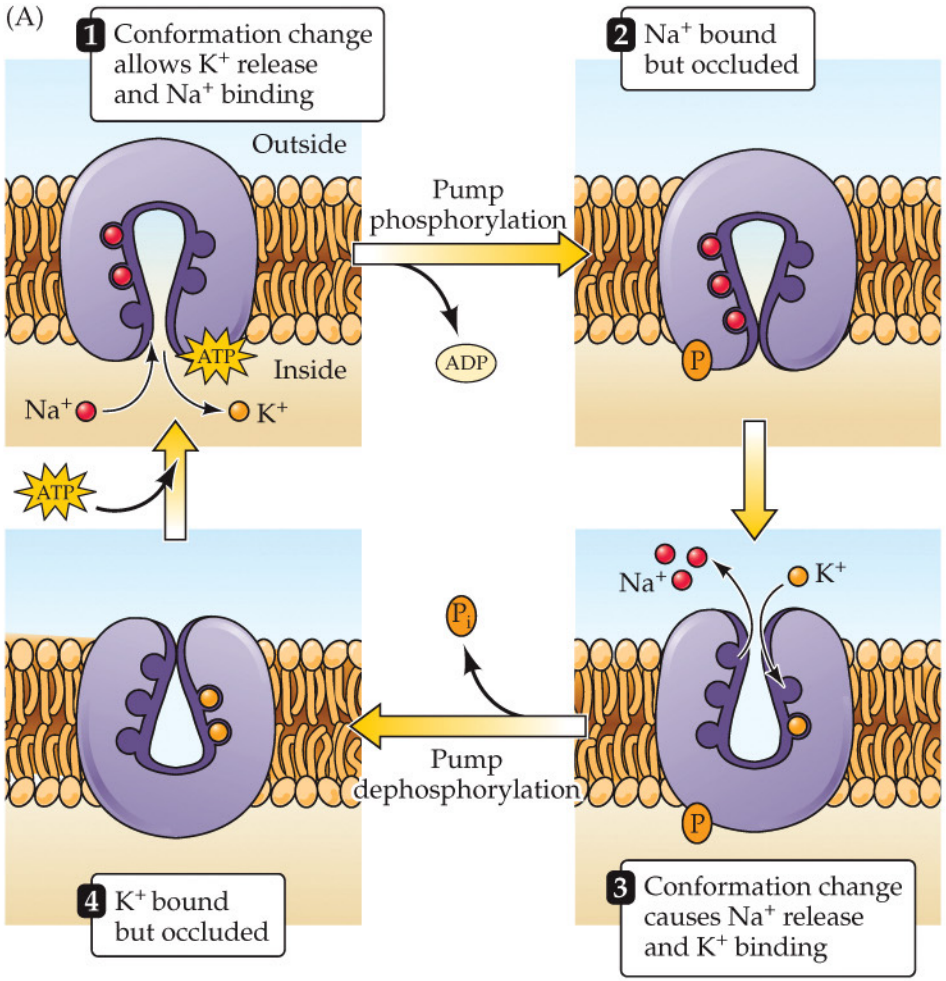
NEUROSCIENCE 6e, Figure 4.10

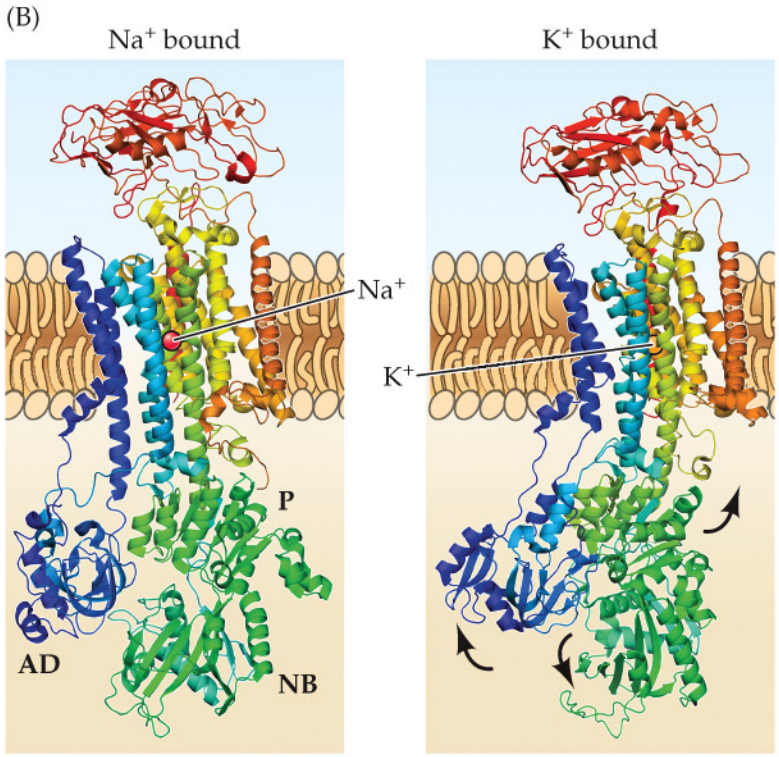
Ion movements due to the Na^+ pump



NEUROSCIENCE 6e, Figure 4.11

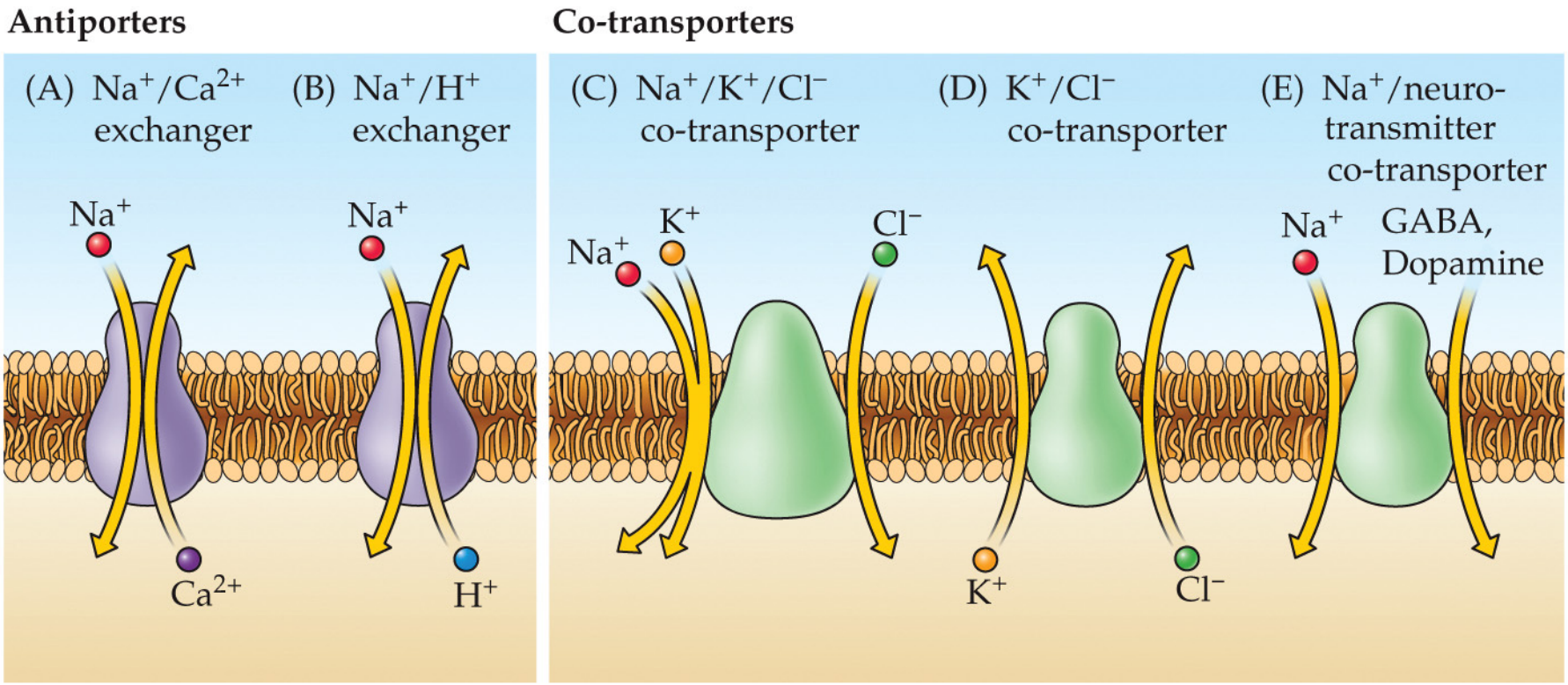
Translocation of Na^+ and K^+ by the Na^+ pump





NEUROSCIENCE 6e, Figure 4.12

Examples of ion exchangers



NEUROSCIENCE 6e, Figure 4.13