

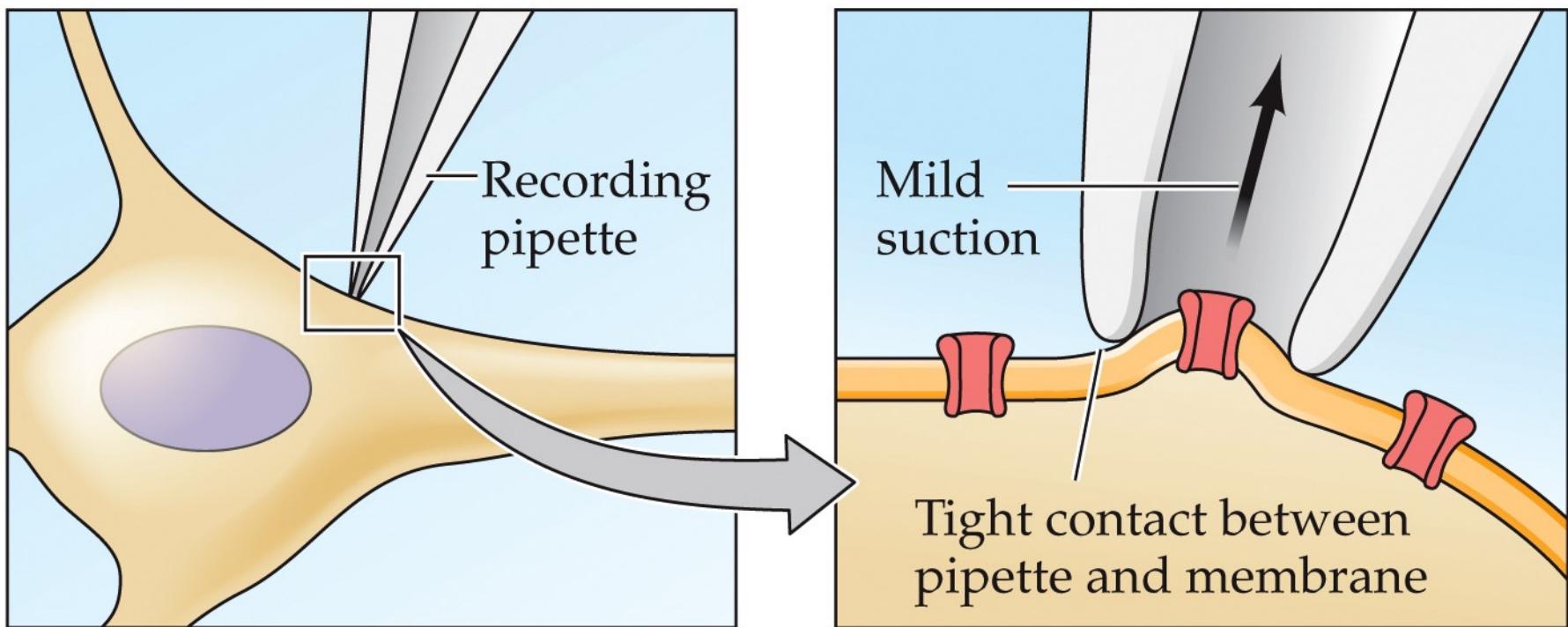
BMD ENG 301
Quantitative Systems Physiology
(Nervous System)

Lecture 8: Action Potential (Ion Channels)

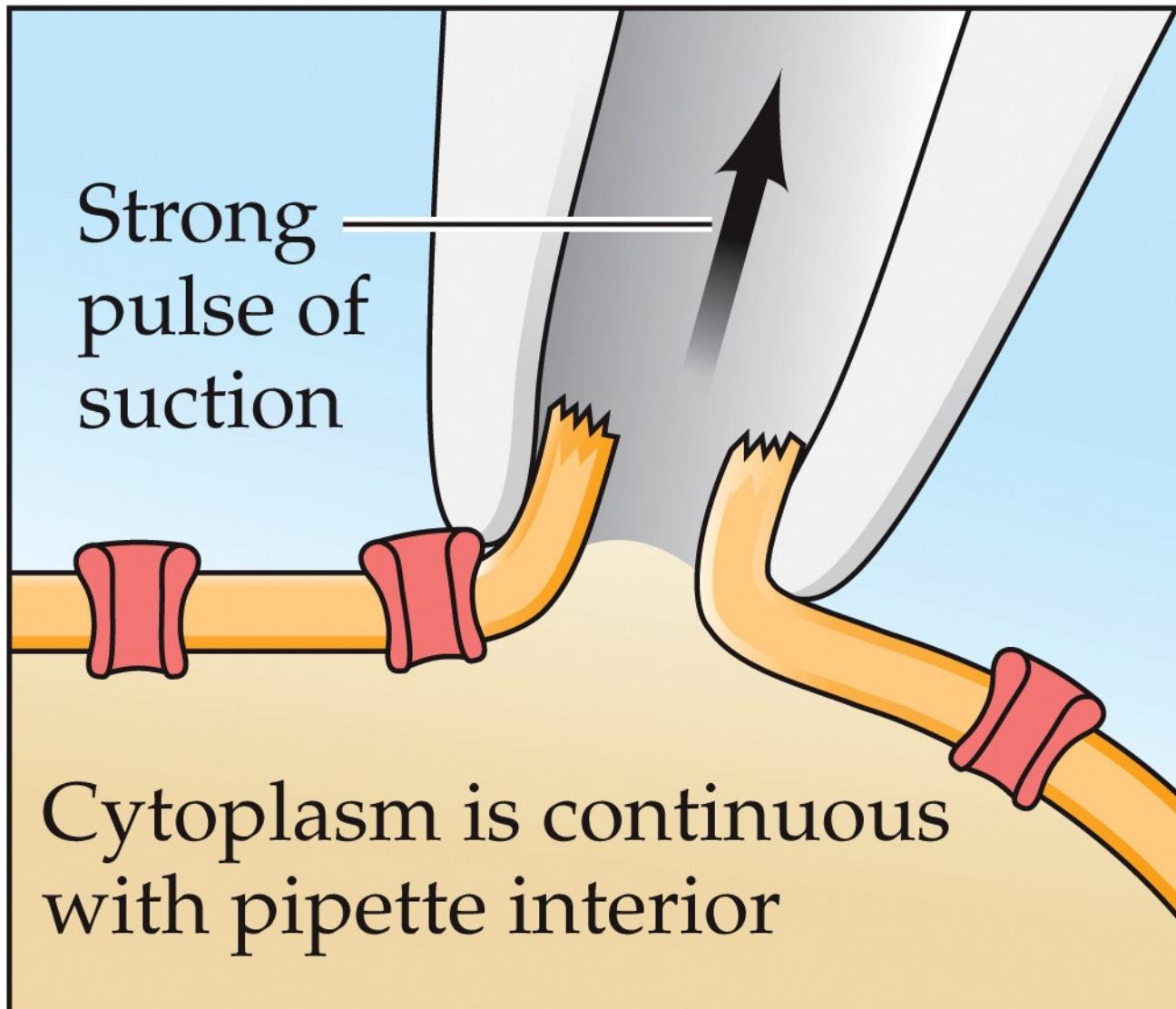
2022_v2

Professor Malcolm MacIver

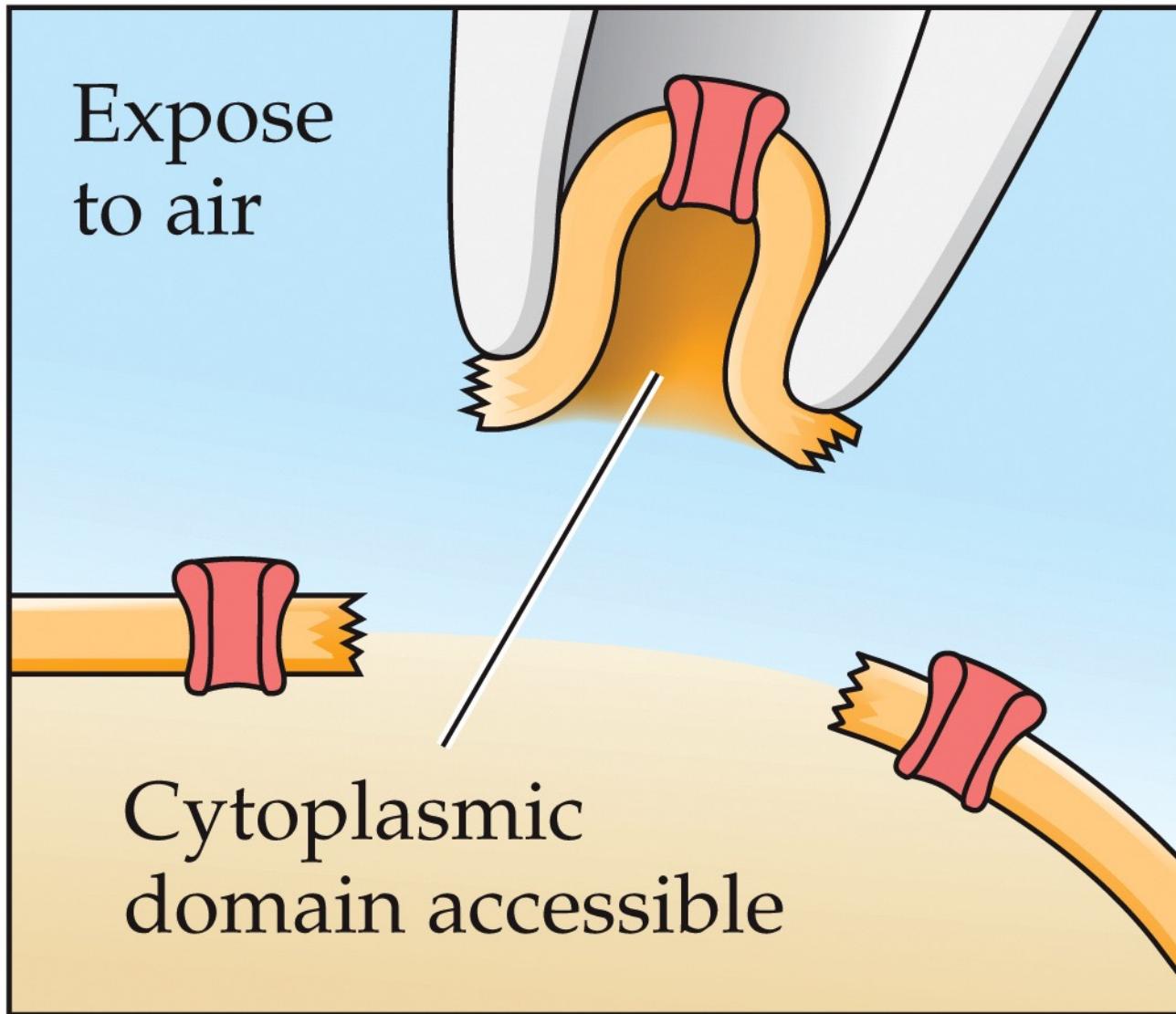
Cell-attached recording



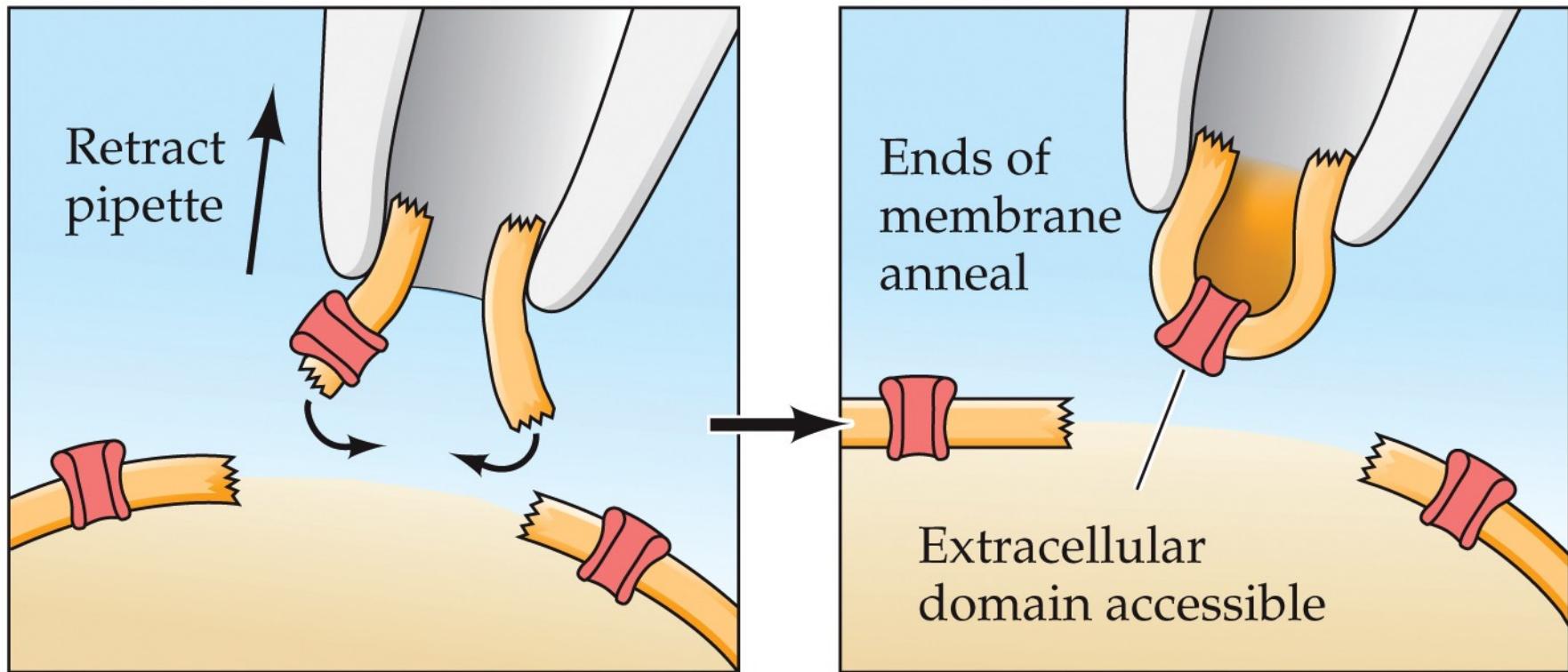
Whole-cell recording

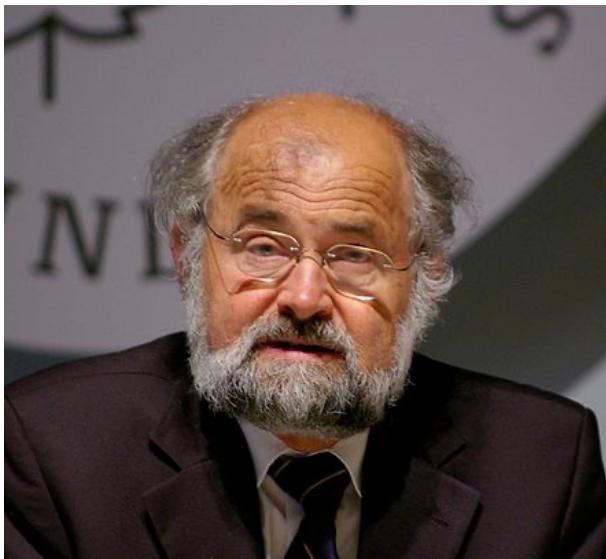


Inside-out recording



Outside-out recording

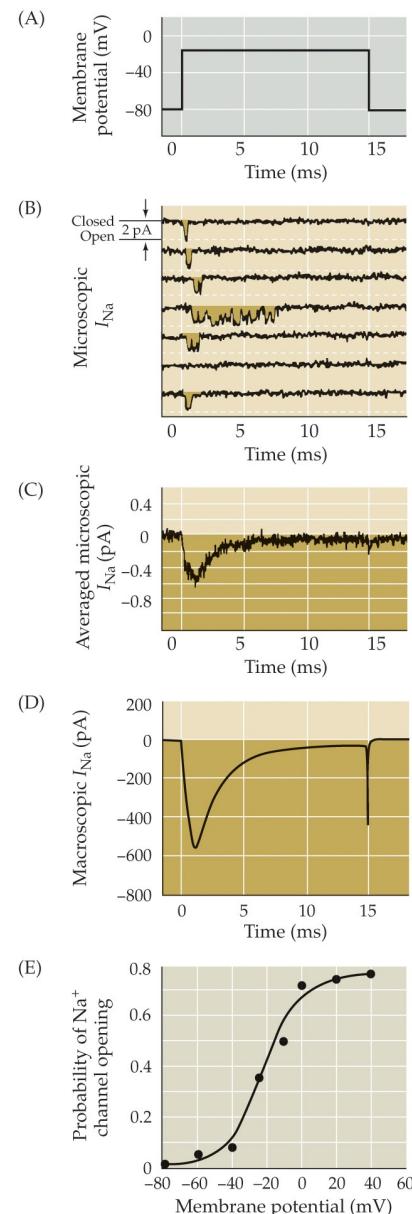




Erwin Neher and
Bert Sakmann
Nobel Prize for
Physiology or Medicine,
1991

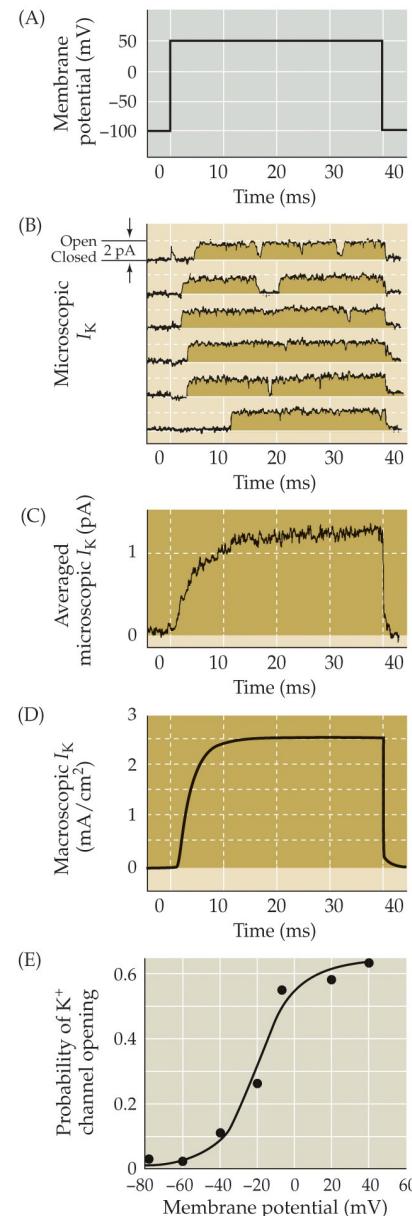


Patch clamp measurements of ion currents flowing through single Na^+ channels in a squid giant axon

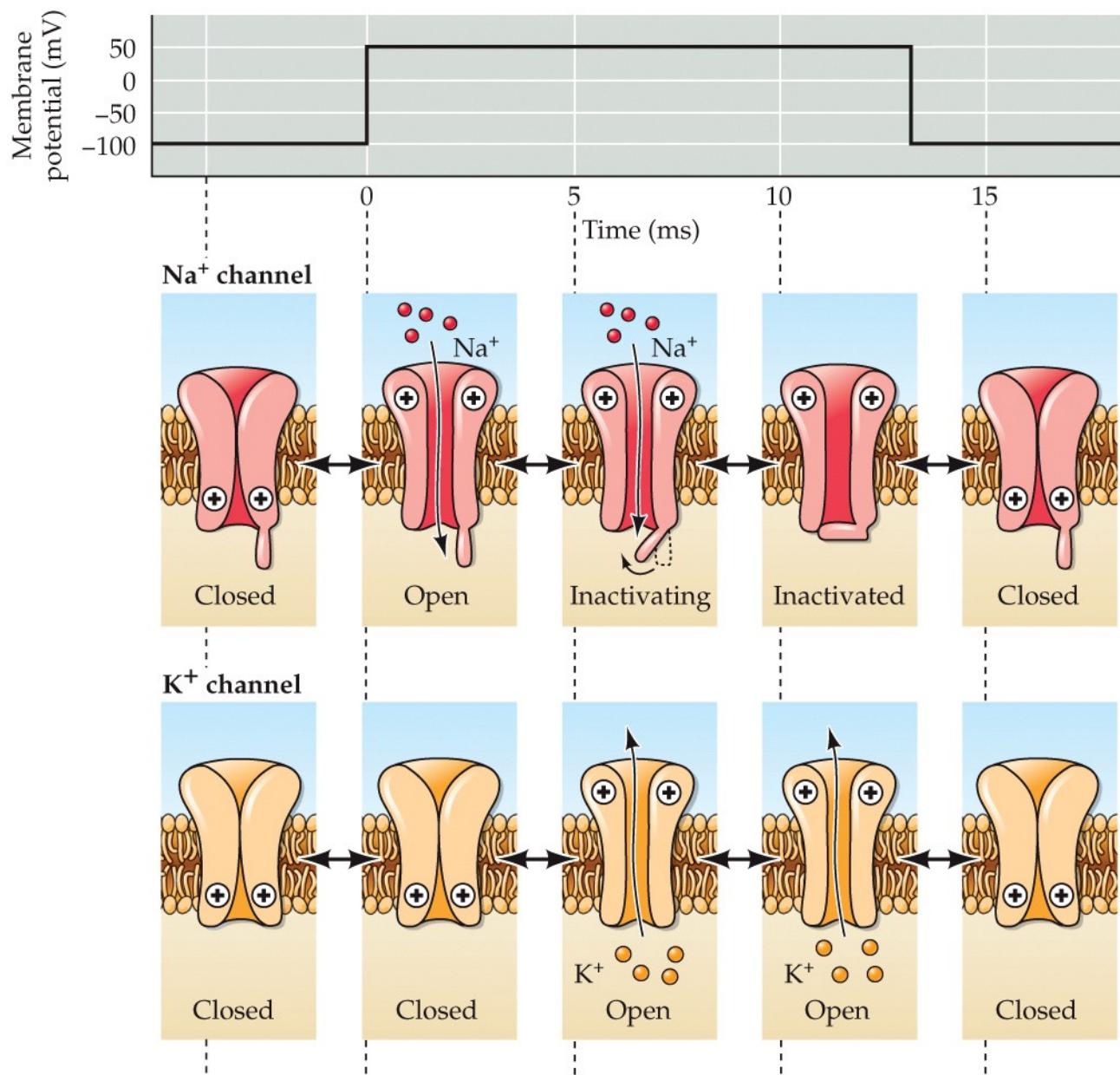


NEUROSCIENCE 6e, Figure 4.1
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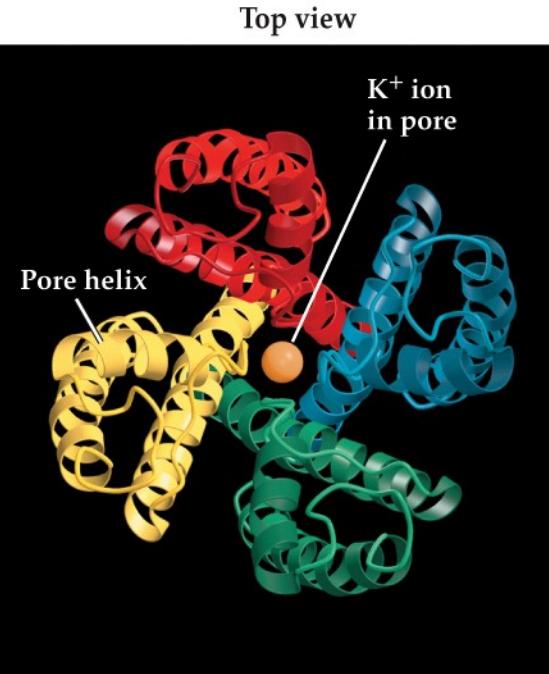
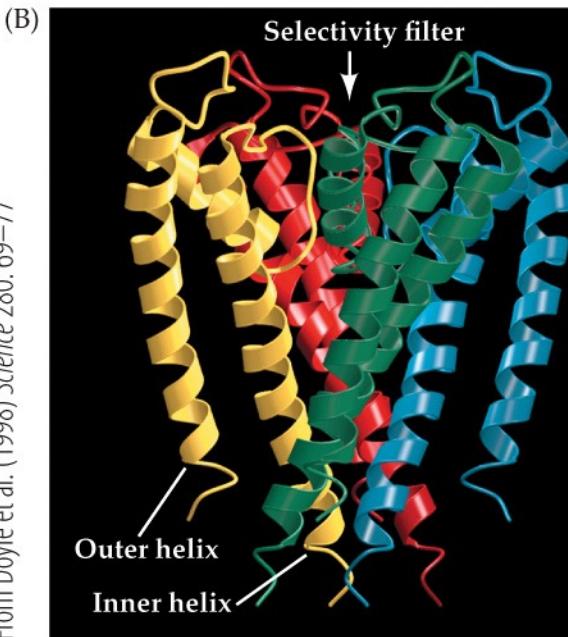
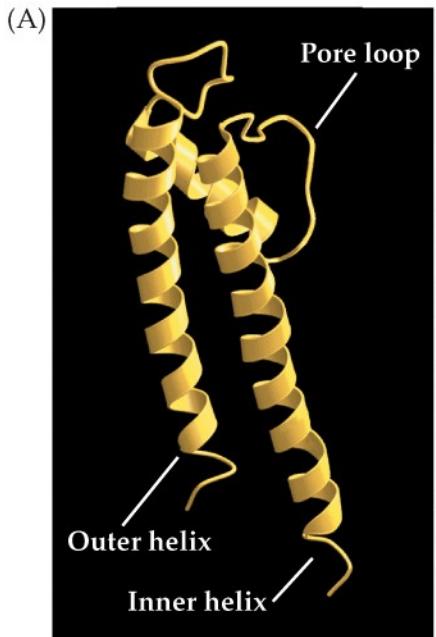
Patch clamp measurements of ion currents flowing through single K⁺ channels in a squid giant



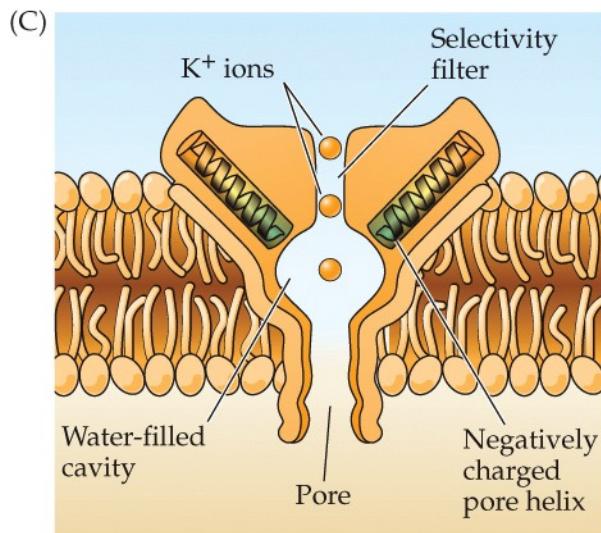
Functional states of voltage-gated Na⁺ and K⁺ channels



Structure of a simple bacterial K⁺ channel determined by crystallography



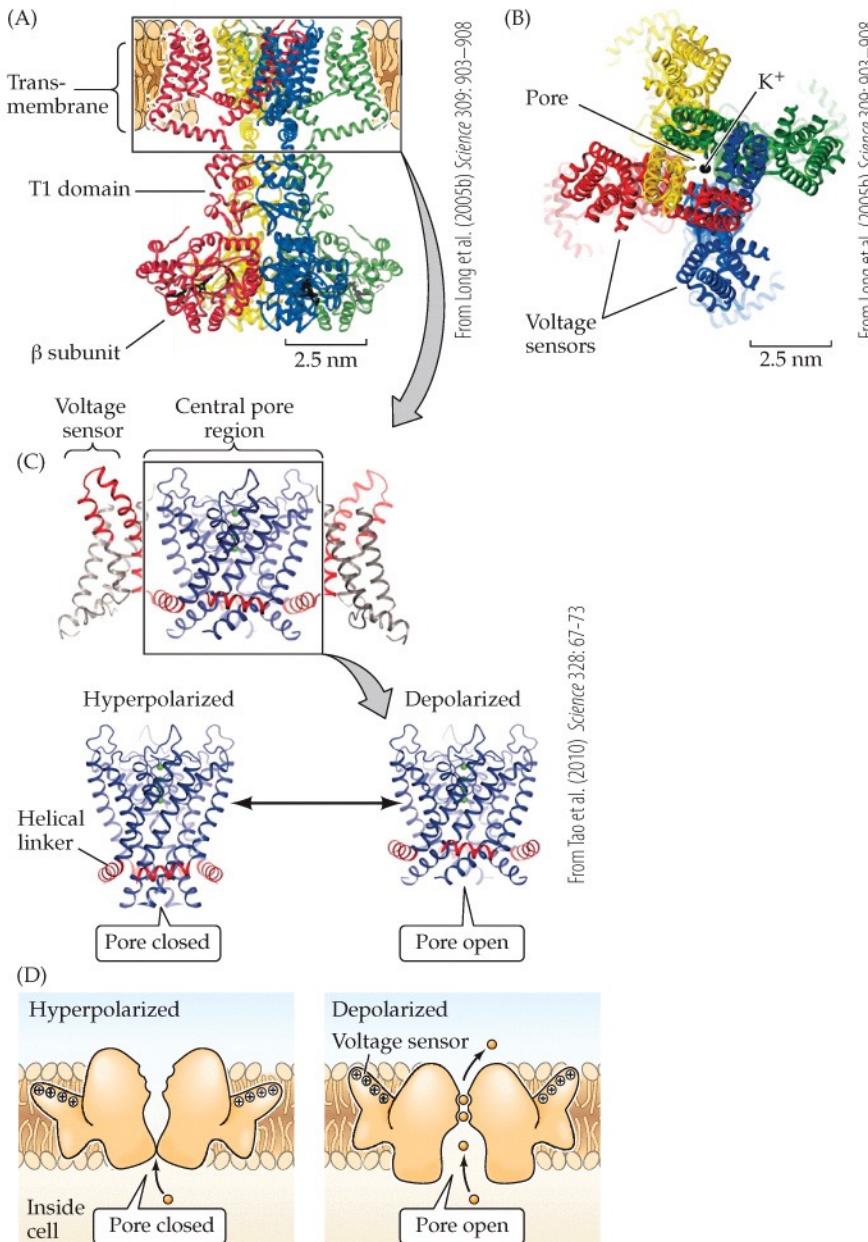
From Doyle et al. (1998) *Science* 280: 69–77



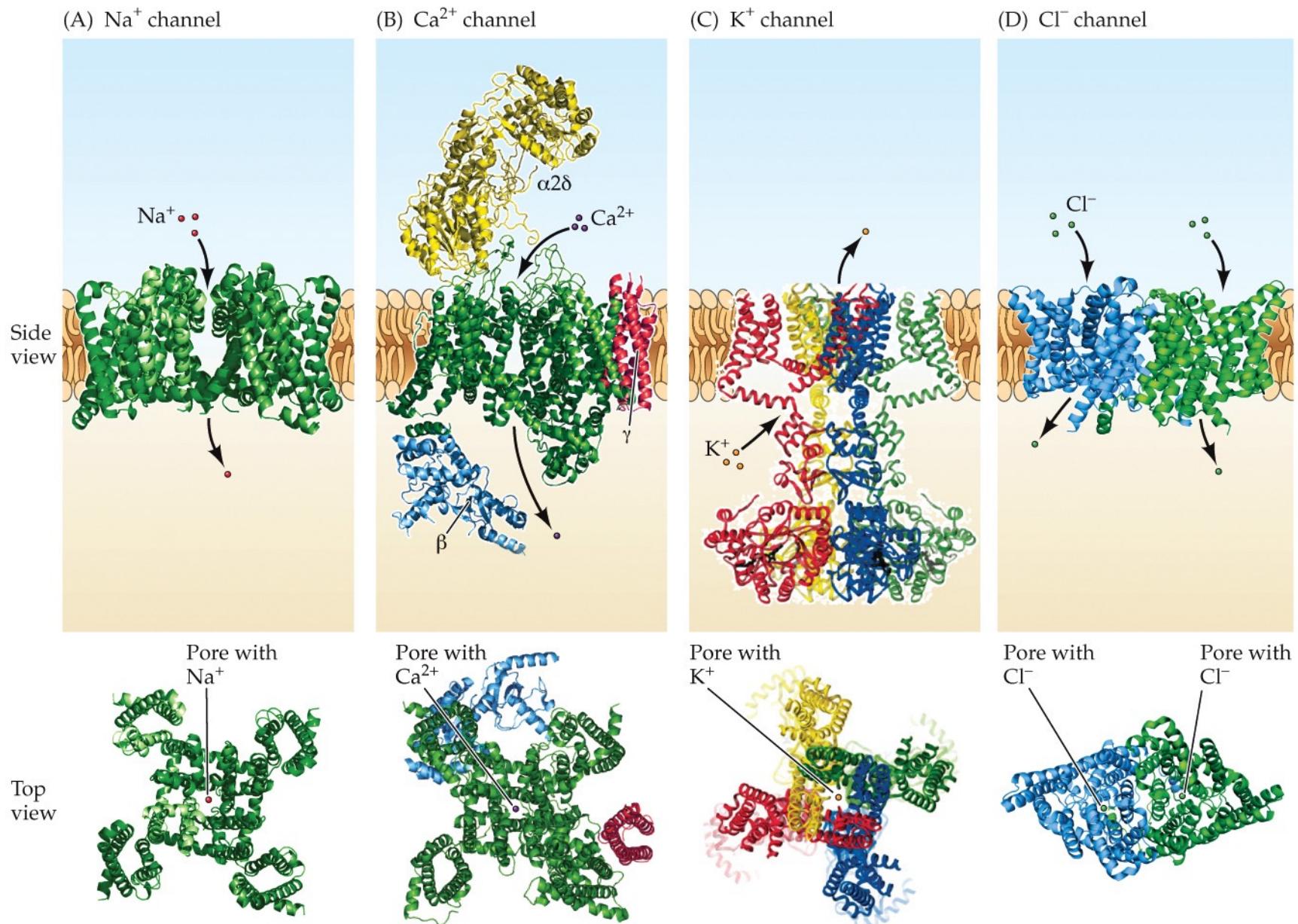
Roderick MacKinnon
Nobel Prize in
Chemistry 2003



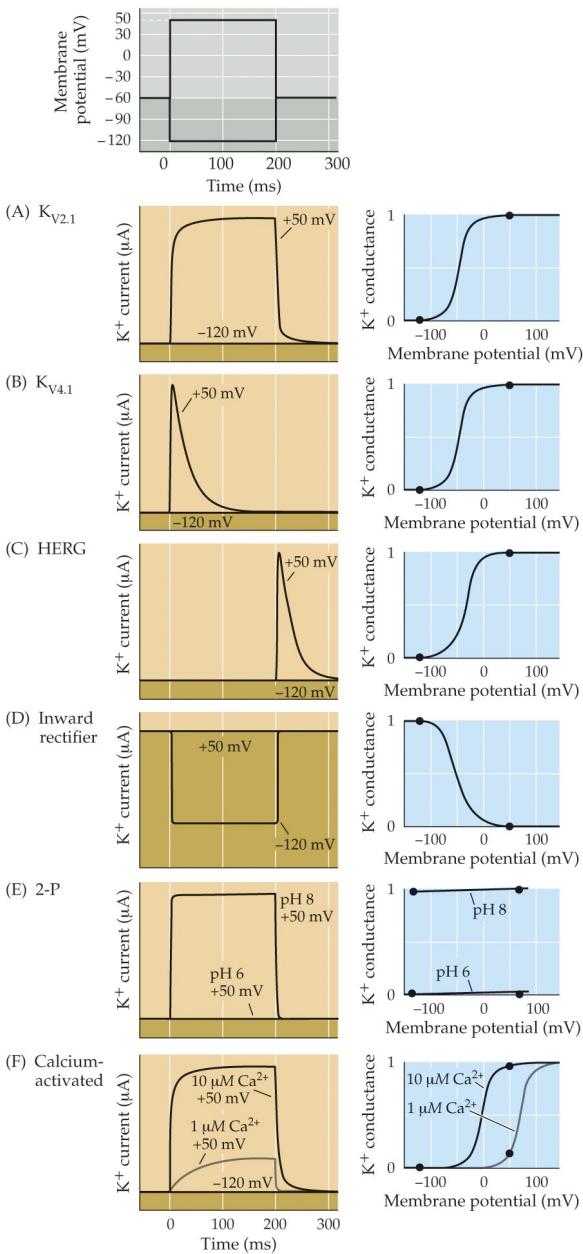
Structure of a mammalian voltage-gated K⁺ channel



Types of voltage-gated ion channels



Diverse properties of K⁺ channels

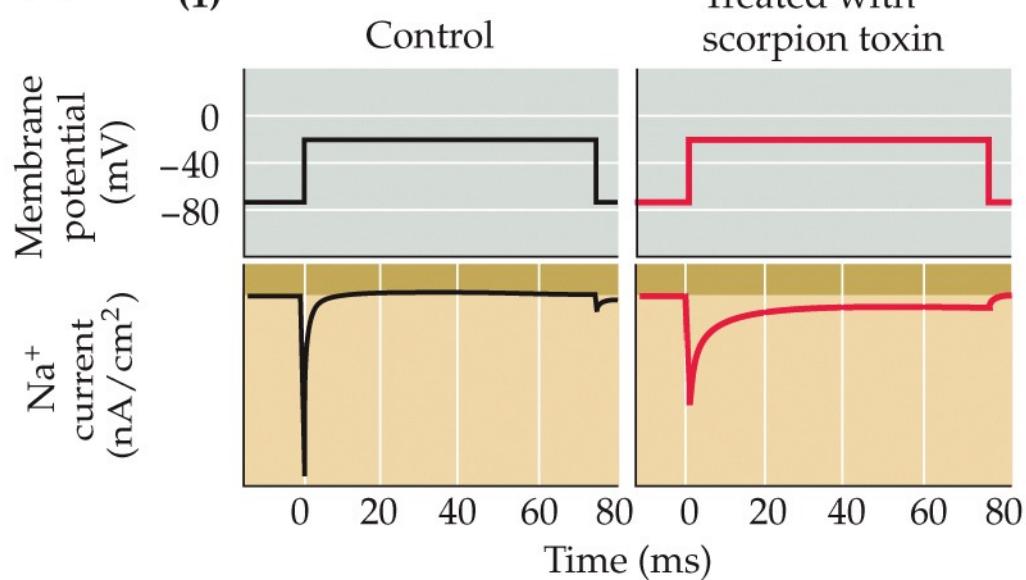


NEUROSCIENCE 6e, Figure 4.7
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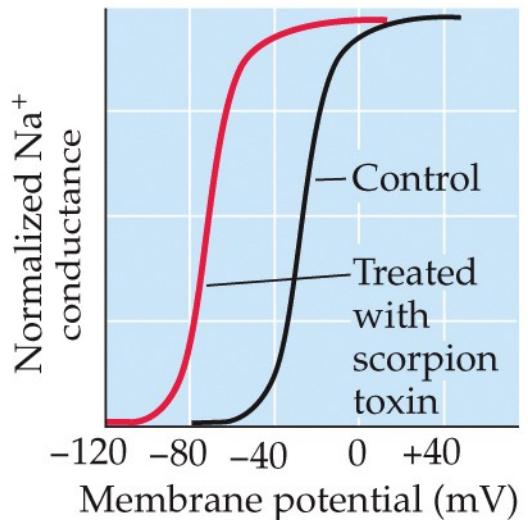
Toxins That Poison Ion Channels

(A)

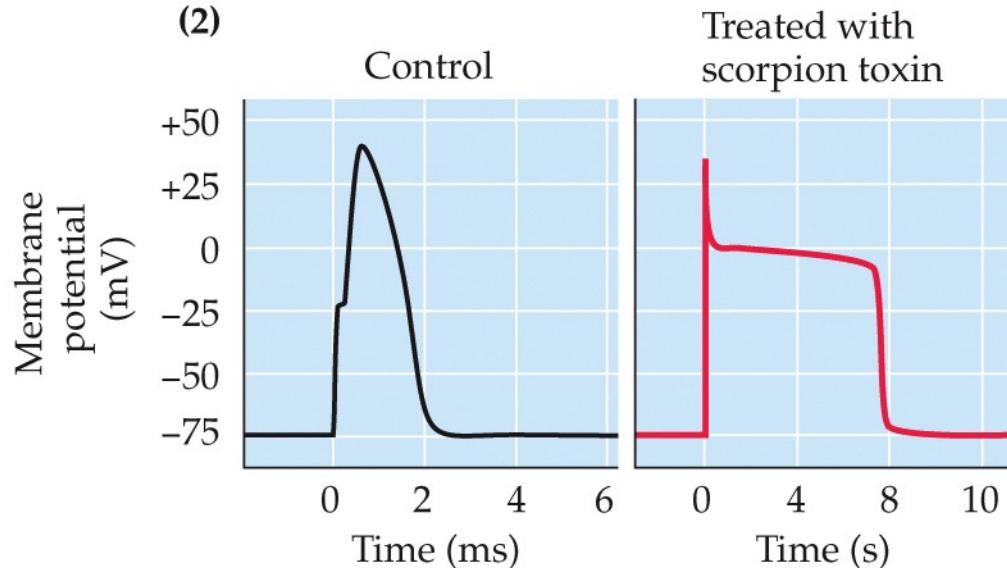
(1)



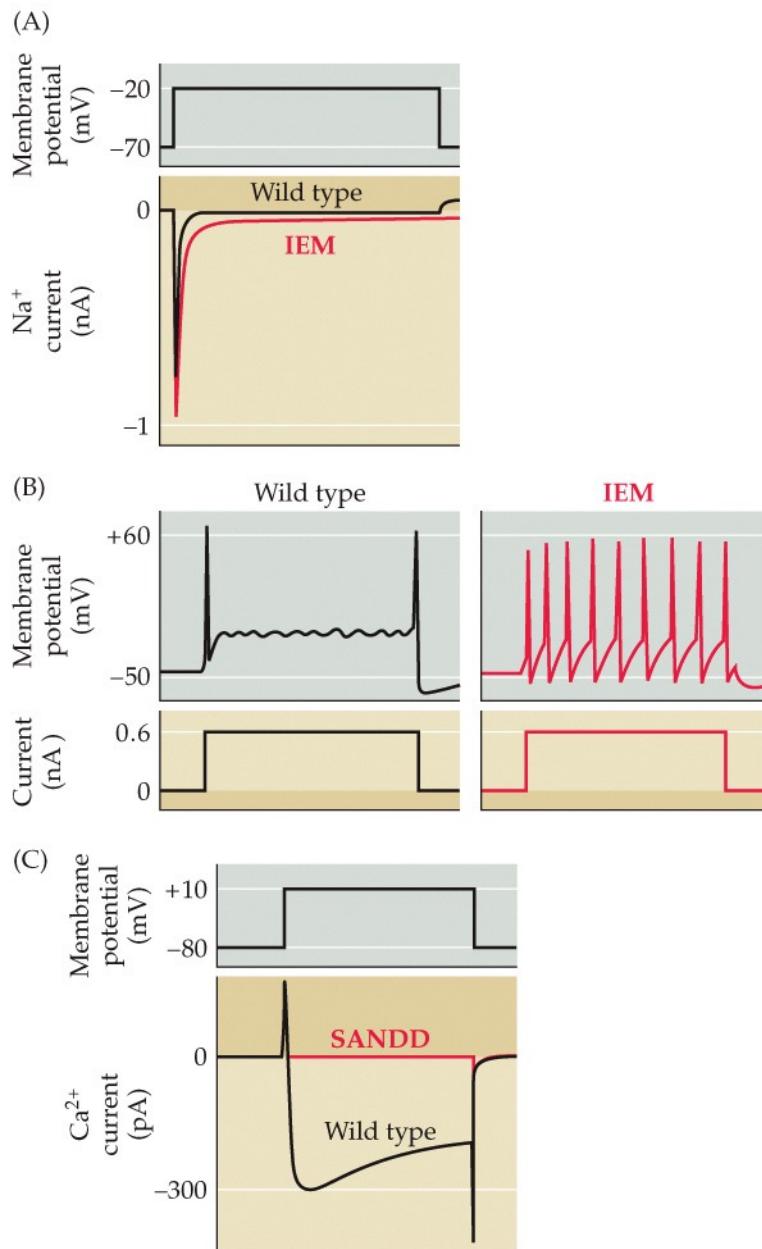
(B)



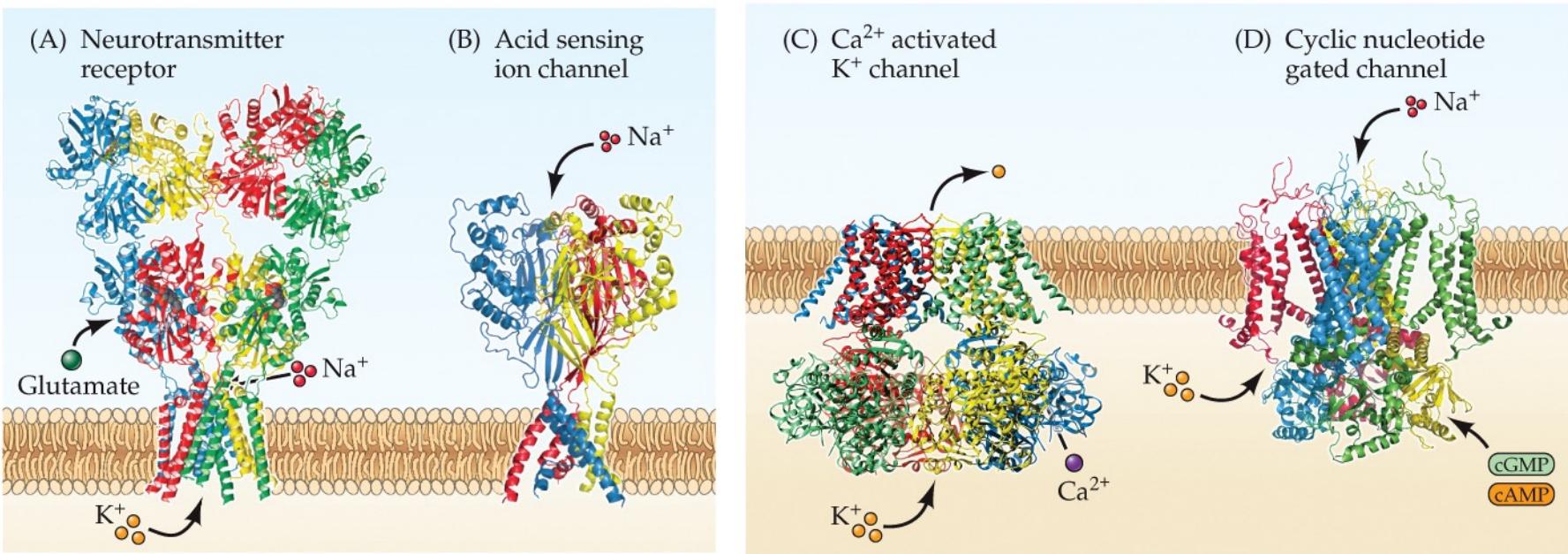
(2)



CLINICAL APPLICATIONS Neurological Diseases Caused by Altered Ion Channels



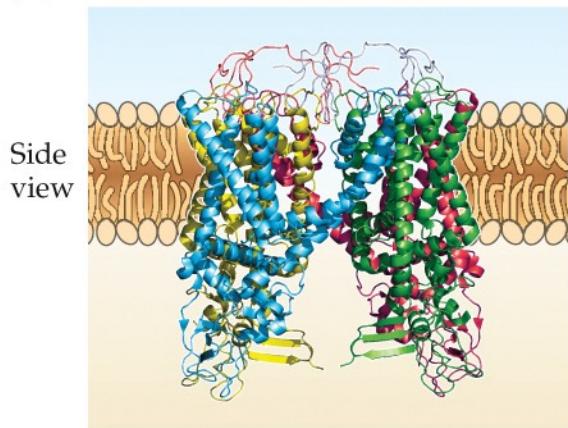
Ligand-gated ion channels



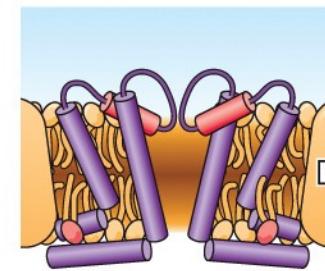
NEUROSCIENCE 6e, Figure 4.8
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Thermosensitive and mechanosensitive channels

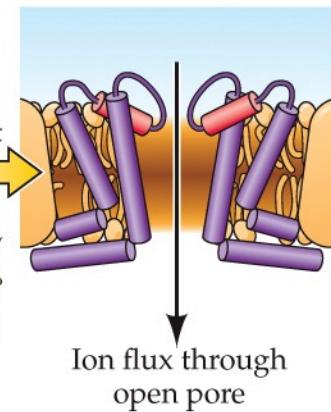
(A) Thermosensitive channel



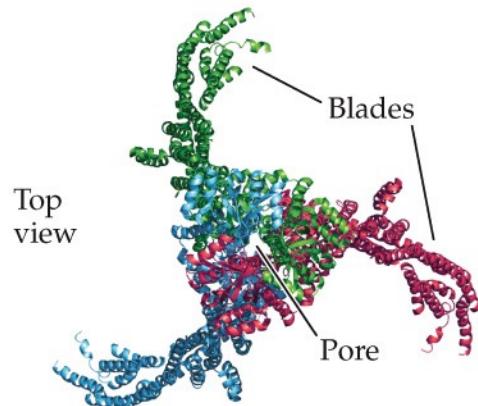
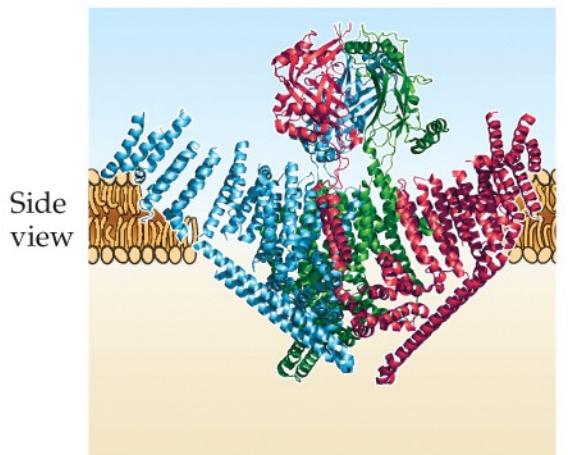
(B) Channel closed



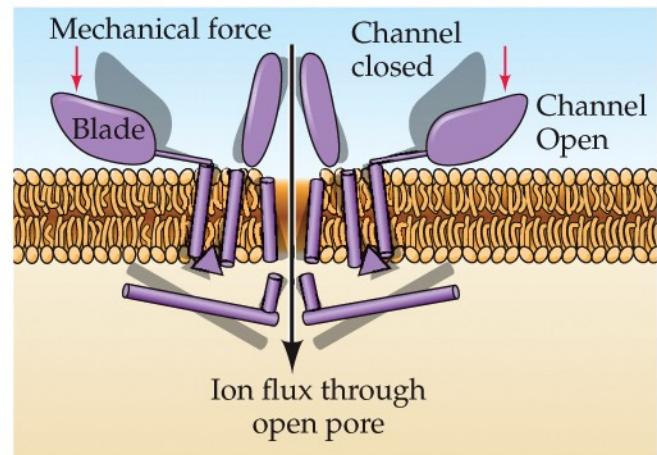
Channel open



(C) Mechanosensitive channel

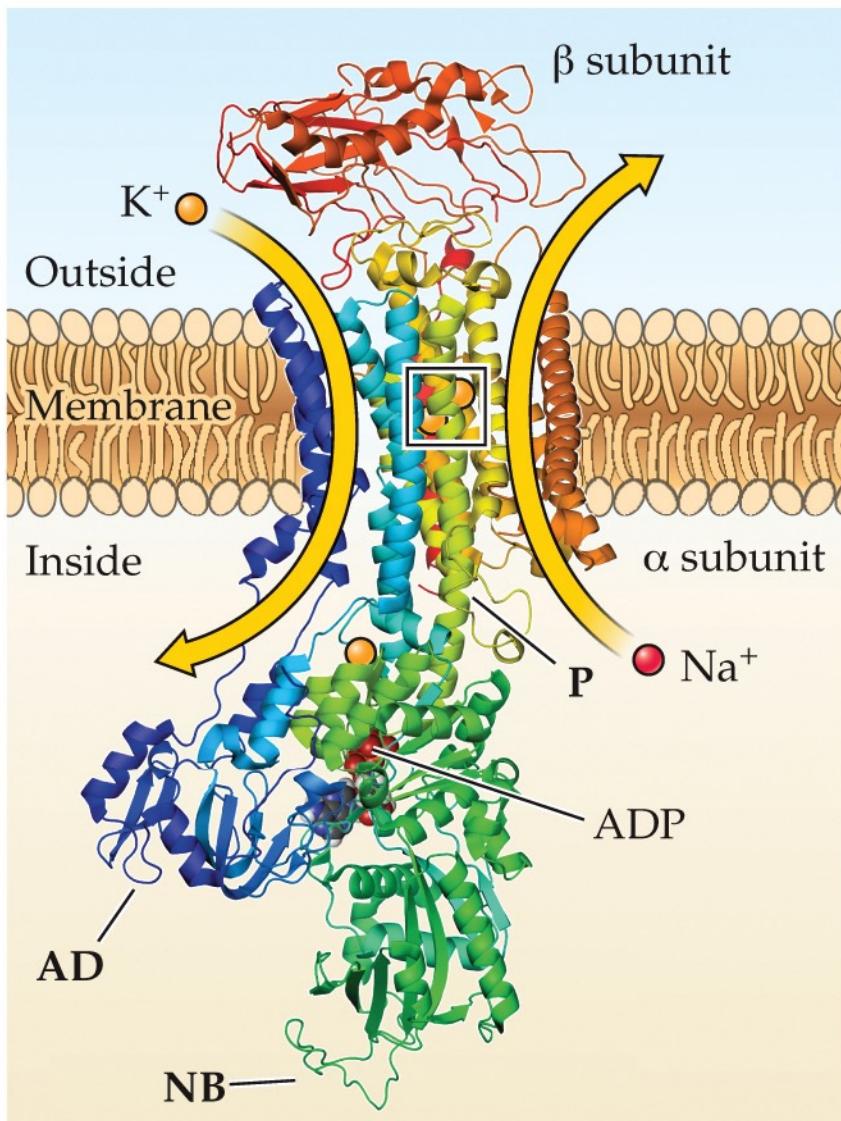


(D)

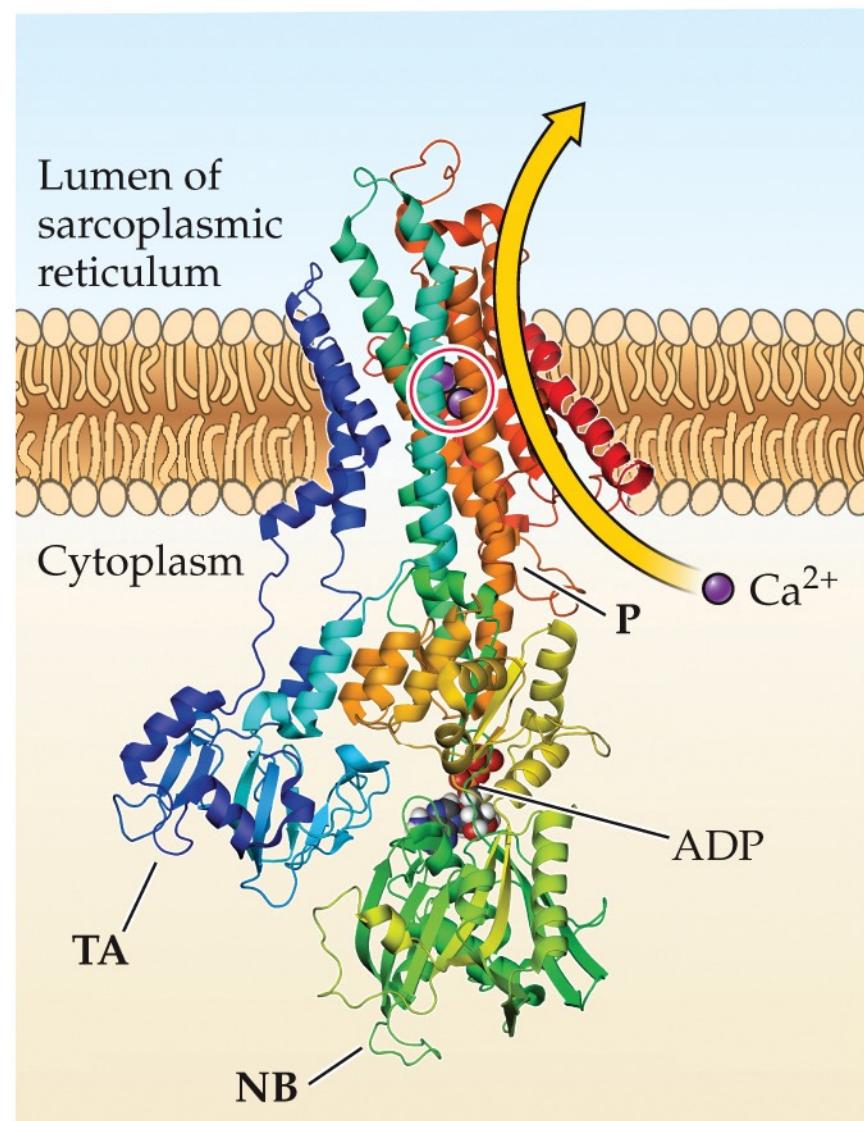


Examples of ATPase pumps

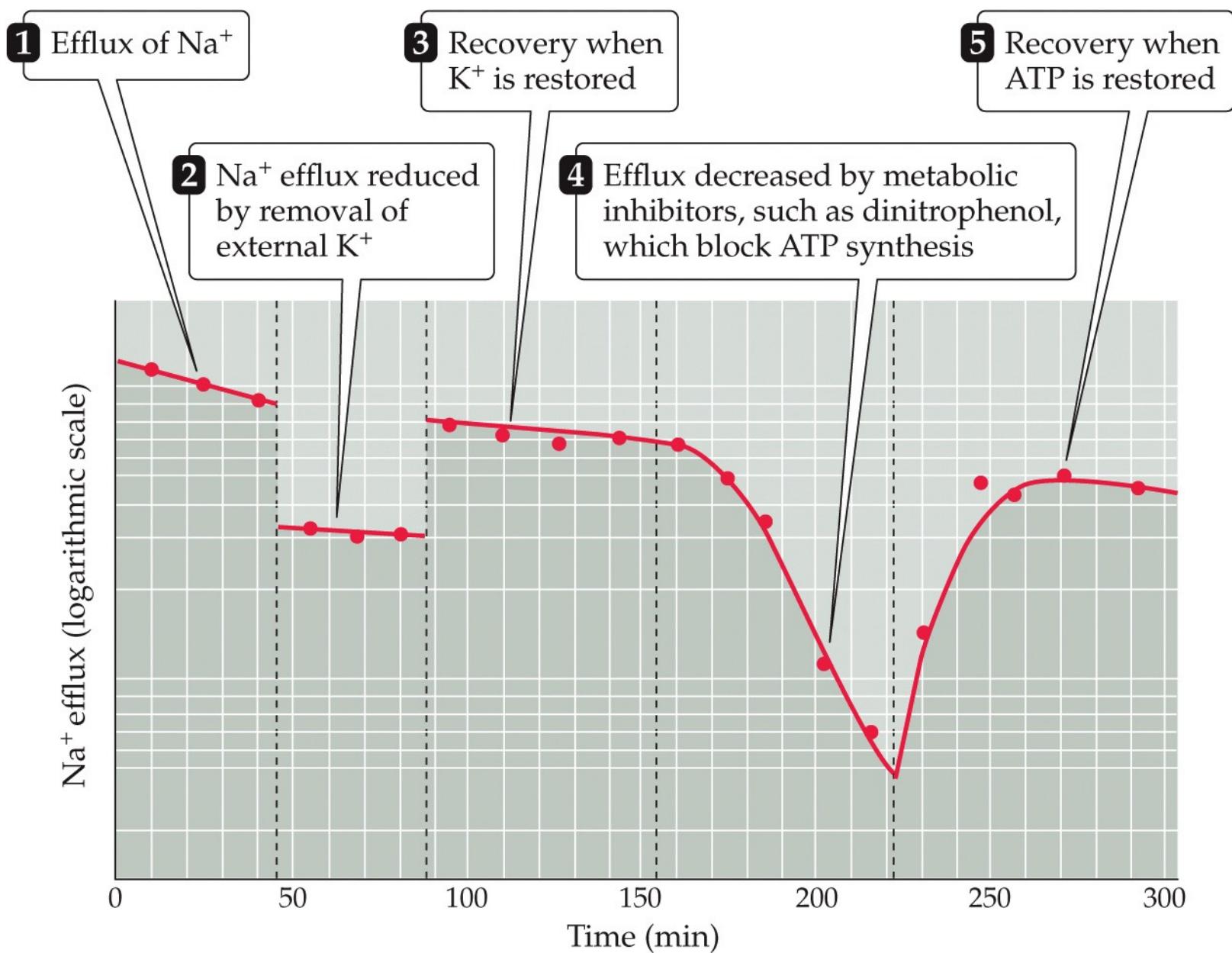
(A) Na^+/K^+ pump



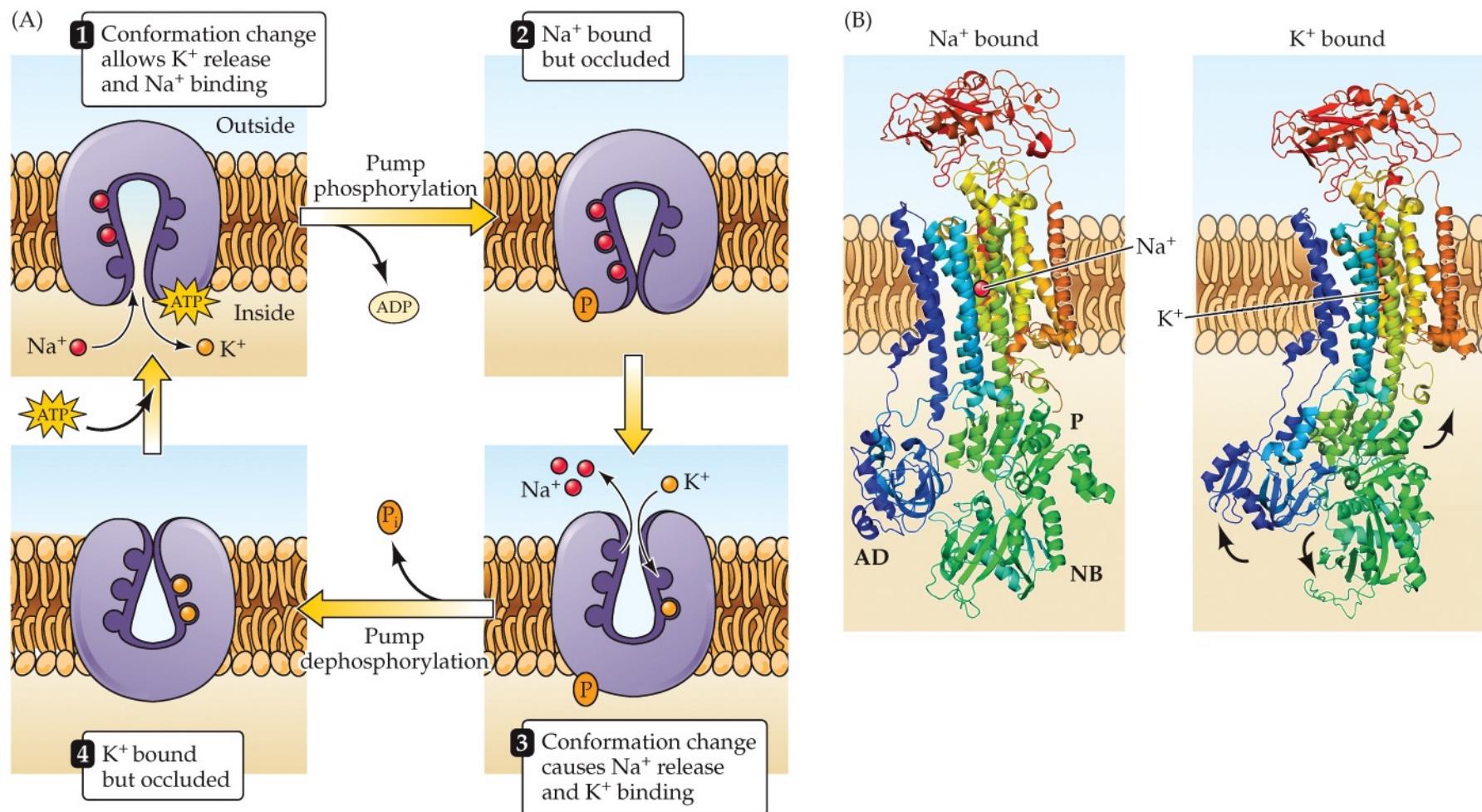
(B) Ca^{2+} pump



Ion movements due to the Na⁺ pump



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

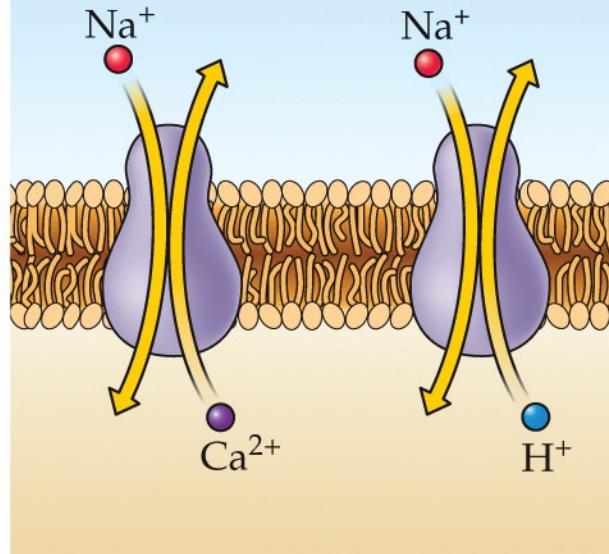


NEUROSCIENCE 6e, Figure 4.12
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Examples of ion exchangers

Antiporters

- (A) $\text{Na}^+/\text{Ca}^{2+}$ exchanger (B) Na^+/H^+ exchanger



Co-transporters

- (C) $\text{Na}^+/\text{K}^+/\text{Cl}^-$ co-transporter (D) K^+/Cl^- co-transporter (E) $\text{Na}^+/\text{neurotransmitter}$ co-transporter

