

Chem 452 - Lecture 9

Pumps and Channels

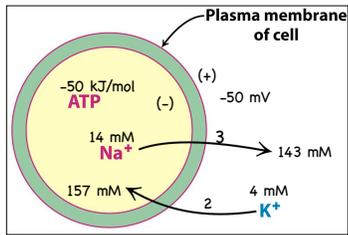
Part 2

Question of the Day: How is the action potential of nerve conduction like a human wave at a Packer game?

ATPase Pumps

• The energetics of active transport

- Na⁺/K⁺ ATPase
- Pumps 3 Na⁺ out while pumping 2 K⁺ in.



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ATPase Pumps

• The energetics of active transport

- Na⁺/K⁺ ATPase
- Pumps 3 Na⁺ out while pumping 2 K⁺ in.

$$\Delta G = RT \ln \left(\frac{c_2}{c_1} \right) + ZF\Delta V$$

$$= \left(8.314 \times 10^{-3} \frac{\text{kJ}}{\text{mol}\cdot\text{K}} \right) (310 \text{ K}) \ln \left(\frac{(0.143)^3 (0.157)^2}{(0.014)^3 (0.004)^2} \right) + (+1) \left(96.5 \frac{\text{kJ}}{\text{mol}\cdot\text{V}} \right) (+0.050 \text{ V})$$

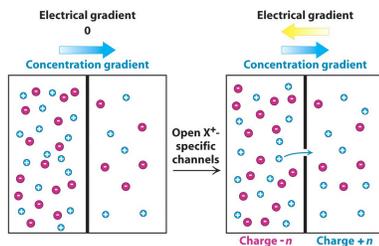
$$= 36.9 \frac{\text{kJ}}{\text{mol}} + 4.8 \frac{\text{kJ}}{\text{mol}}$$

$$= 41.7 \frac{\text{kJ}}{\text{mol}}$$

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Channels and the Action Potential

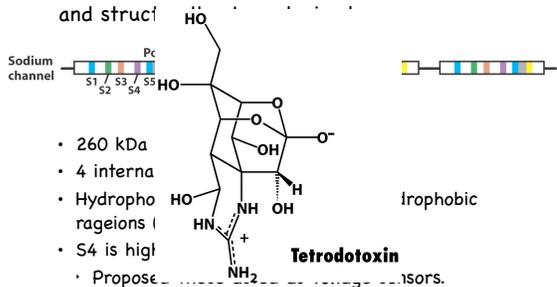
• Due to a small movement of K⁺ ions, the resting nerve fiber has a resting membrane potential of -60mV



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Channels and the Action Potential

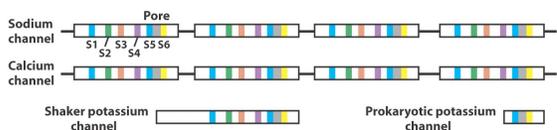
• The Na⁺ channel was the first to be isolated and structurally characterized.



- 260 kDa
- 4 internal
- Hydrophobic regions
- S4 is highly conserved
- Proposed

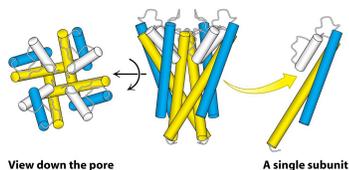
Channels and the Action Potential

• The K⁺ channel was more difficult to isolate and structurally characterize.



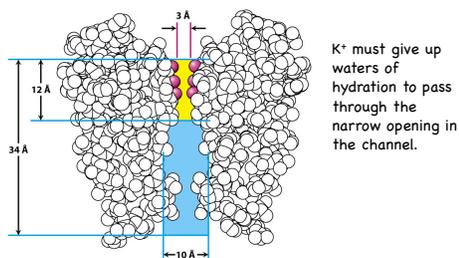
Channels and the Action Potential

• The basic channel is illustrated by bacterial K⁺ channel.



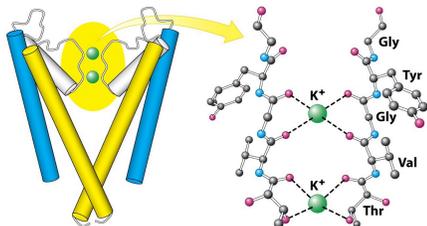
Channels and the Action Potential

• K⁺ channel illustrates ion selectivity.



Channels and the Action Potential

- + K^+ channel illustrates ion selectivity.
- The sequence Thr-Val-Gly-Tyr-Gly is highly conserved.



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Channels and the Action Potential

- + K^+ channel illustrates ion selectivity.

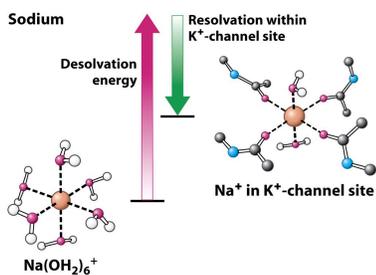
TABLE 13.1 Properties of alkali cations

Ion	Ionic radius (Å)	Hydration free energy in kJ mol^{-1} (kcal mol^{-1})
Li^+	0.60	-410 (-98)
Na^+	0.95	-301 (-72)
K^+	1.33	-230 (-55)
Rb^+	1.48	-213 (-51)
Cs^+	1.69	-197 (-47)

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Channels and the Action Potential

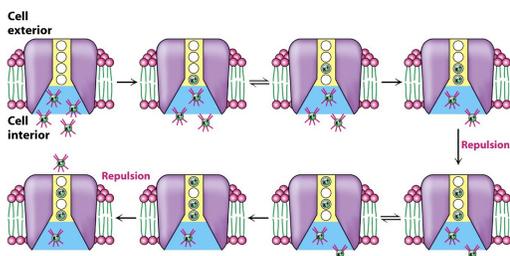
- + K^+ channel illustrates ion selectivity.



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Channels and the Action Potential

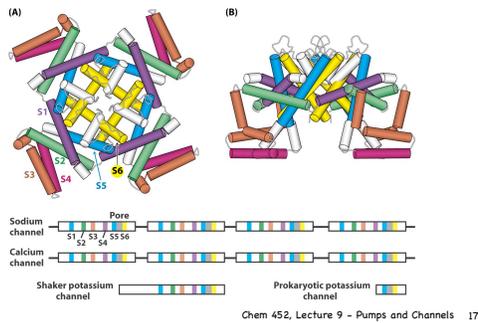
- + K^+ channel illustrates basis for rapid transport.
- Charge repulsion increases the rate of flow



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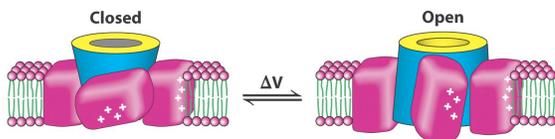
Channels and the Action Potential

• The voltage-gated K^+ channel of nerve cells.



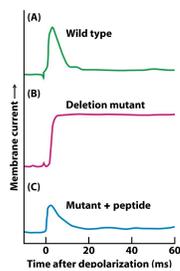
Channels and the Action Potential

• The voltage-gated K^+ channel of nerve cells.
• Voltage rise opens channel



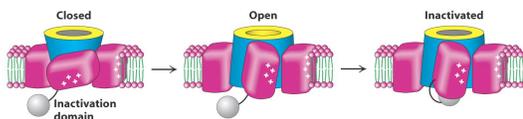
Channels and the Action Potential

• Transport is abruptly halted by a plug



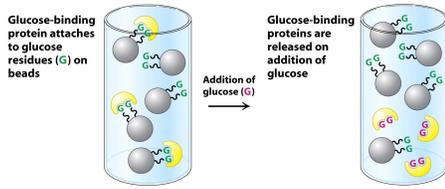
Channels and the Action Potential

• Transport is abruptly halted by a plug



Channels and the Action Potential

- † The Acetylcholine receptor can be isolated with affinity chromatography using cobratoxin as the ligand.

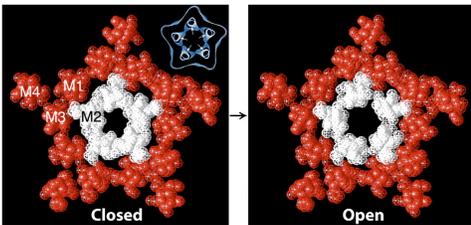


Affinity Chromatography

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Channels and the Action Potential

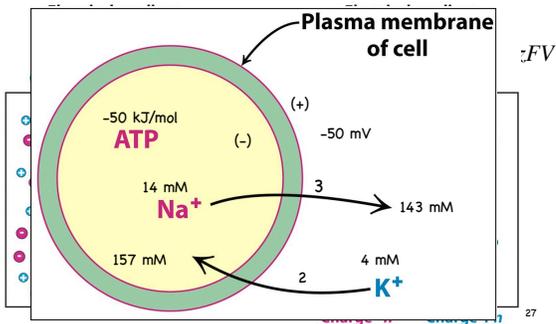
- † The binding of acetylcholine to the he acetylcholine opens the flow to Na^+ and K^+ ions.



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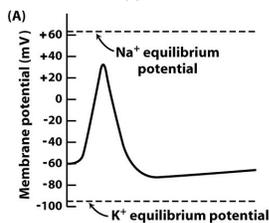
Channels and the Action Potential

- † The resting, equilibrium potential is -60mV .



Channels and the Action Potential

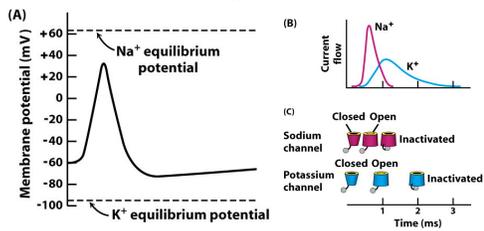
- † The binding of acetylcholine to the he acetylcholine opens the flow to Na^+ and K^+ ions.
- When the voltage climbs past -40 mV , the voltage-gated channels are triggered



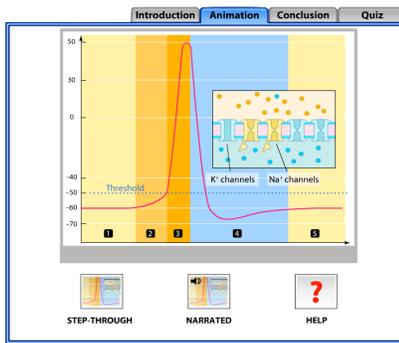
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Channels and the Action Potential

- The binding of acetylcholine to the receptor opens the flow to Na^+ and K^+ ions.
- When the voltage climbs past -40 mV, the voltage-gated channels are triggered

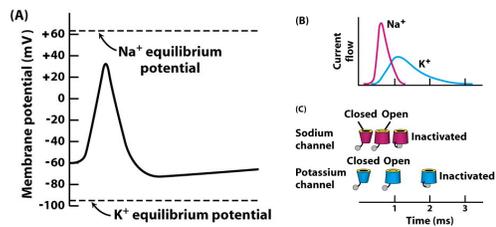


Channels and the Action Potential



Channels and the Action Potential

- Transport is abruptly halted by a plug



Next up

- Lecture 10, Signal Transduction and Sensory Systems. (Chapter 14 & 33)