CCIB
The Seventh Block

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Core Course in Integrative Biosciences (BIMS 6000)

CCIB: the Seventh Block

- Complete Block Seven Syllabus
- By day:
  - **Thursday, November 16 (1st Beenhakker Lecture):** Ion Channels, Pumps and the Membrane Potential
    - Powerpoint Slides for Channel Lecture (or as a PDF)
    - Recorded Lecture
  - **Friday, November 17 (2nd Beenhakker Lecture):** Synaptic Transmission
    - Powerpoint Slides for Transmission Lecture (or as a PDF)
    - Recorded Lecture
  - **Friday, November 17 (3rd Beenhakker Lecture):** Neural Circuits
    - Powerpoint Slides for Circuit Lecture (or as a PDF)
    - Recorded Lecture
- A peaceful afternoon of neurophysiology simulations. Follow me here.

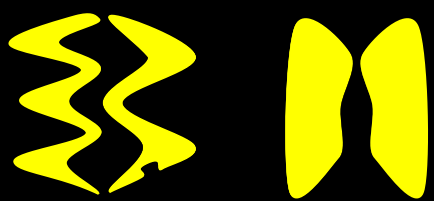
You can find the Beenhakker Lab in 5058 Pinn Hall
The University of Virginia School of Medicine
Charlottesville, VA 22908

Questions? Email Mark: markbeen@virginia.edu

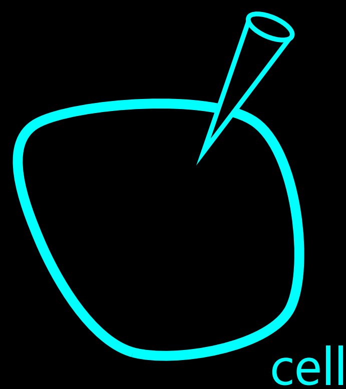
http://beenhakkerlab.org/

Ion Channels & Cellular Electrophysiology

Mark Beenhakker
markbeen@virginia.edu



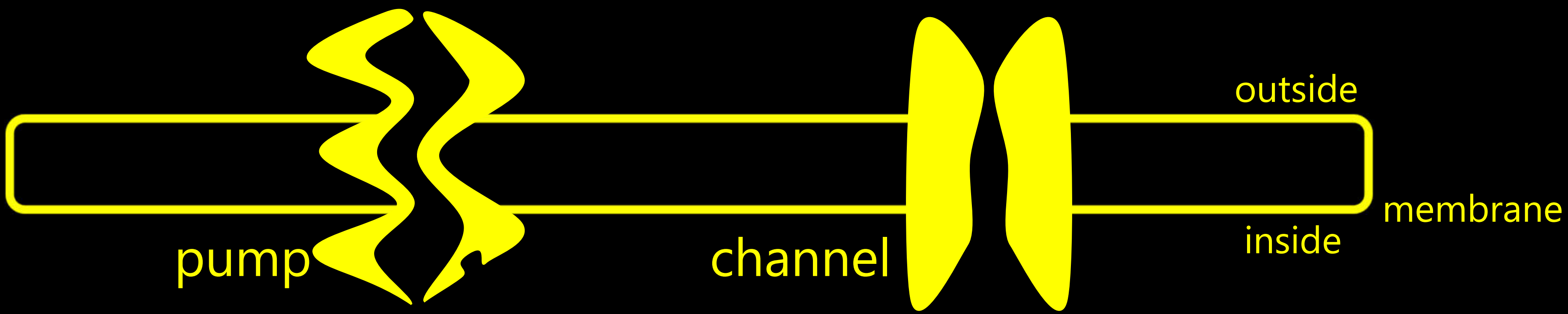
pumps & channels



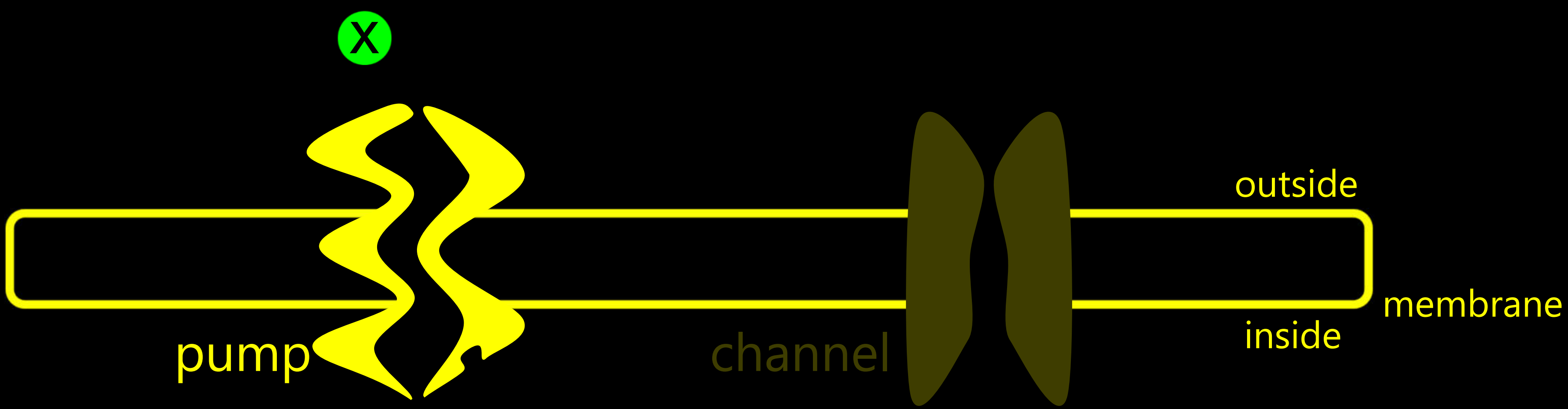
membrane voltage

electrical signals

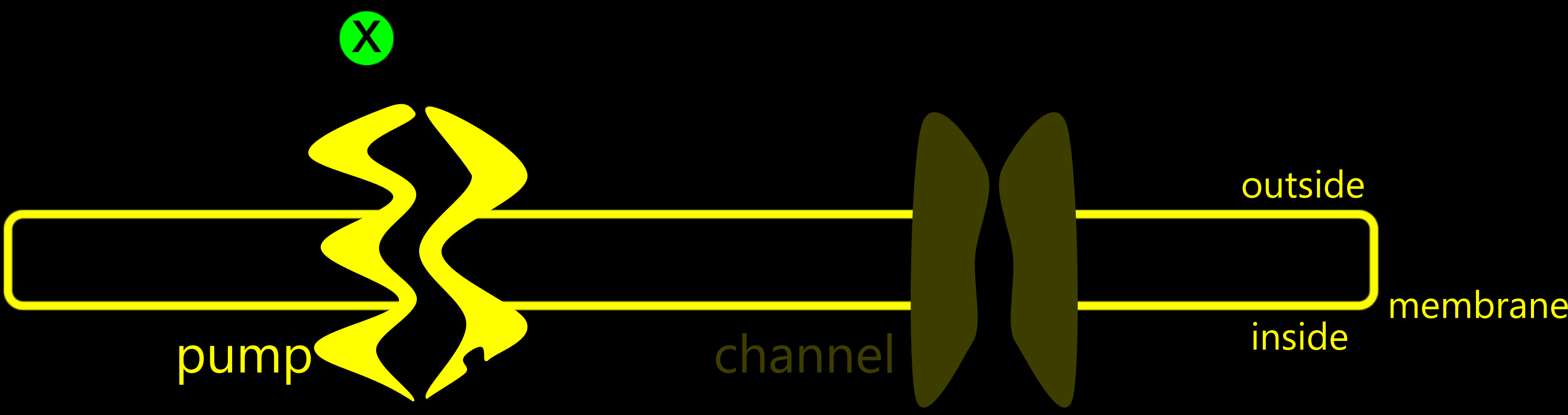
Pumps & Channels



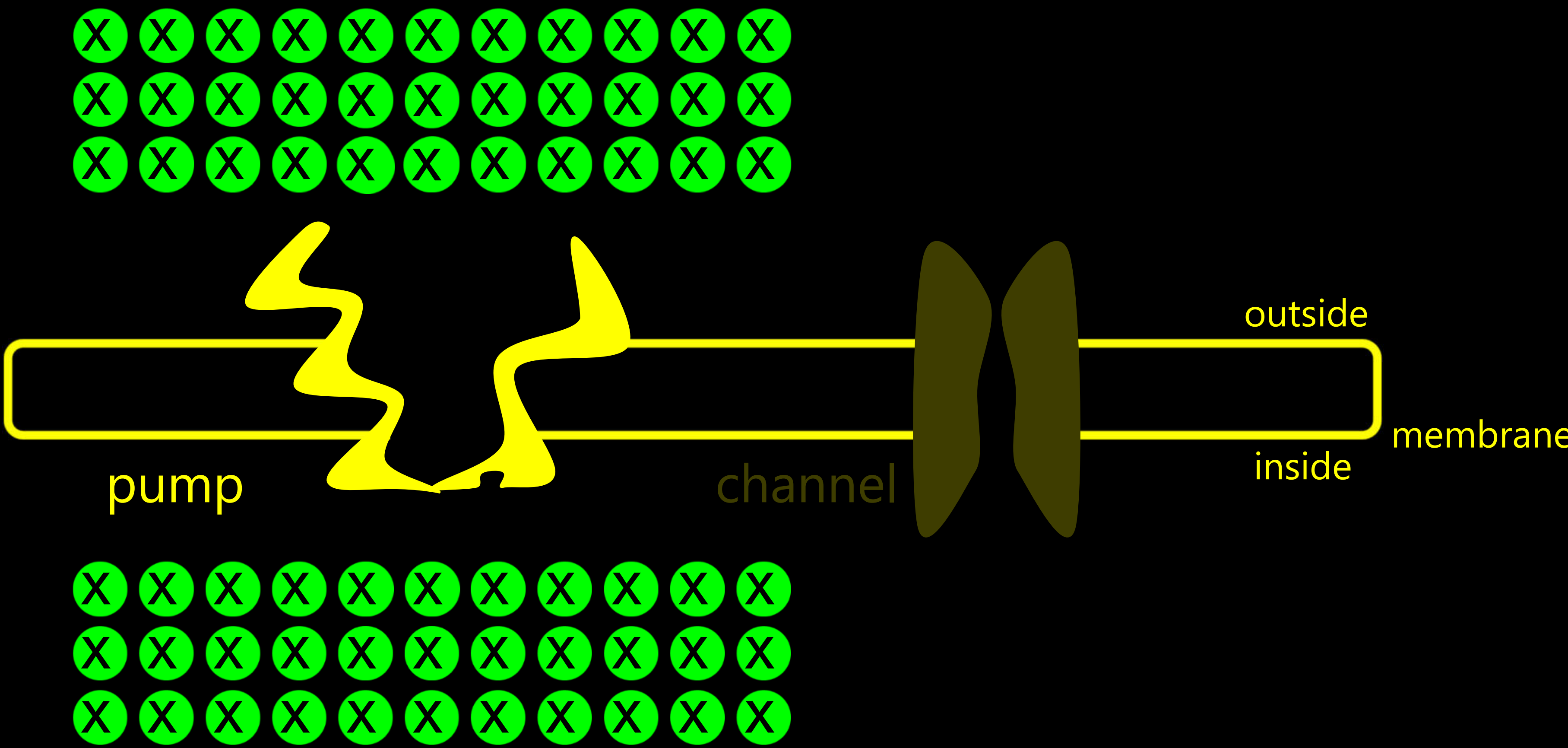
Pumps & Channels



Pumps & Channels

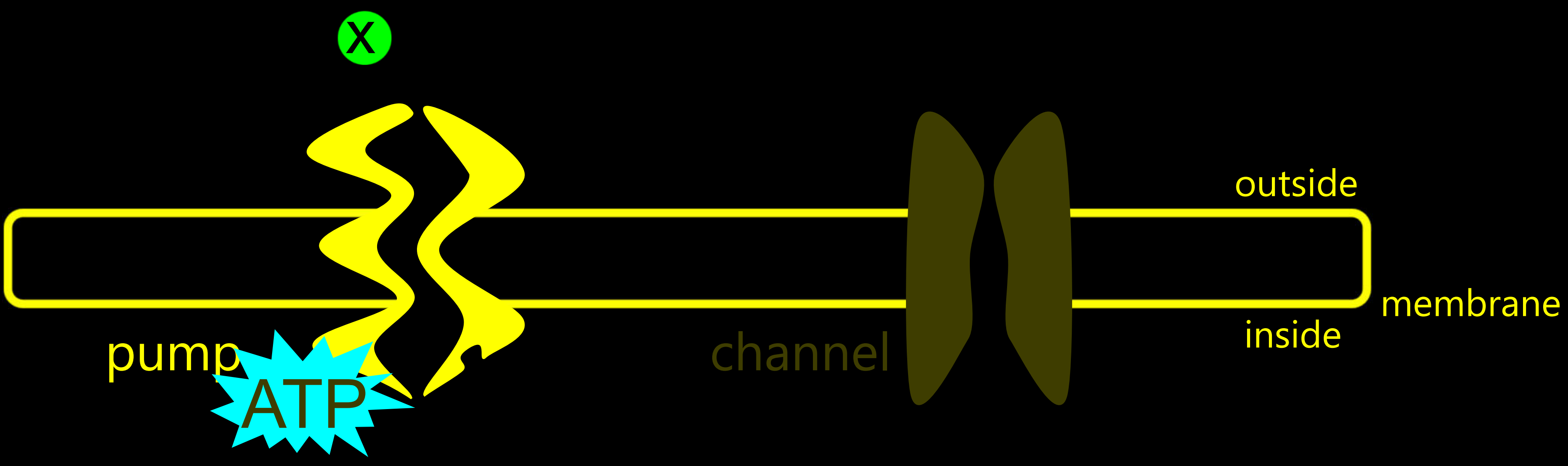


Pumps & Channels



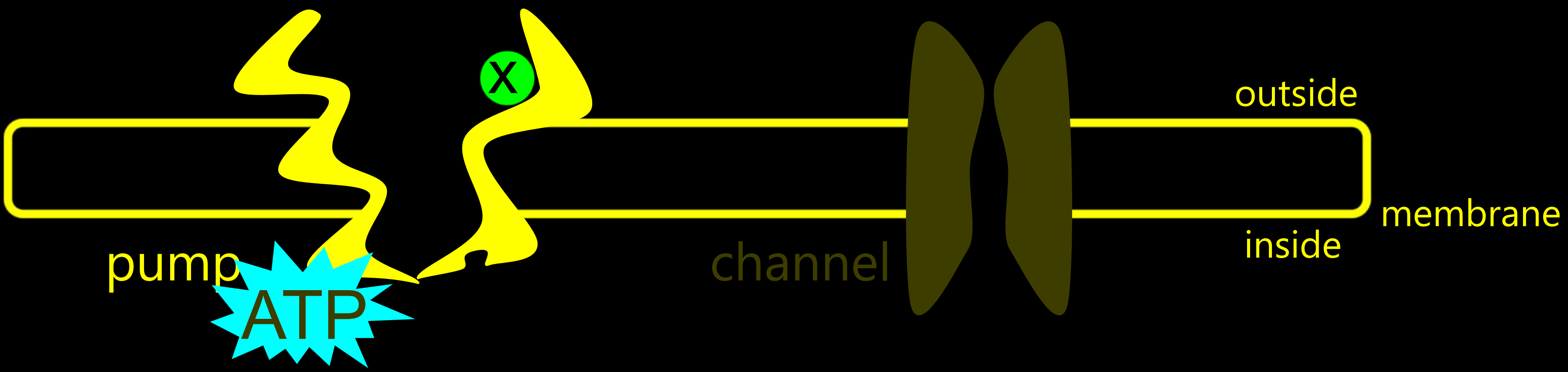
passive transport
active transport

Pumps & Channels



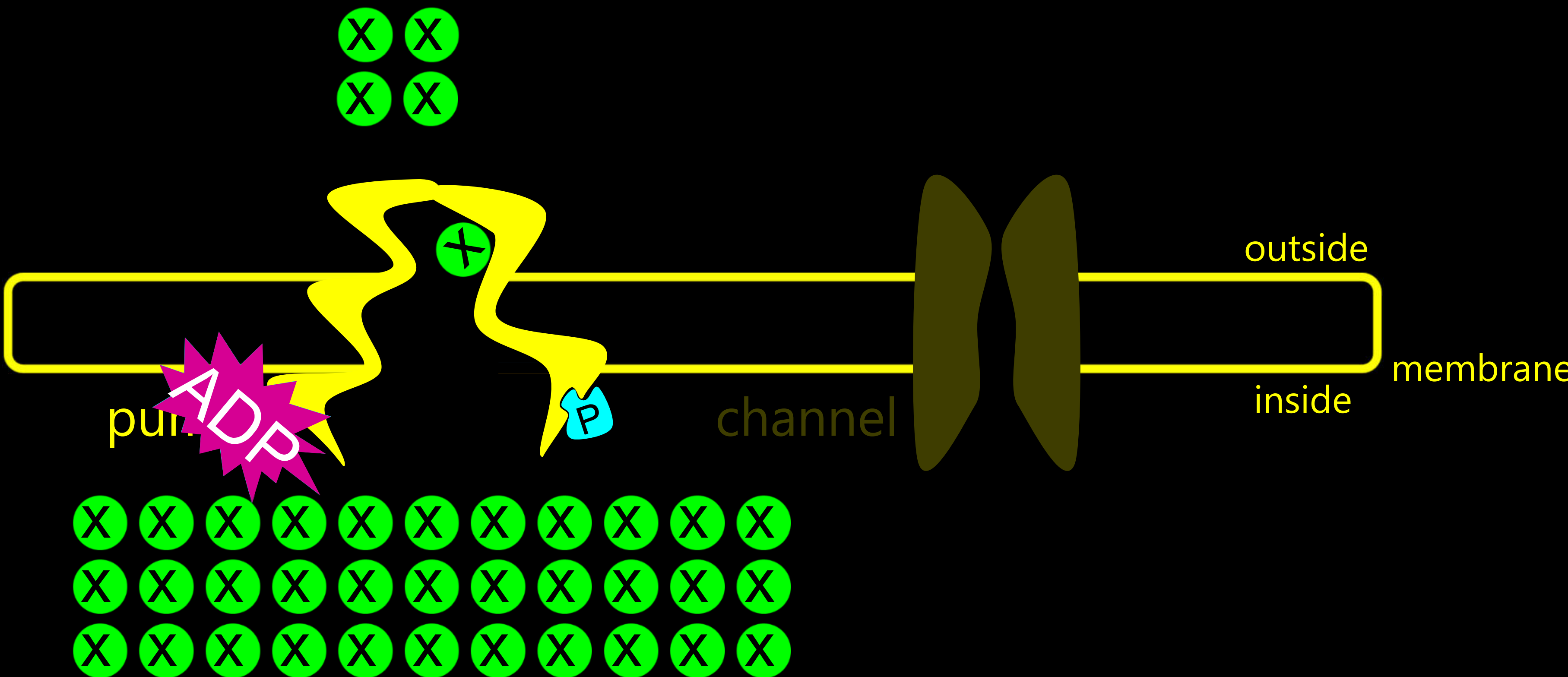
active transport

Pumps & Channels



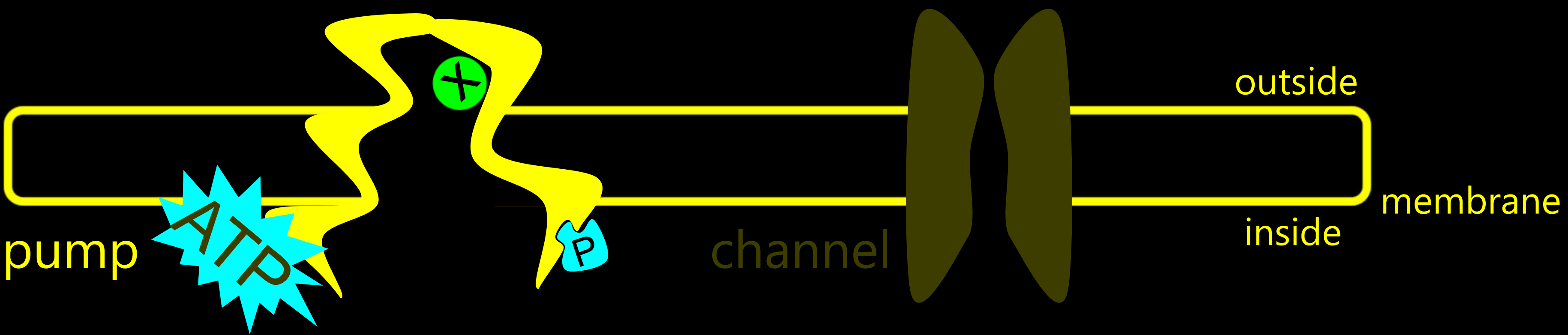
active transport

Pumps & Channels



active transport

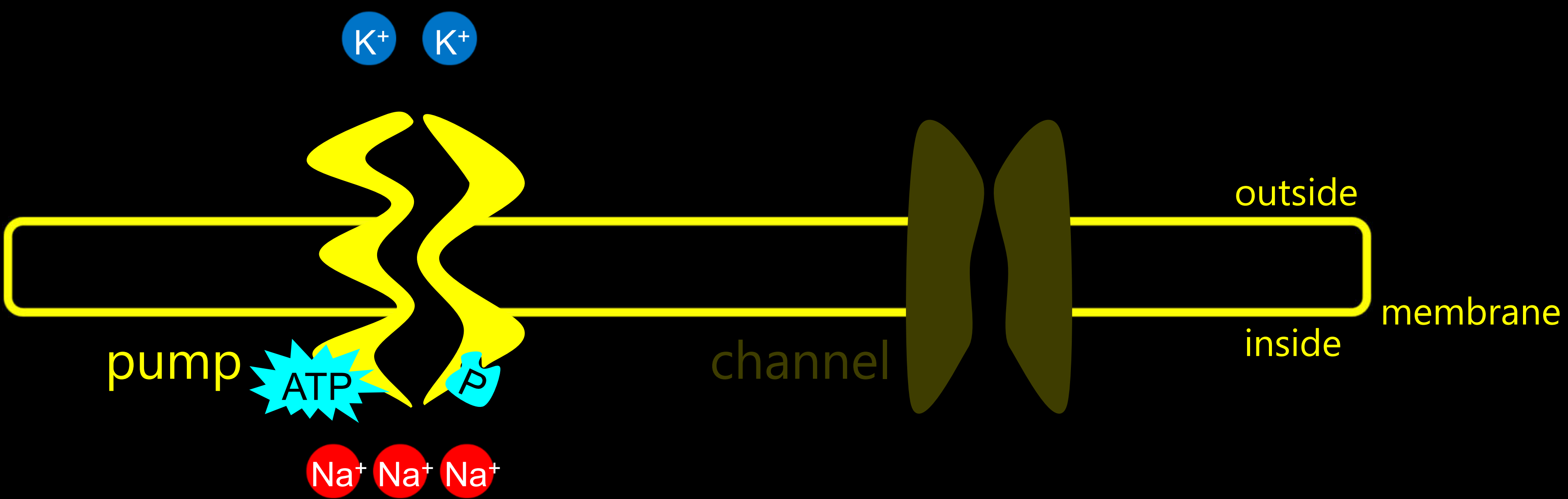
Pumps & Channels



ATP-Driven Pumps
- P-type pumps
- ABC transporters
- V-type pumps

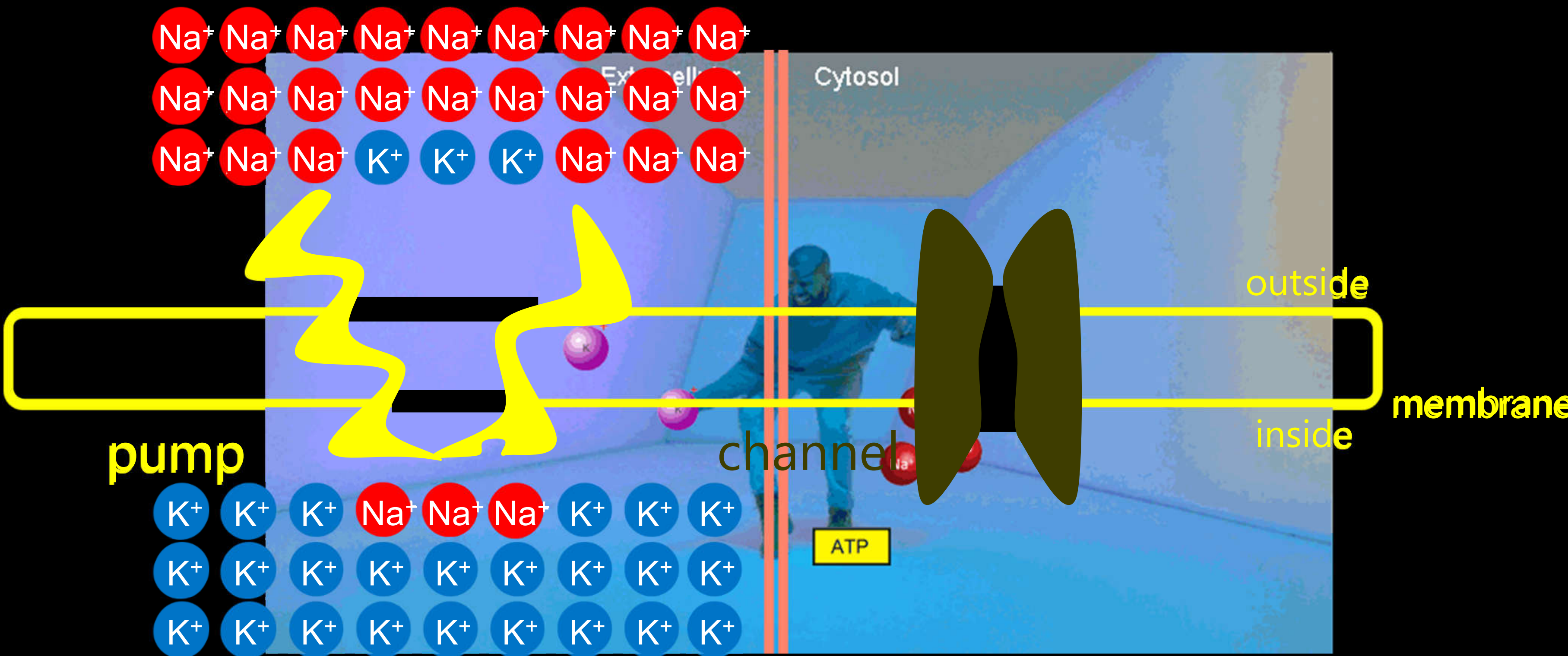
Na^+-K^+ Pump

Pumps & Channels



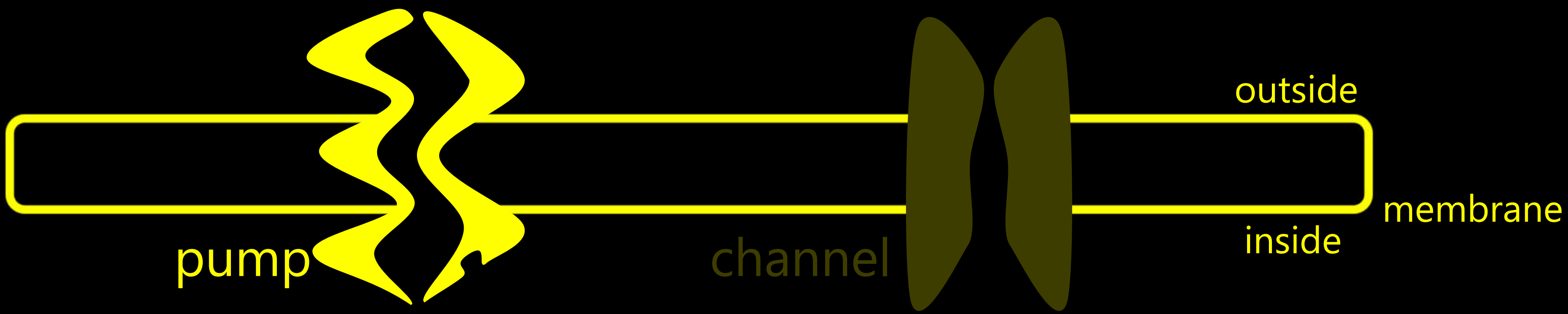
Na$^+$-K$^+$ Pump

Pumps & Channels

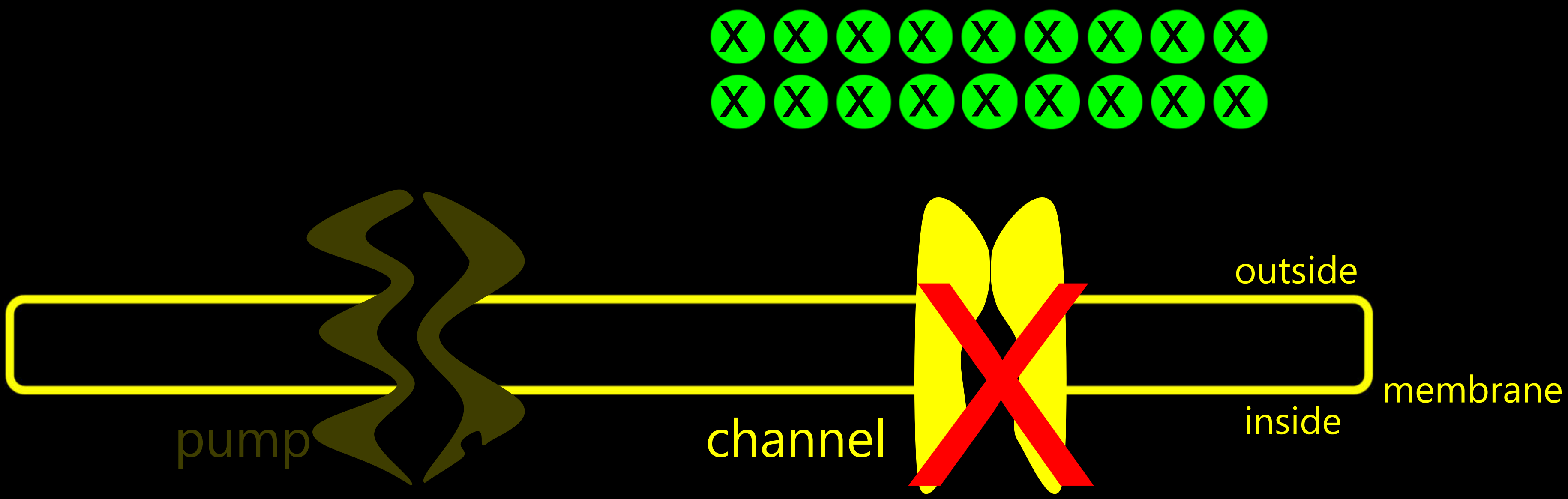


Na⁺-K⁺ Pump

Pumps & Channels



Pumps & Channels

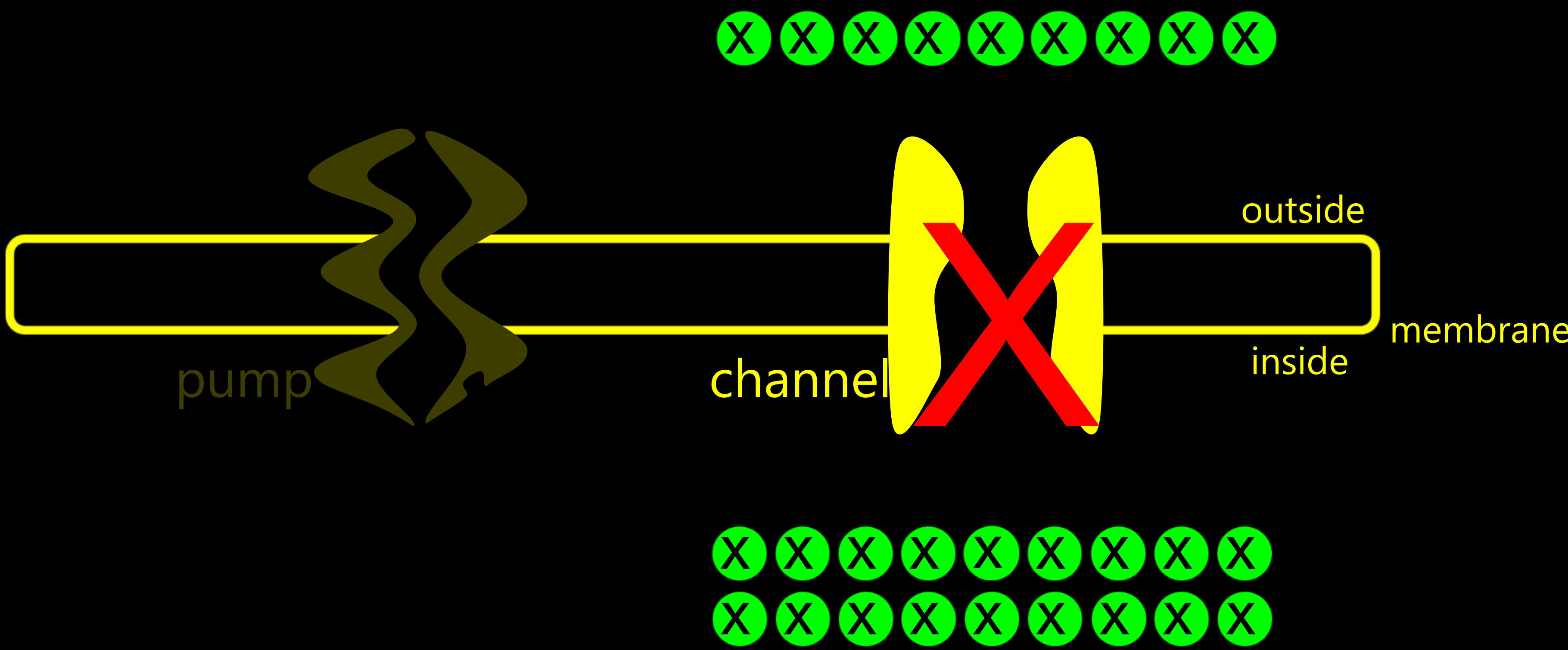


passive movement

Pumps & Channels

when will it end?

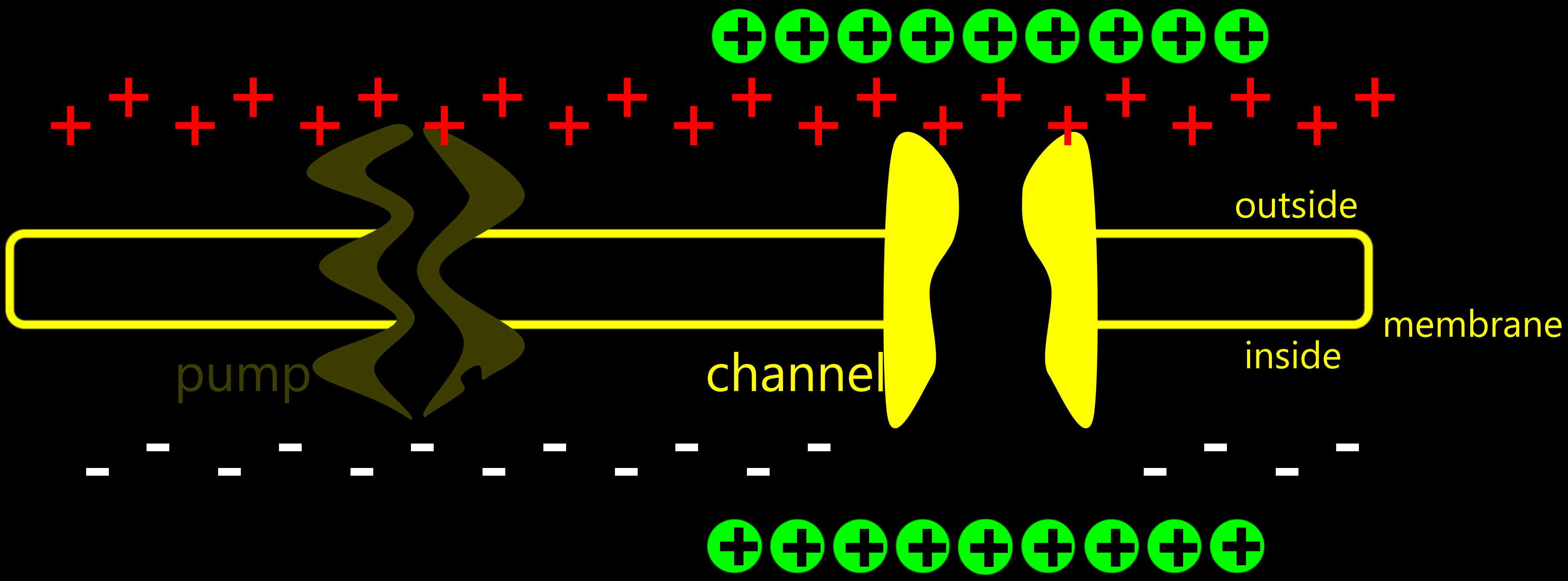
equilibrium



passive movement

Pumps & Channels

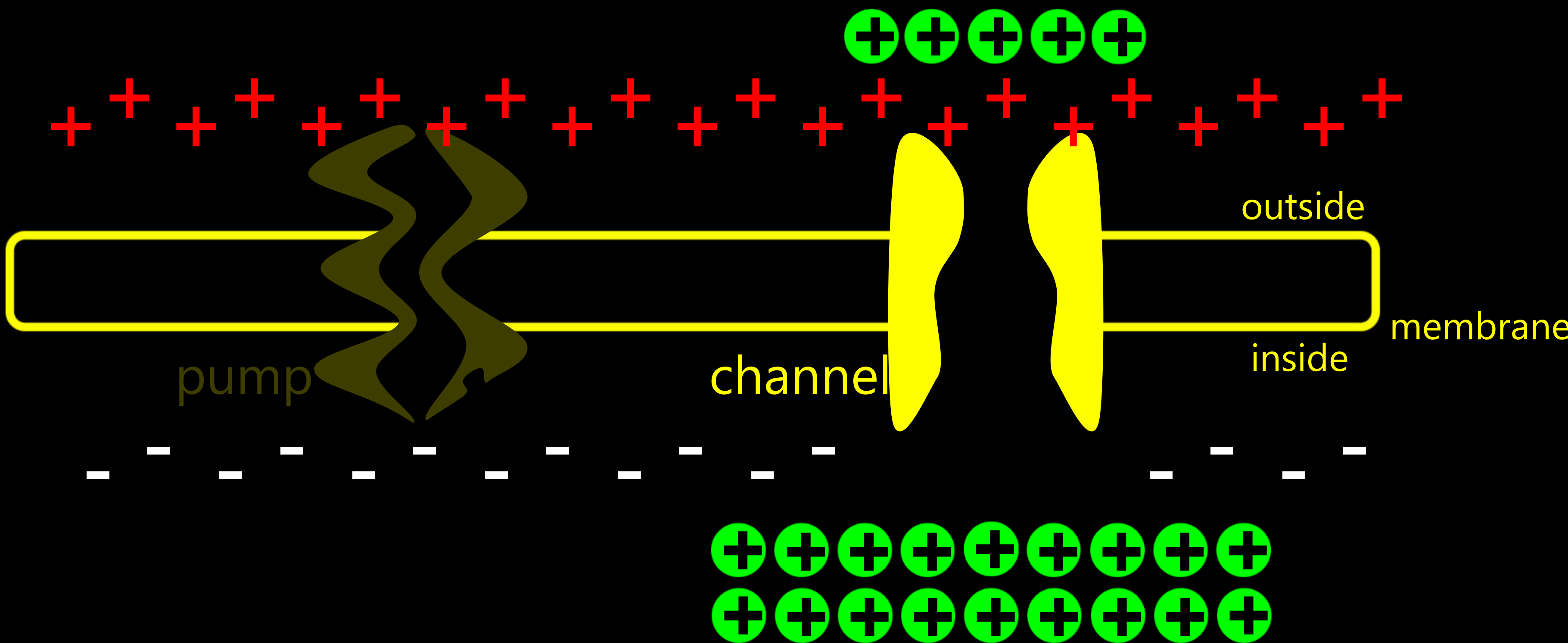
equilibrium



passive movement

Pumps & Channels

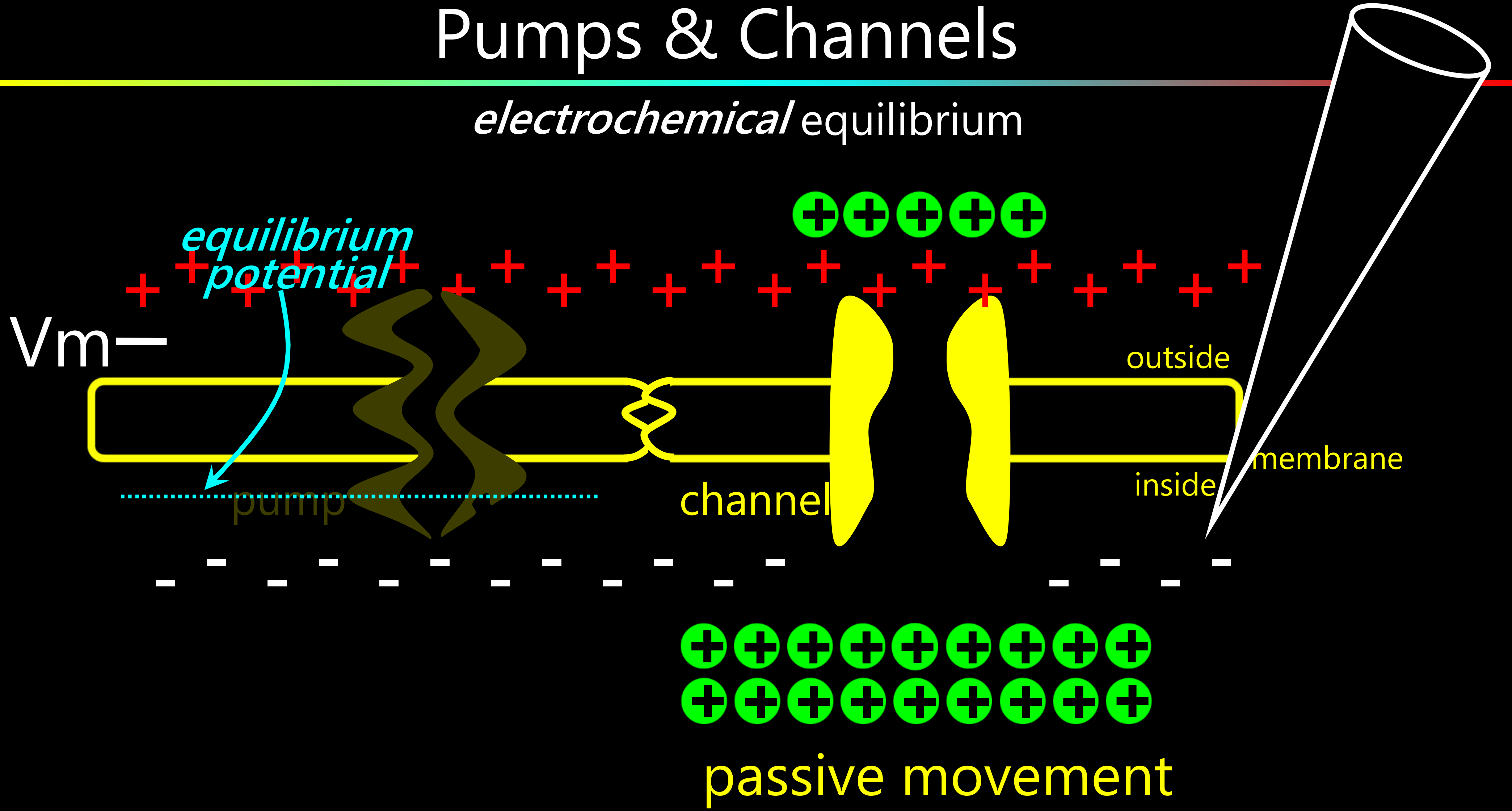
electrochemical equilibrium



passive movement

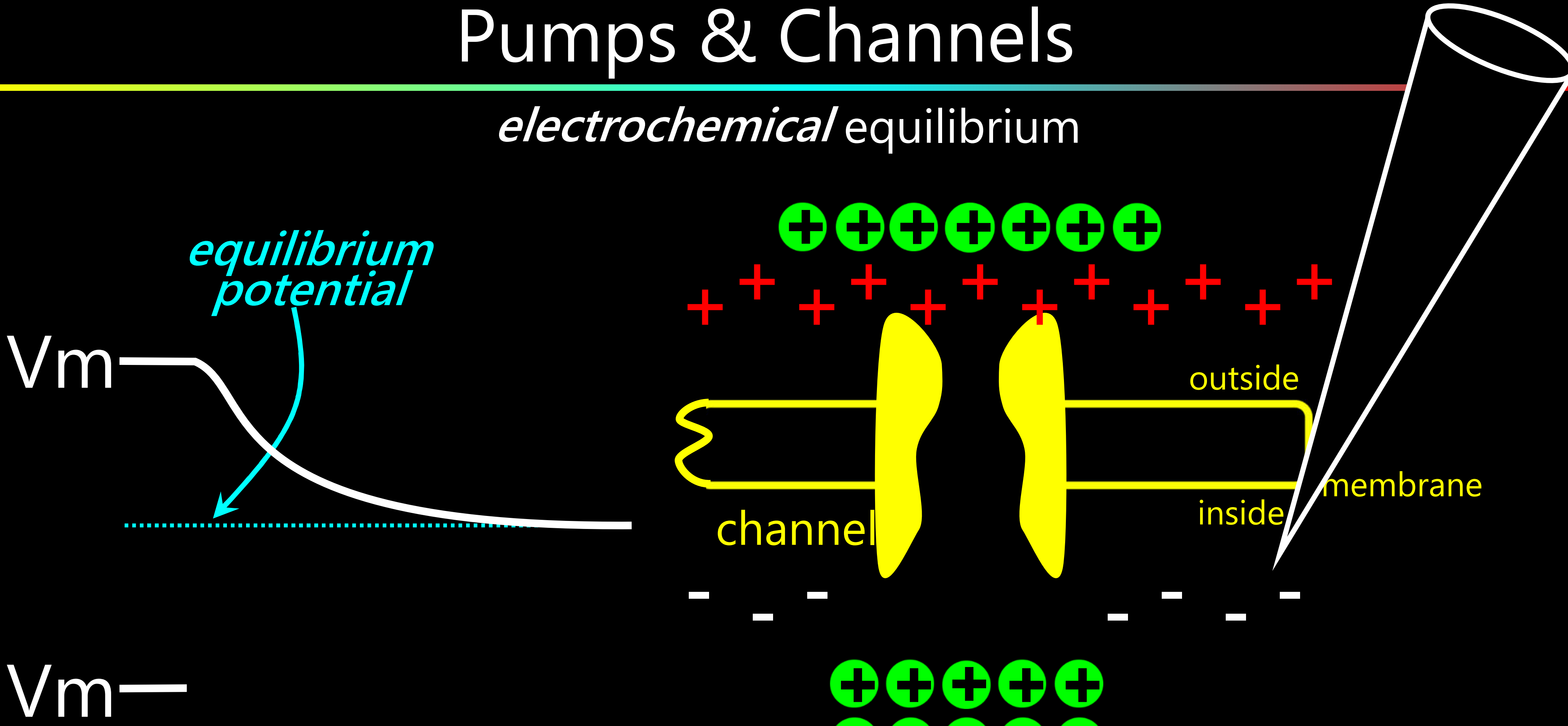
Pumps & Channels

electrochemical equilibrium



Pumps & Channels

electrochemical equilibrium



- *"reversal" potential*
- *"Nernst" potential*

passive movement

Pumps & Channels

electrochemical equilibrium

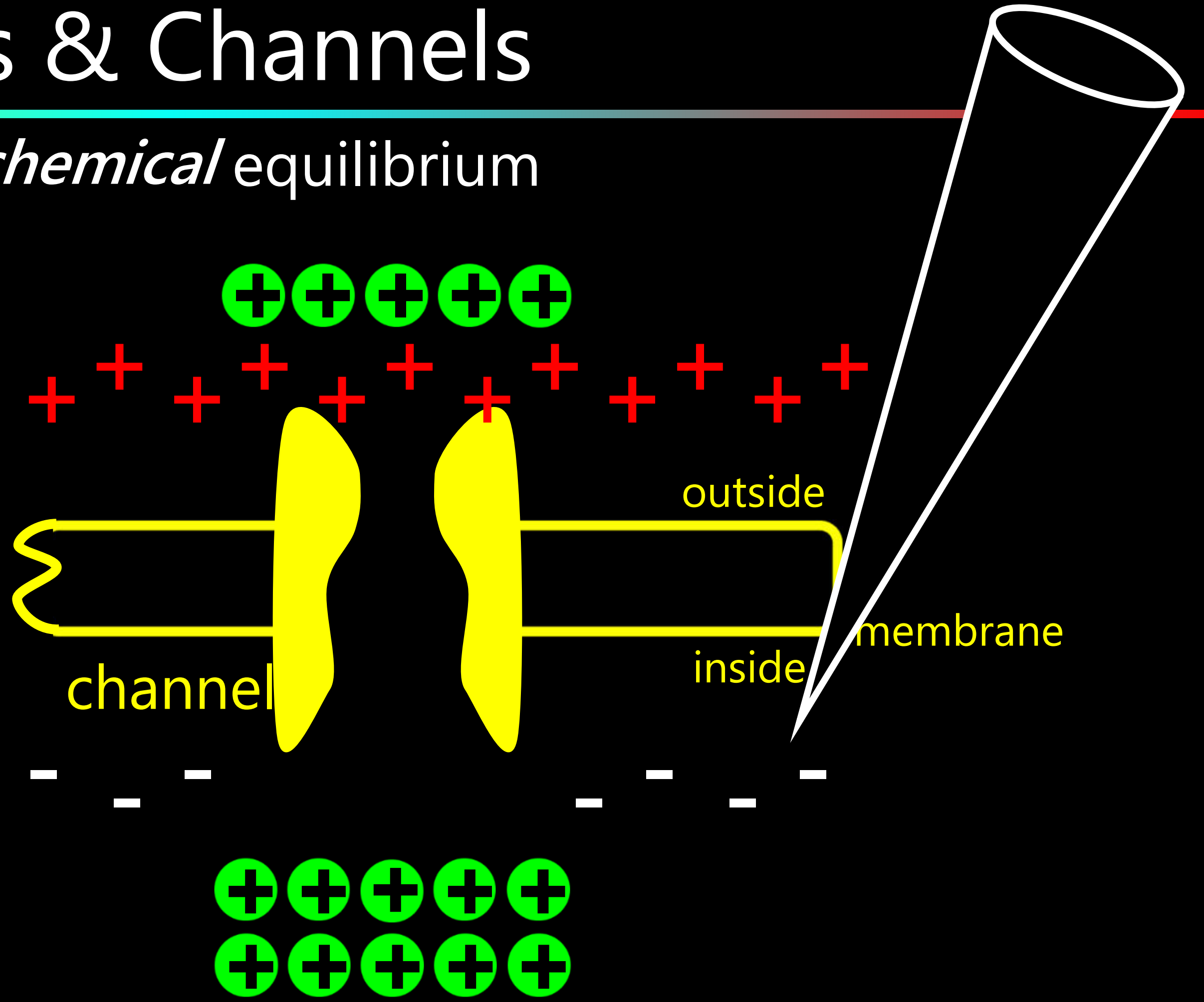
equilibrium potential

Nernst Equation

$$V_{equilibrium} = \frac{RT}{zF} \ln \frac{[X]_o}{[X]_i}$$

- R = gas constant
- T = temperature
- Z = valence of the ion
- F = Faraday's constant
    - *"reversal" potential*
    - *"Nernst" potential*

Vm



passive movement

Pumps & Channels

electrochemical **equilibrium**

Nernst Equation

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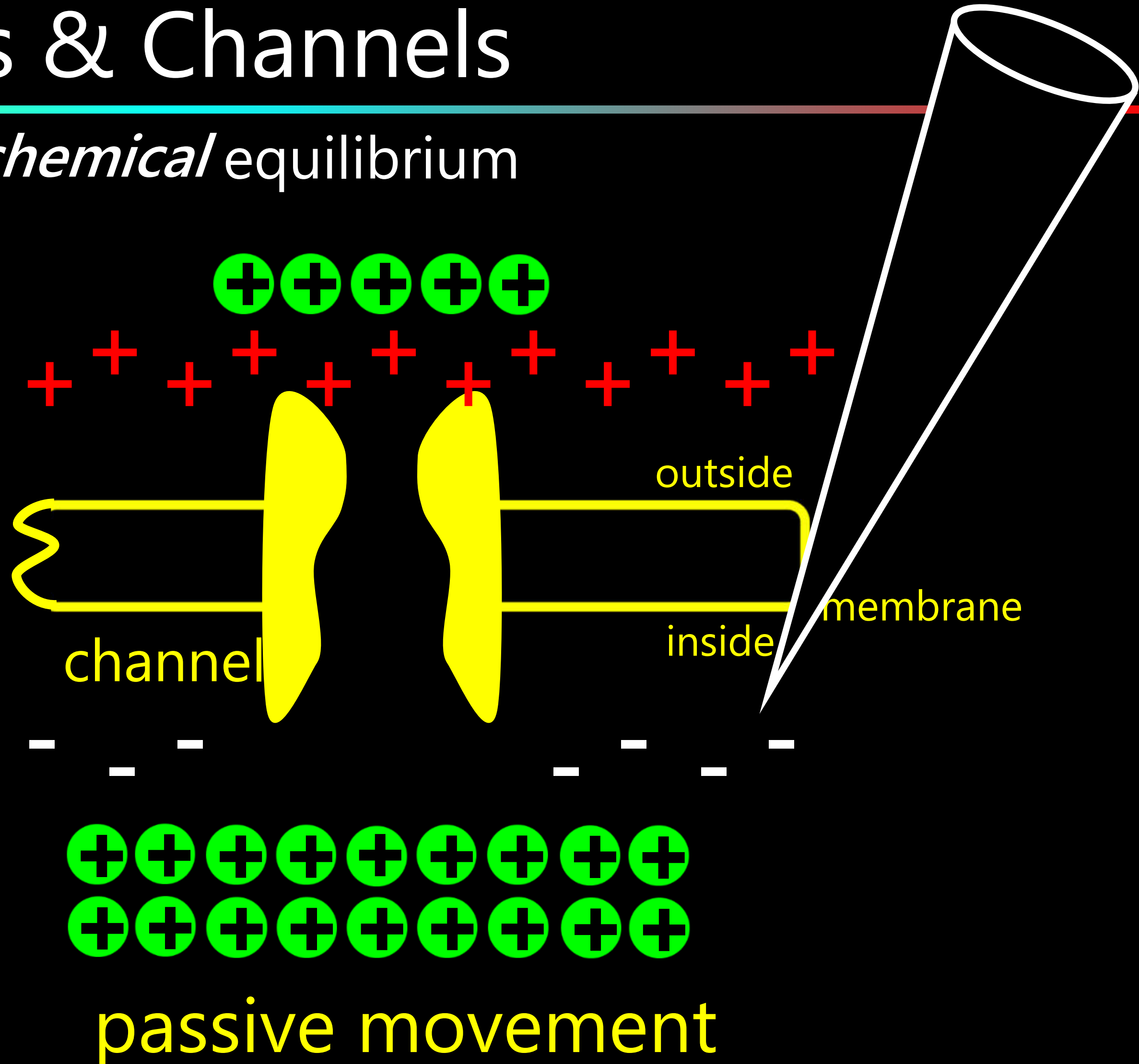

Pumps & Channels

electrochemical equilibrium

Nernst Equation

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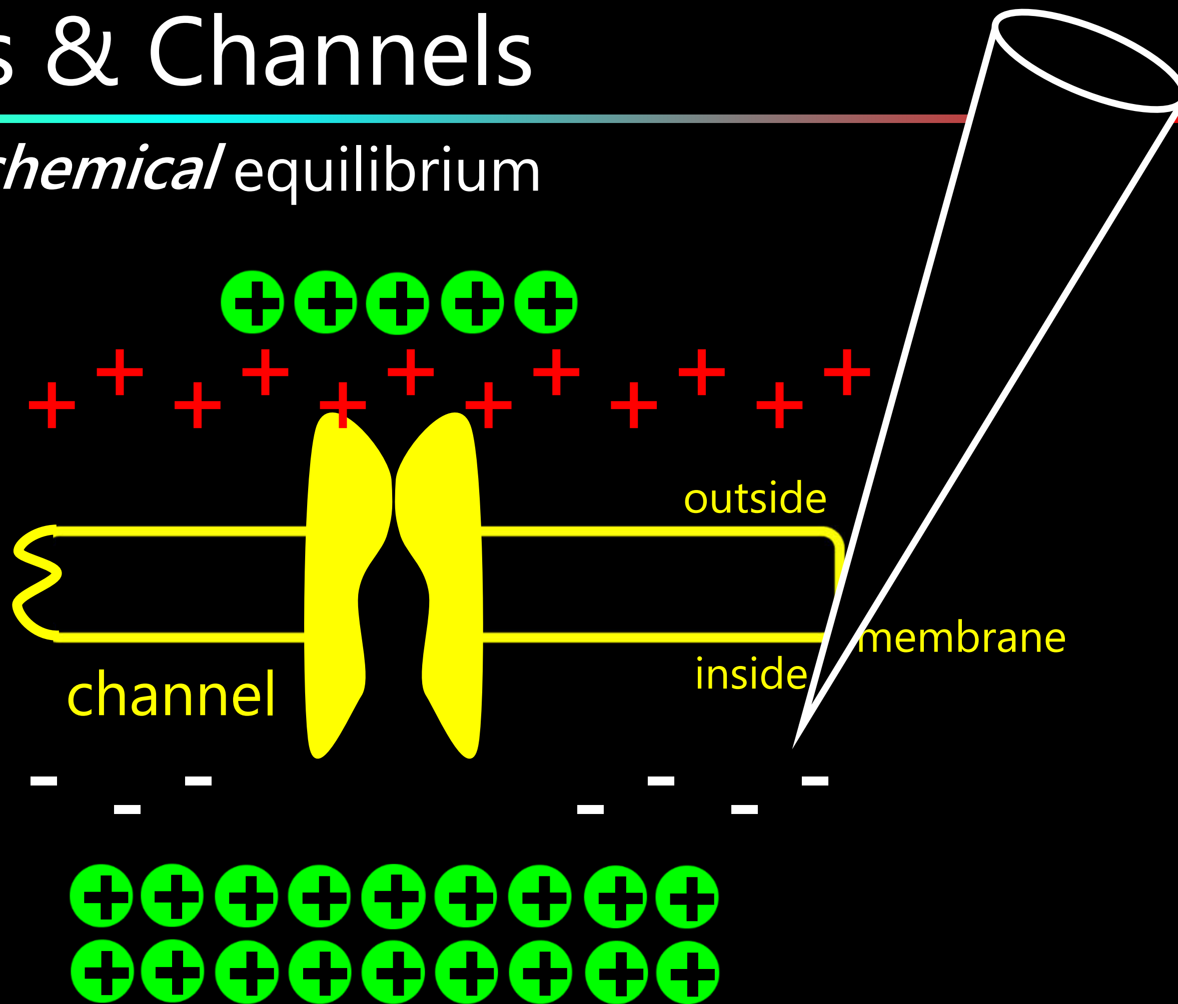

passive movement

Pumps & Channels

Pumps & Channels

Nernst Equation

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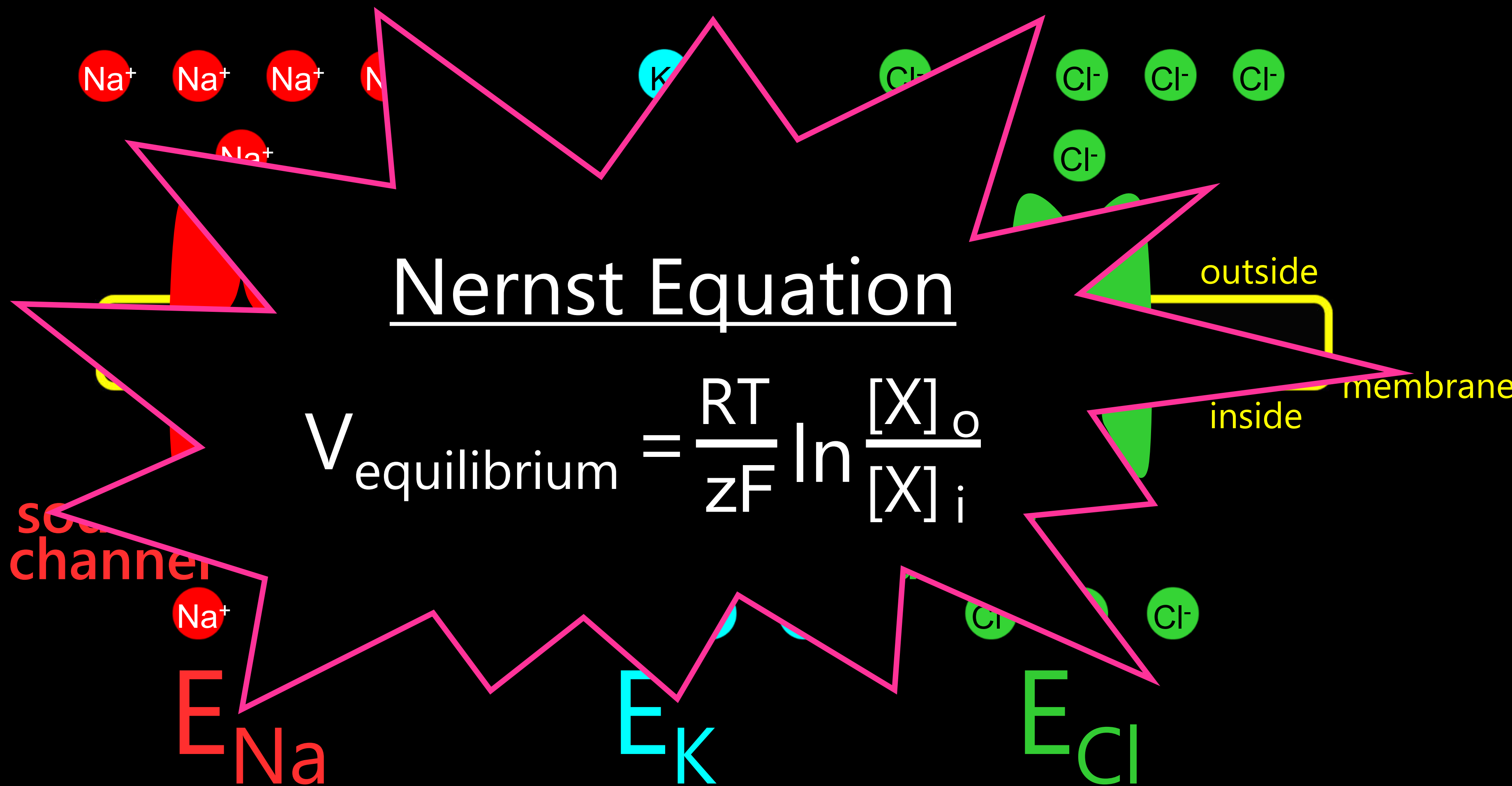
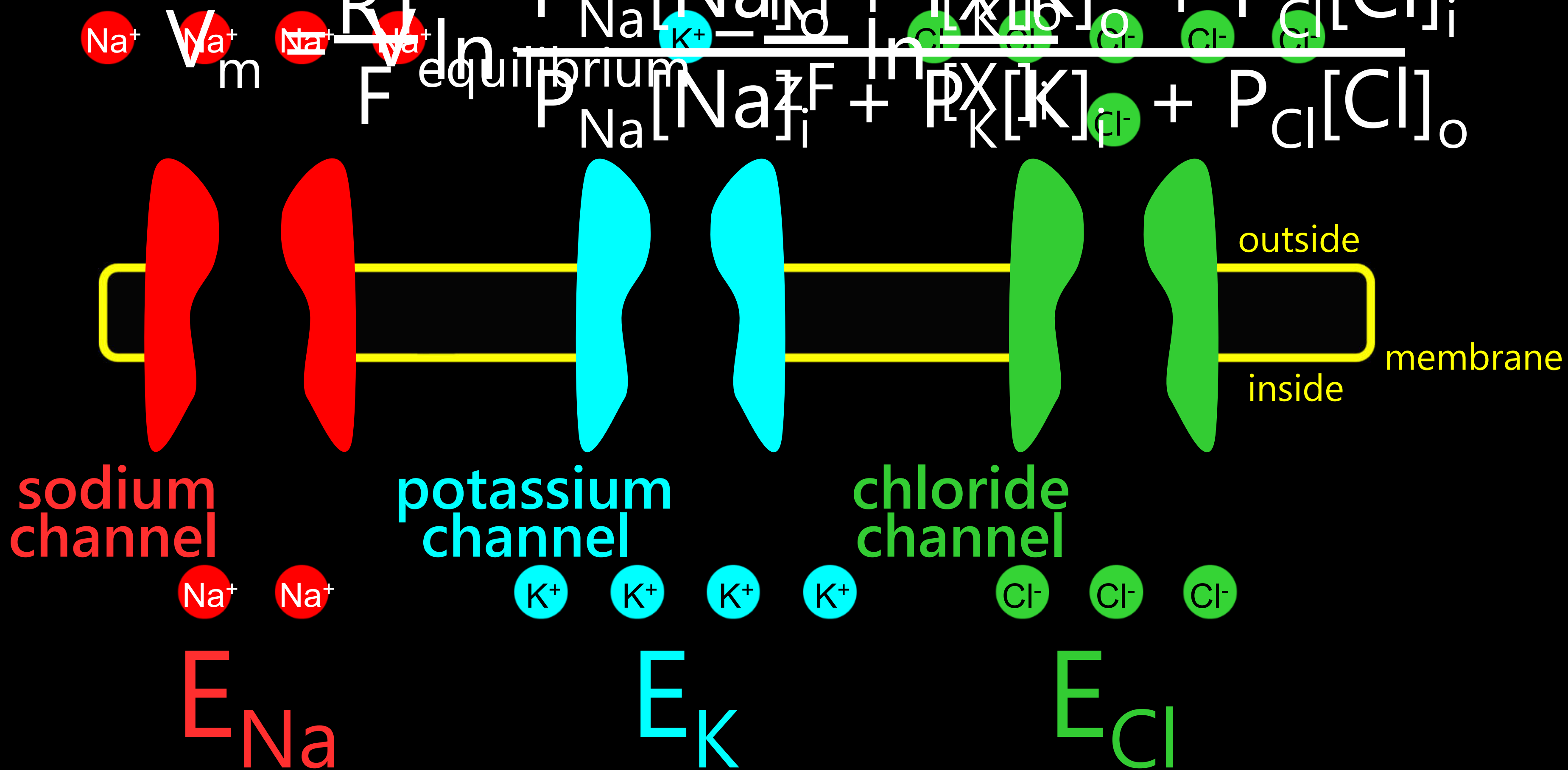


Pumps & Channels

$$V_m = \frac{RT}{F}\ln\frac{P_{Na}[Na]_o + P_K[K]_o + P_{Cl}[Cl]_i}{P_{Na}[Na]_i + P_K[K]_i + P_{Cl}[Cl]_o}$$

$$V_{equilibrium} = \frac{RT}{zF}\ln\frac{[X]_o}{[X]_i}$$



Pumps & Channels

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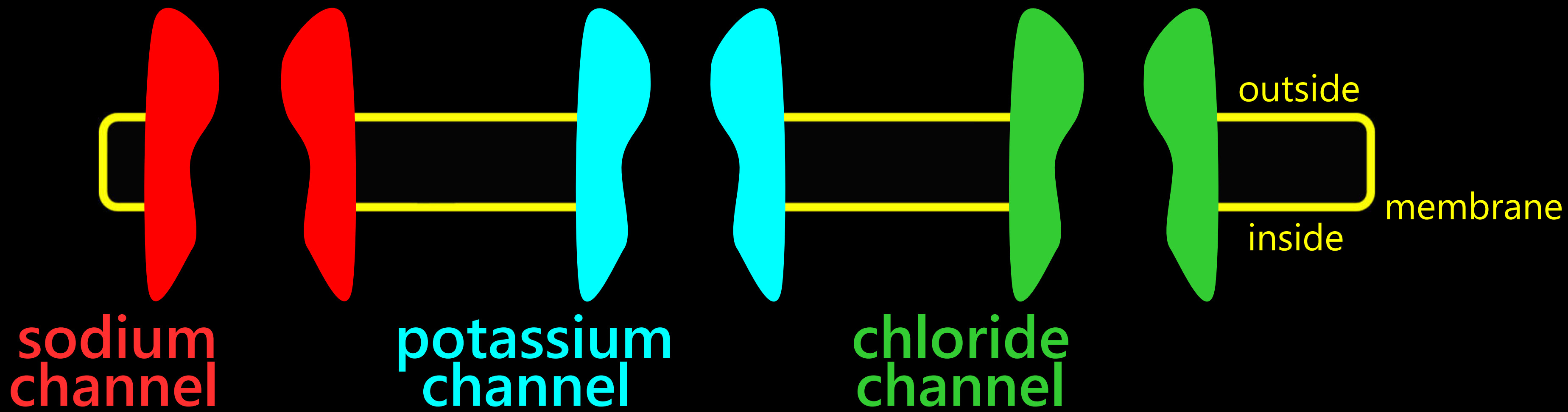
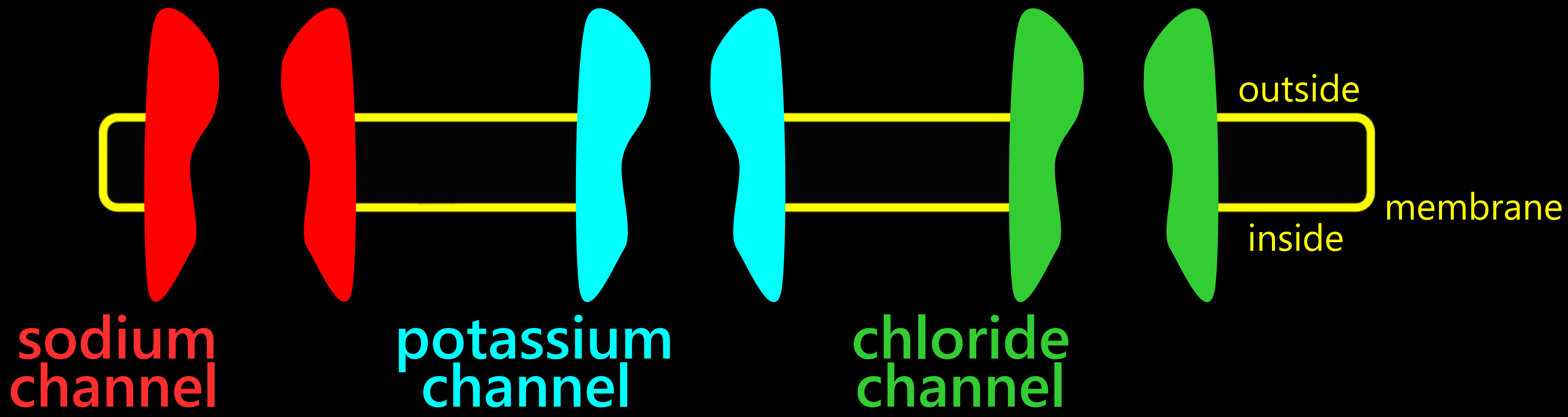


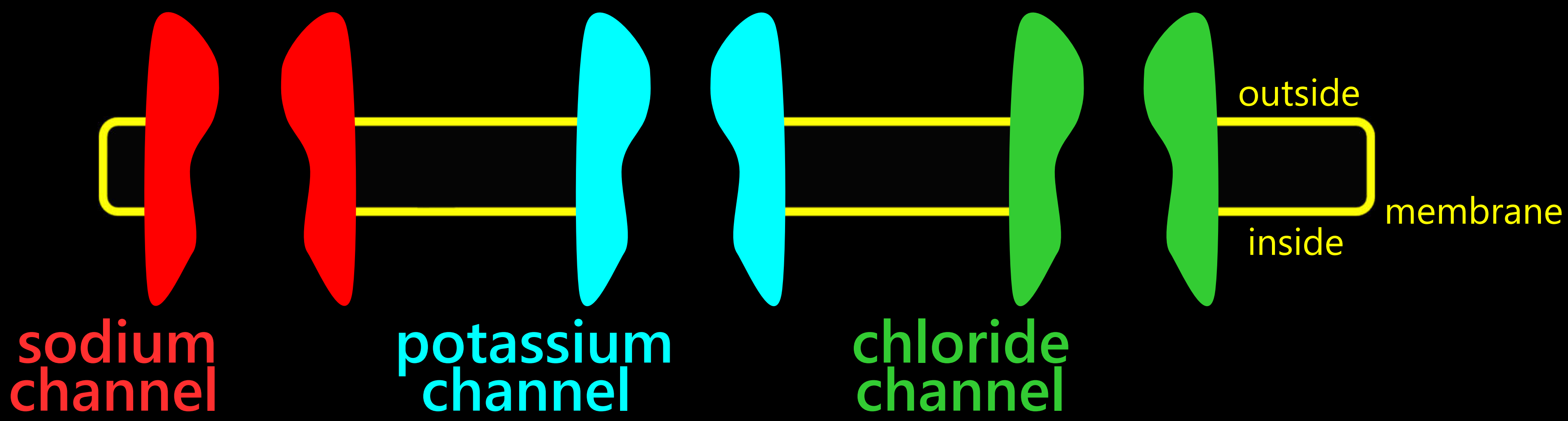
Pumps & Channels

per·me·a·bil·i·ty: *the state or quality of a material or membrane that causes it to allow liquid or gases to pass through it.*



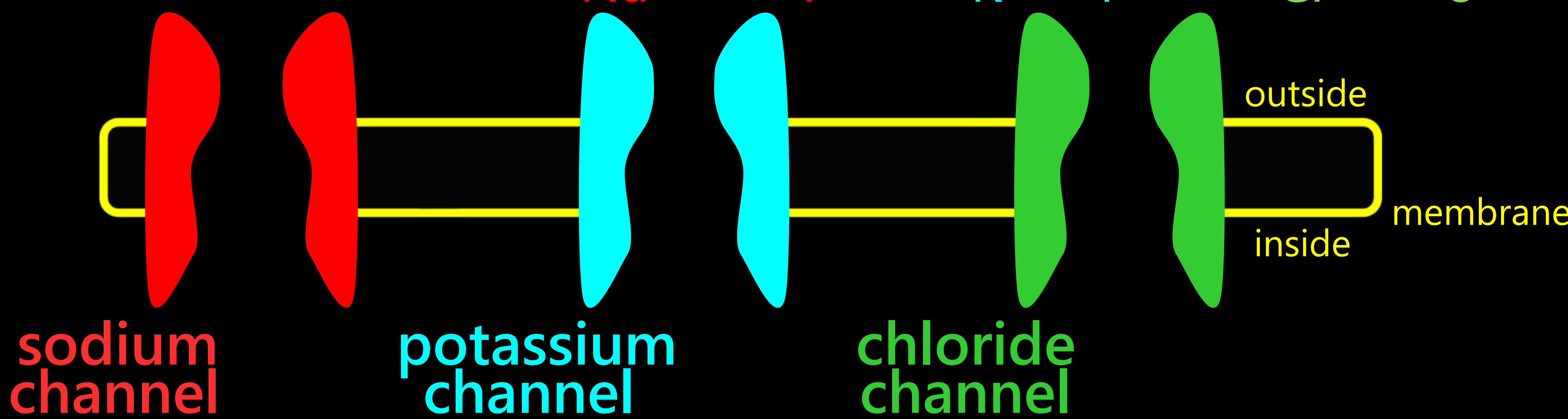
Pumps & Channels

per·me·a·bil·i·ty: *the ability of an ion to pass through the membrane.*



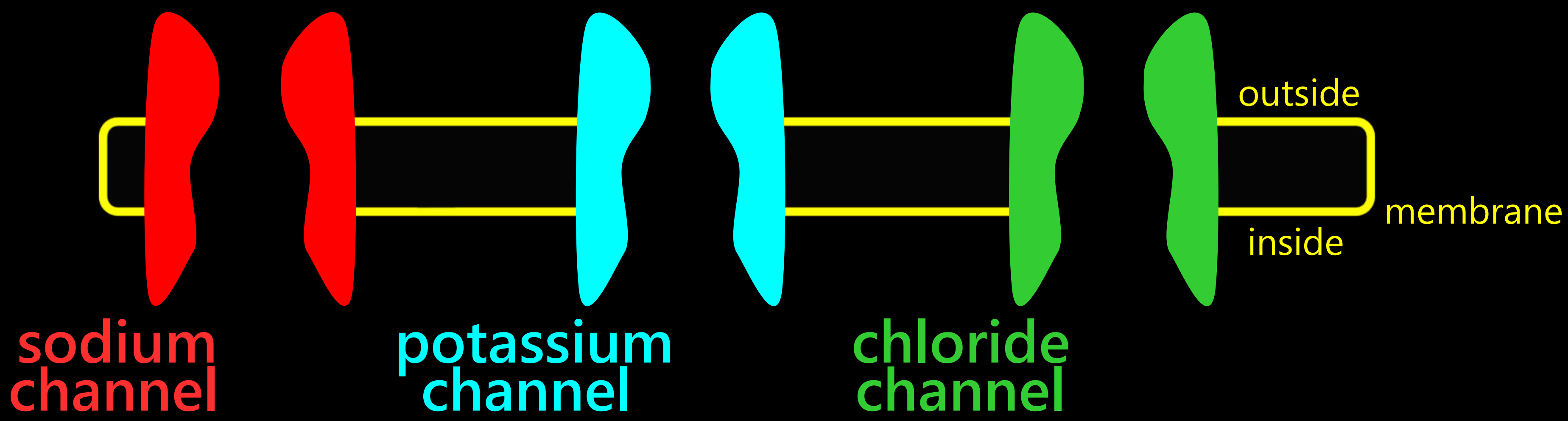
Pumps & Channels

$$V_m = \frac{RT}{F} \ln \frac{P_{Na}[Na]_o + P_K[K]_o + P_{Cl}[Cl]_i}{P_{Na}[Na]_i + P_K[K]_i + P_{Cl}[Cl]_o}$$



Pumps & Channels

what opens a channel?



Pumps & Channels

what opens a channel?

Pumps & Channels

what *gates* a channel?

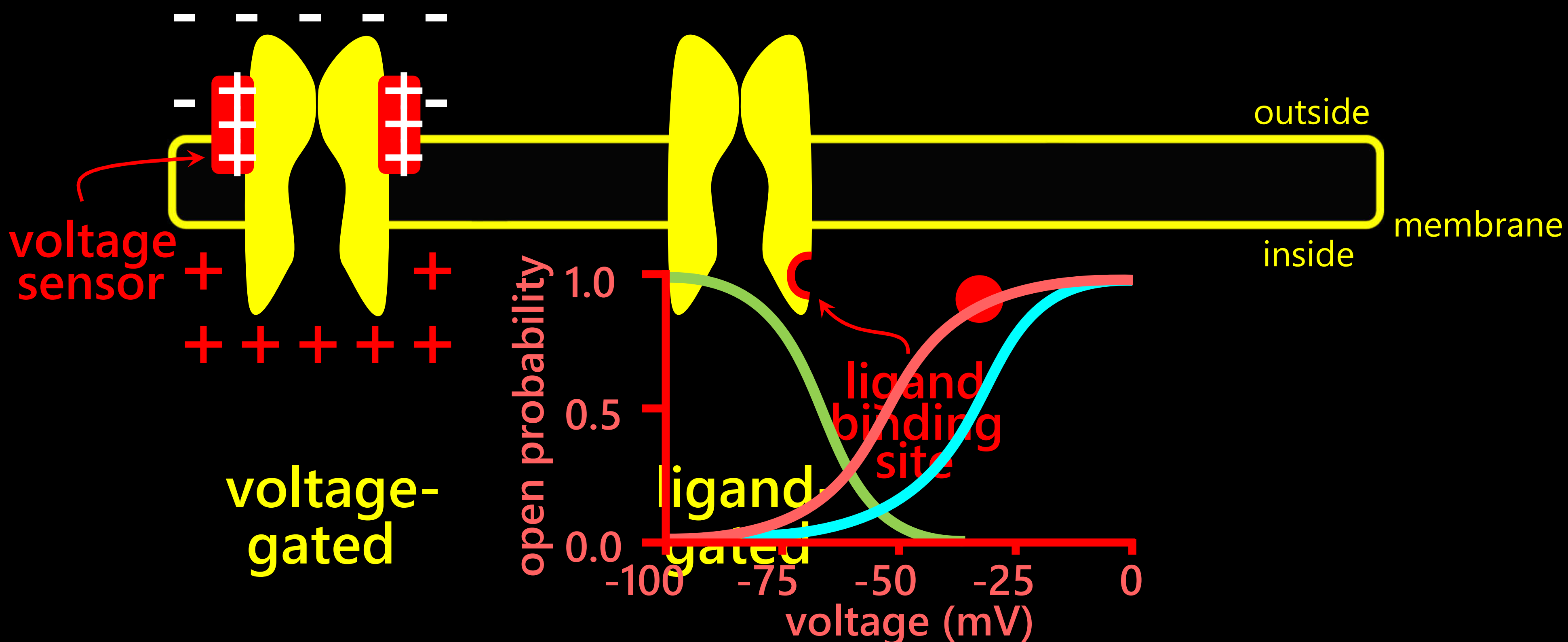
Pumps & Channels

what *gates* a channel?

voltage-gated

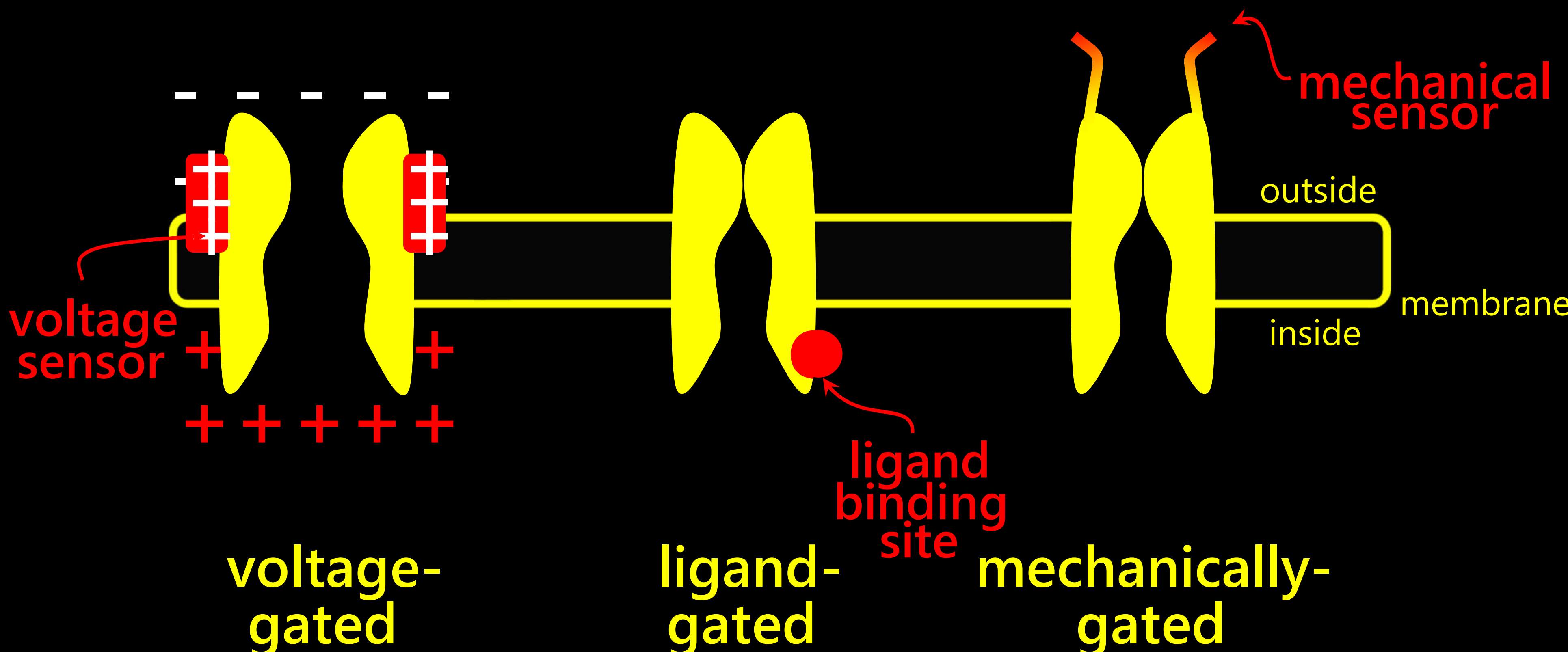
Pumps & Channels

what *gates* a channel?



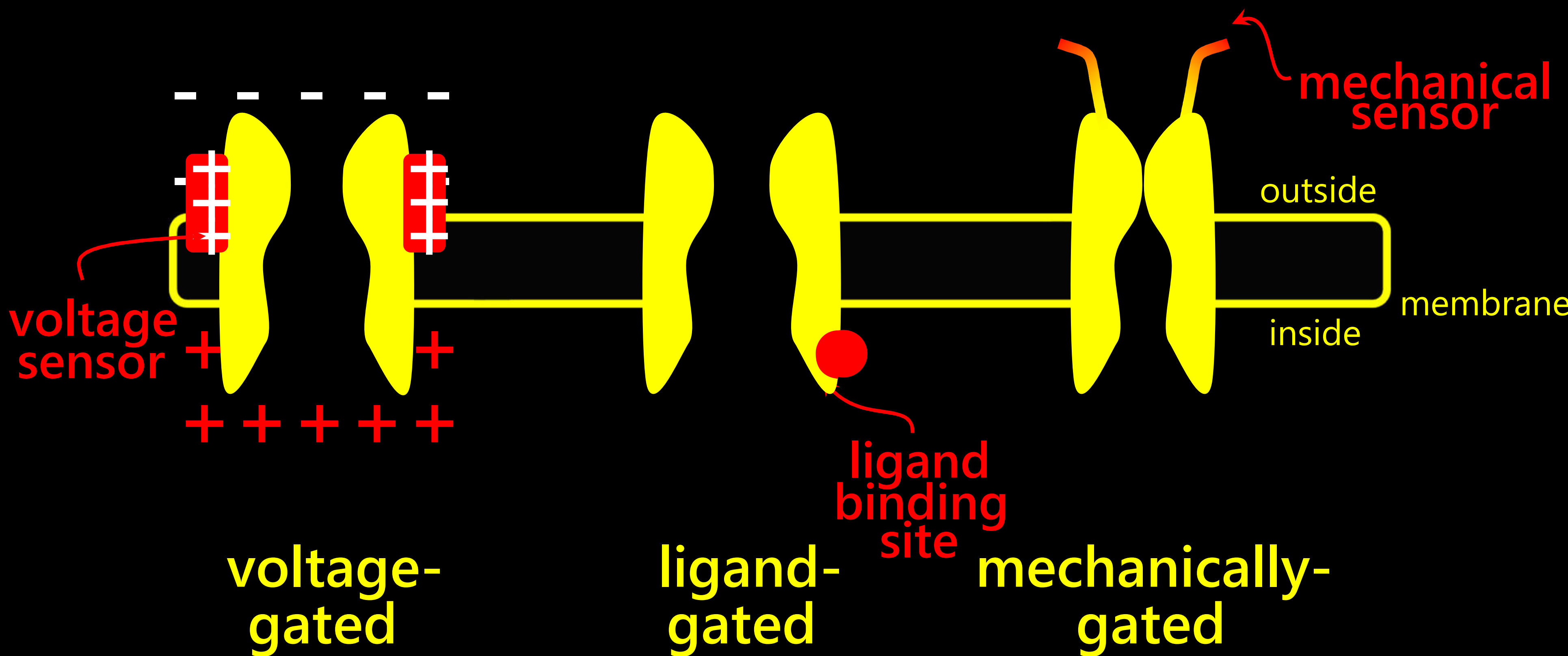
Pumps & Channels

what *gates* a channel?



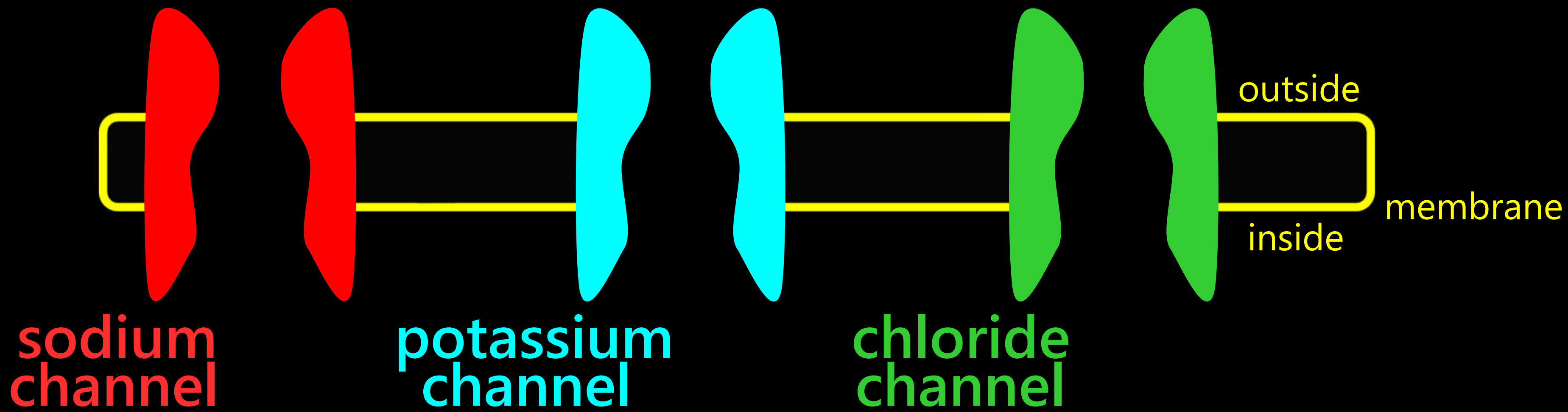
Pumps & Channels

what *gates* a channel?

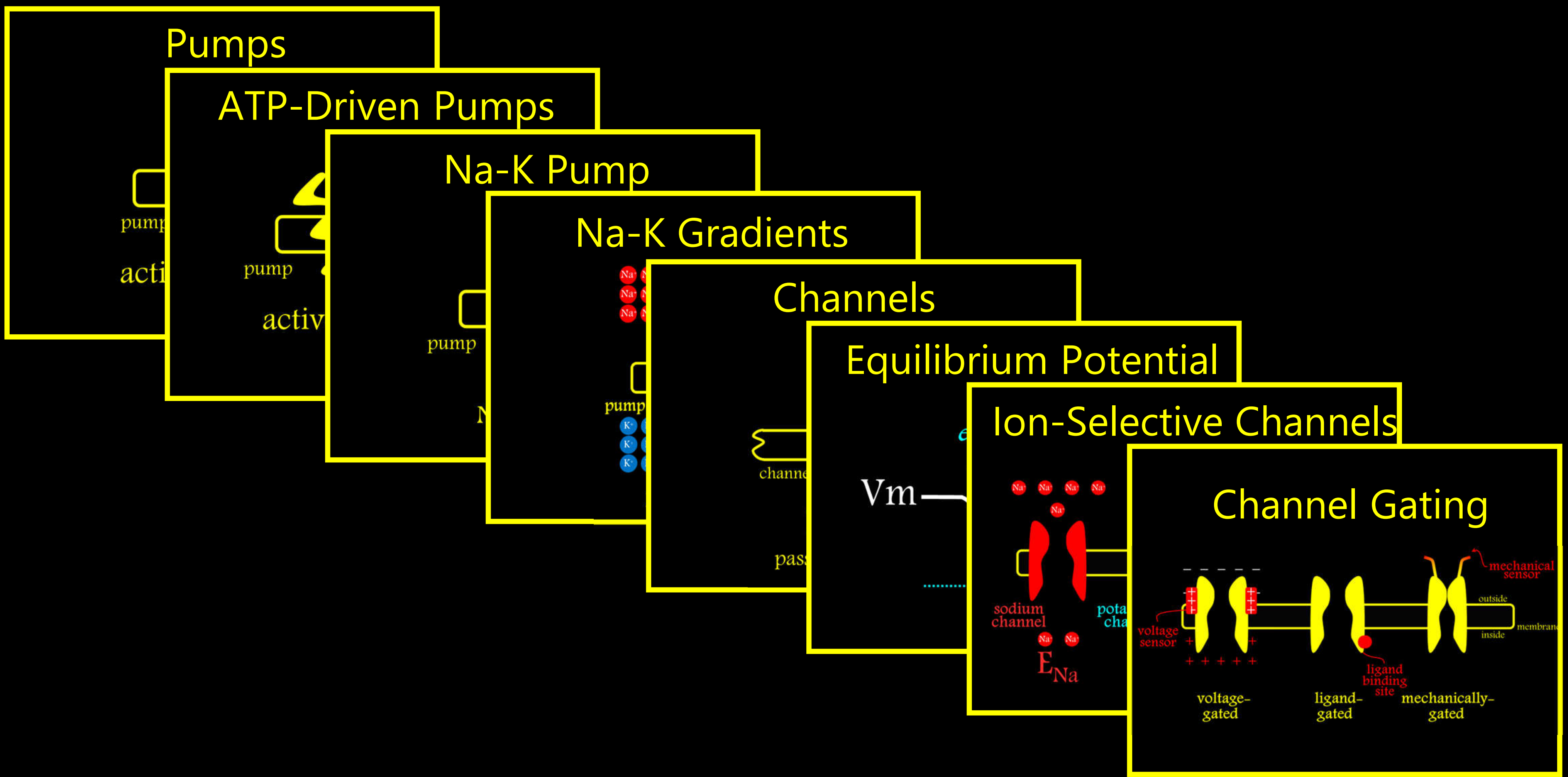


Pumps & Channels

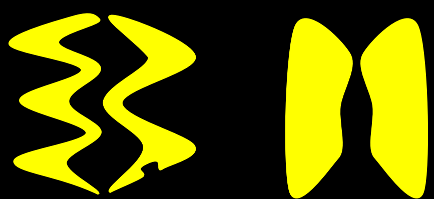
$$V_m = \frac{RT}{F} \ln \frac{P_{Na}[Na]_o + P_K[K]_o + P_{Cl}[Cl]_i}{P_{Na}[Na]_i + P_K[K]_i + P_{Cl}[Cl]_o}$$



Ion Channels & Cellular Electrophysiology



Ion Channels & Cellular Electrophysiology



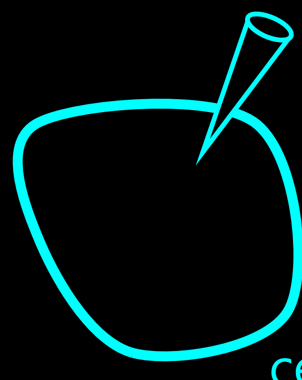
pumps &
channels

membrane
voltage

electrical
signals

Ion Channels & Cellular Electrophysiology

pumps &
channels



membrane
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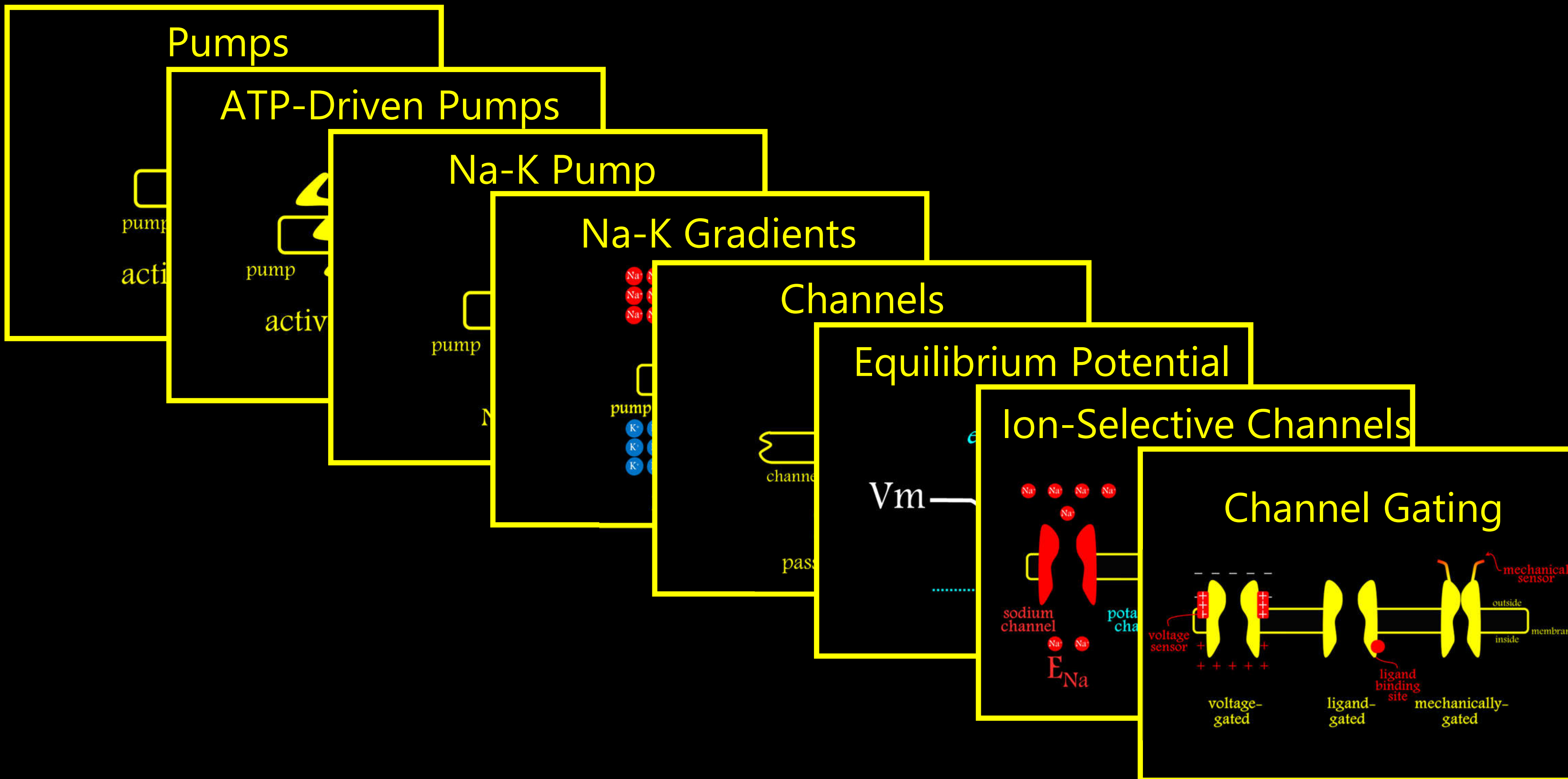
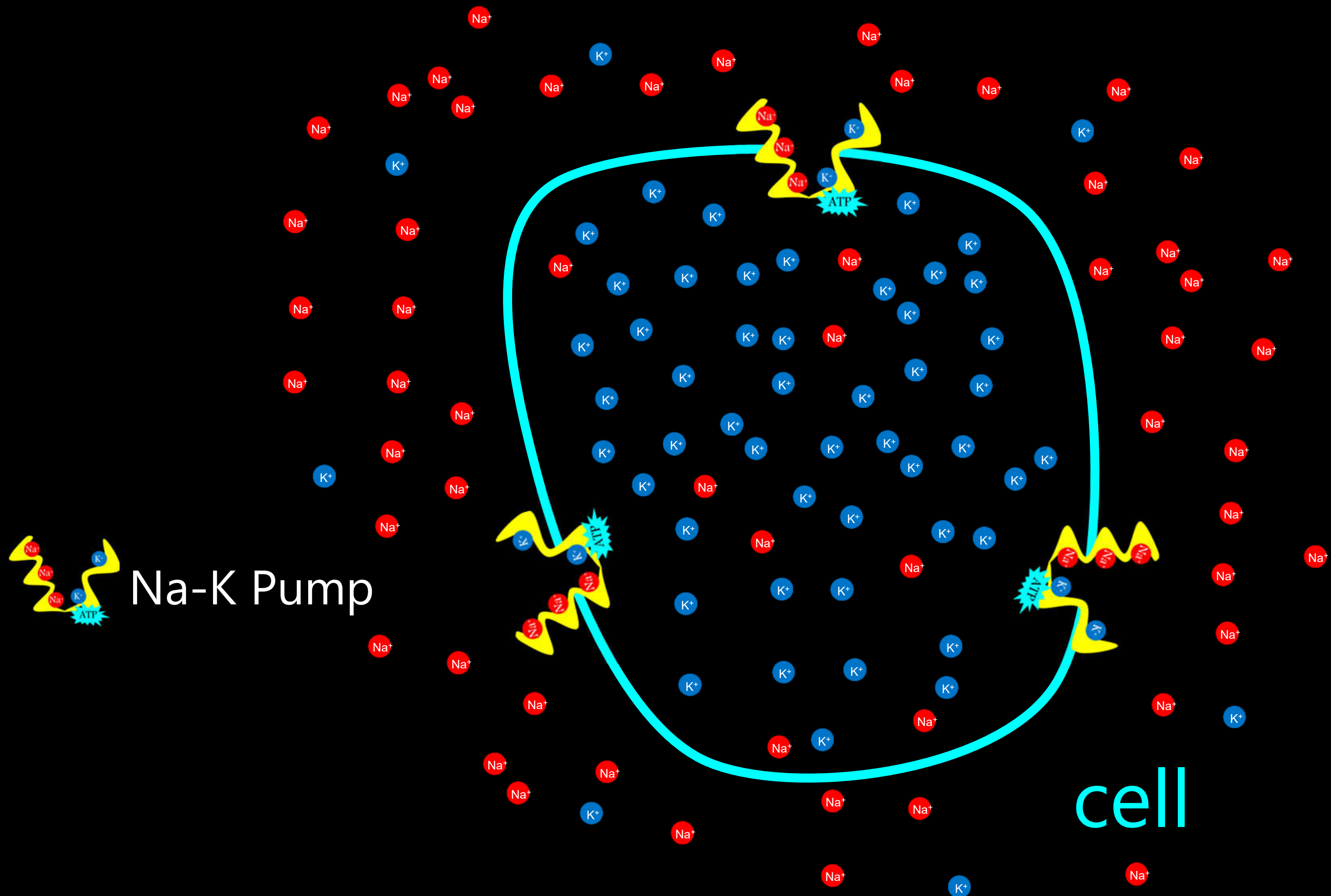
Ion Channels & Cellular Electrophysiology



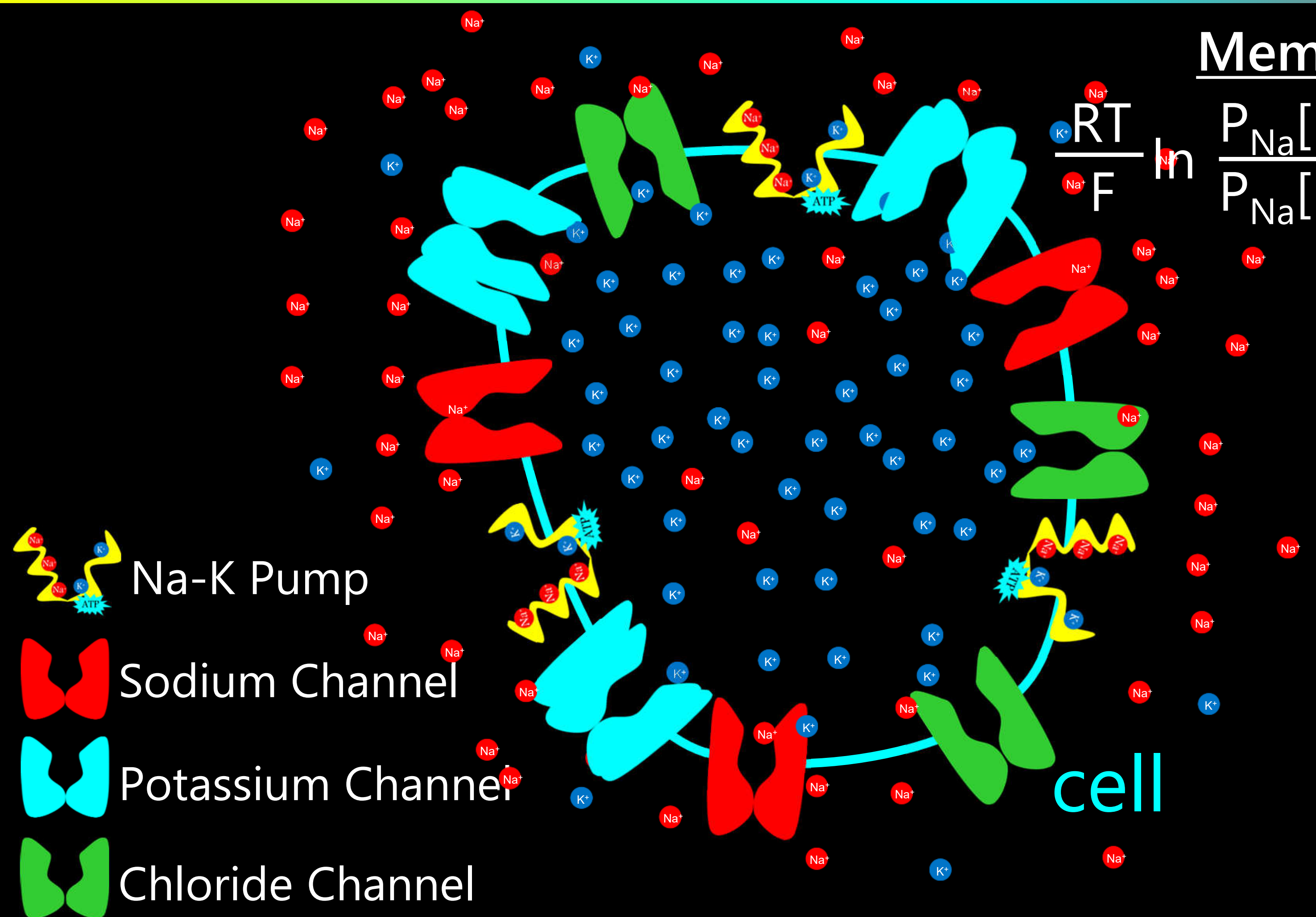
Ion Channels & Cellular Electrophysiology



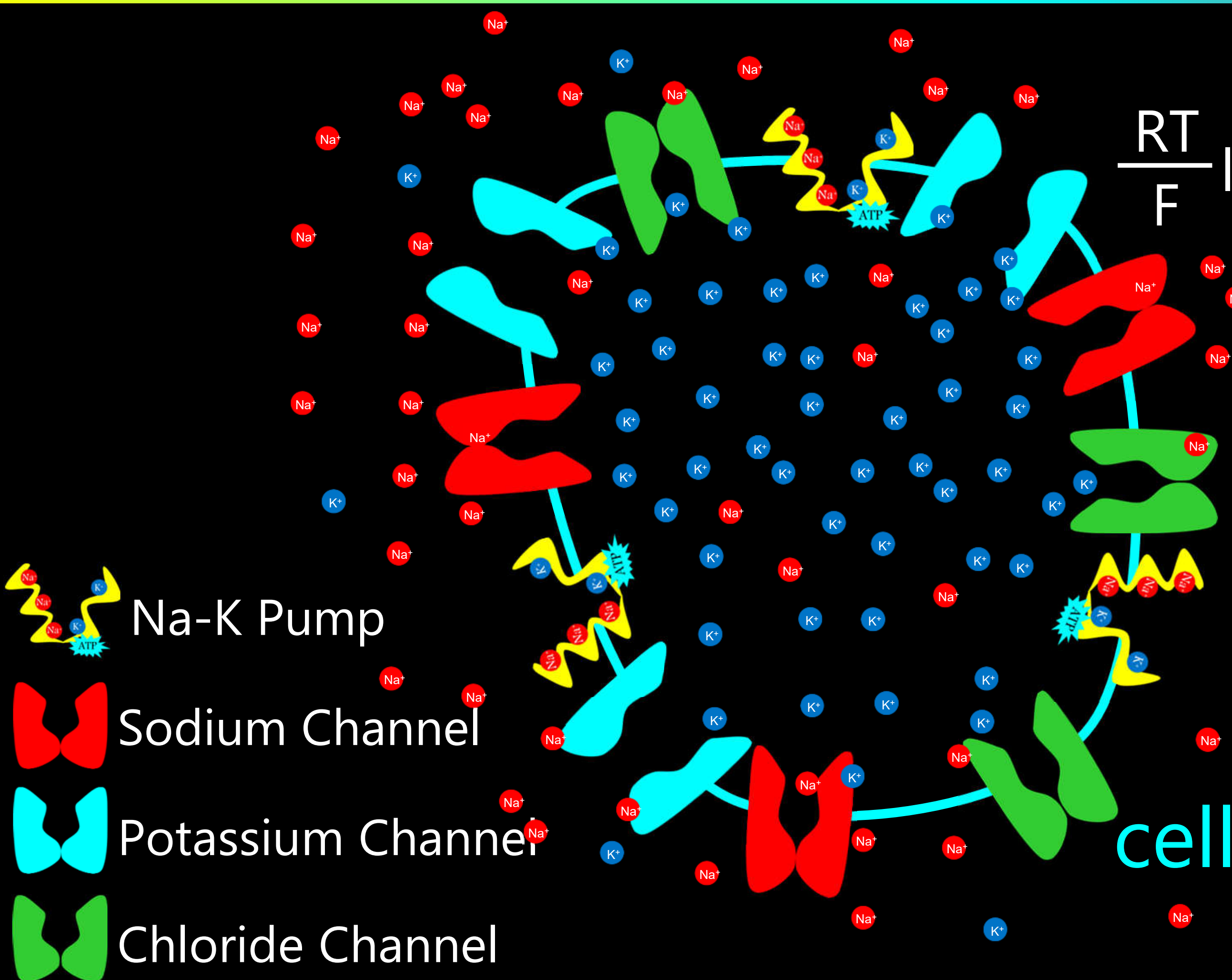
Ion Channels & Cellular Electrophysiology

Membrane Potential

$$\frac{RT}{F}\ln\frac{P_{Na}[Na]_o + P_K[K]_o + P_{Cl}[Cl]_i}{P_{Na}[Na]_i + P_K[K]i + P_{Cl}[Cl]_o}$$



Ion Channels & Cellular Electrophysiology



Membrane Potential

$$\frac{RT}{F}\ln\frac{\cancel{P_{Na}[Na]_o} + P_K[K]_o \cancel{+ P_{Cl}[Cl]_i}}{\cancel{P_{Na}[Na]_i} + P_K[K]i \cancel{+ P_{Cl}[Cl]_o}}$$

Nernst Equation

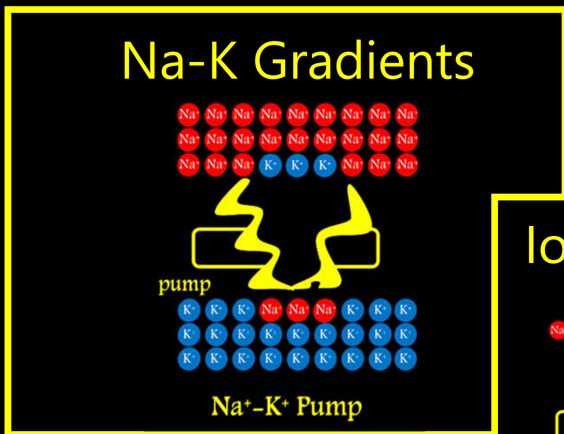
$$E_K = \frac{RT}{zF}\ln\frac{P_K[K]_o}{P_K[K]i}$$

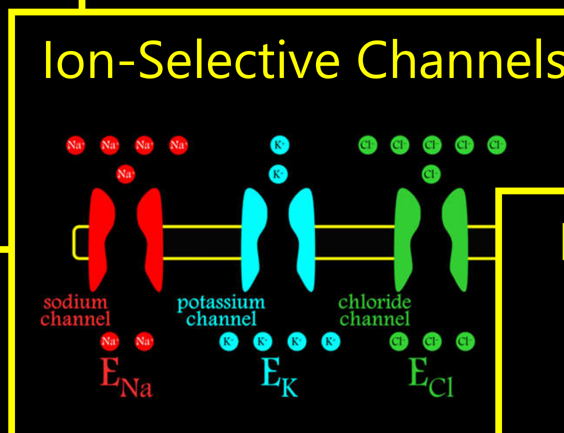
$$E_K = -90mV$$

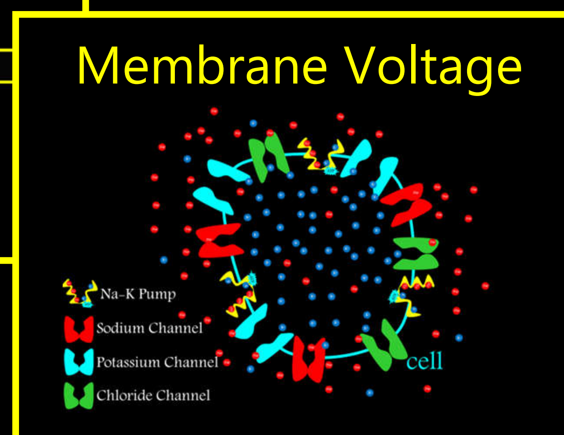
$$E_{Na} = +50mV$$

$$E_{Cl} = -70mV$$

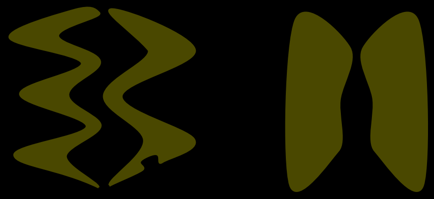
Ion Channels & Cellular Electrophysiology



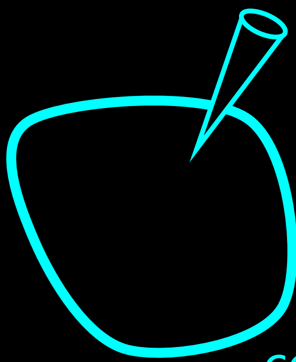




Ion Channels & Cellular Electrophysiology



pumps & channels



membrane voltage

electrical signals

Ion Channels & Cellular Electrophysiology

pumps &
channels

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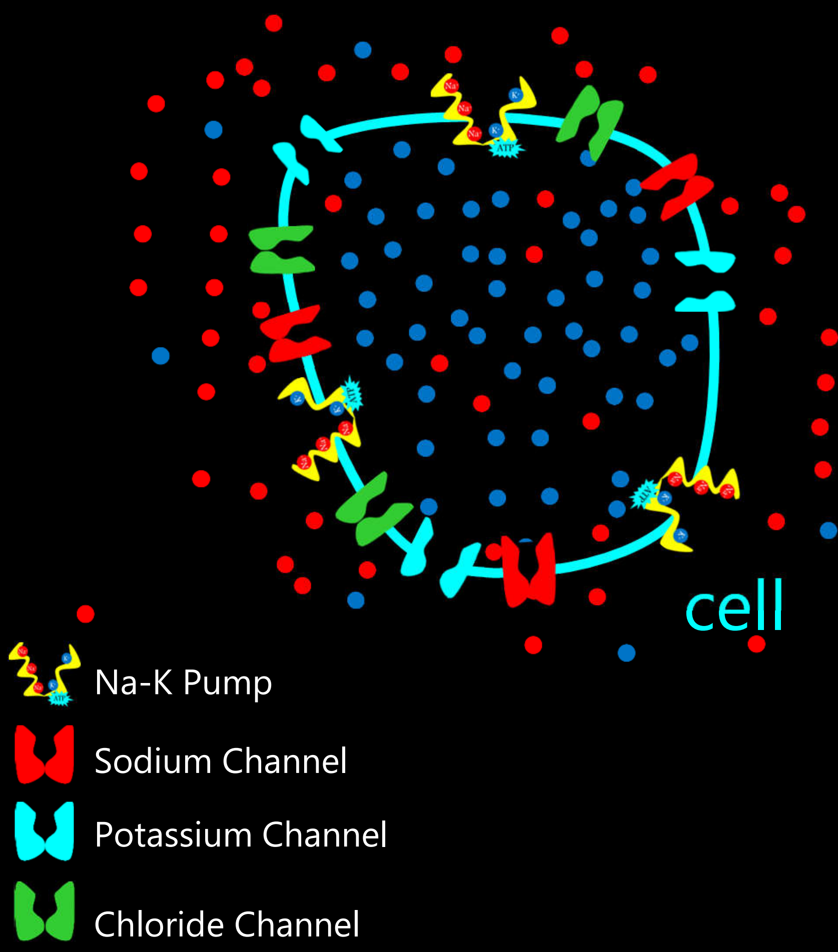
Ion Channels & Cellular Electrophysiology



Membrane Potential

$$\frac{RT}{F} \ln \frac{P_{Na}[Na]_o + P_K[K]_o + P_{Cl}[Cl]_i}{P_{Na}[Na]_i + P_K[K]_i + P_{Cl}[Cl]_o}$$

$E_{Na} = +50mV$

$E_K = -90mV$

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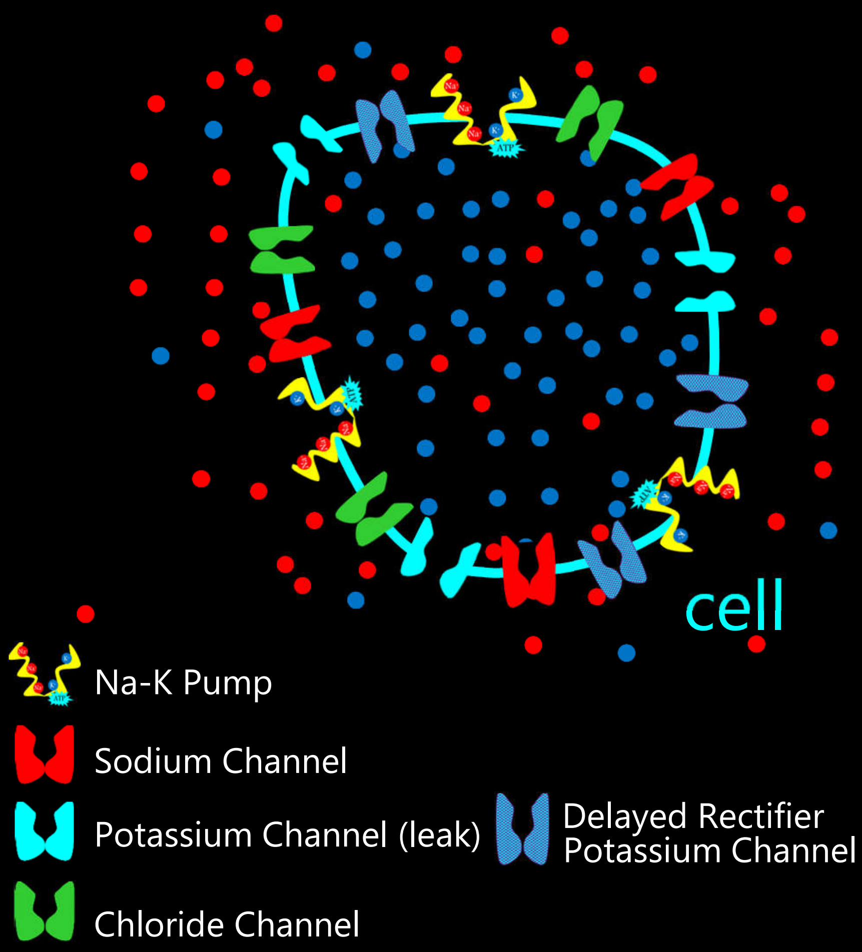
Ion Channels & Cellular Electrophysiology



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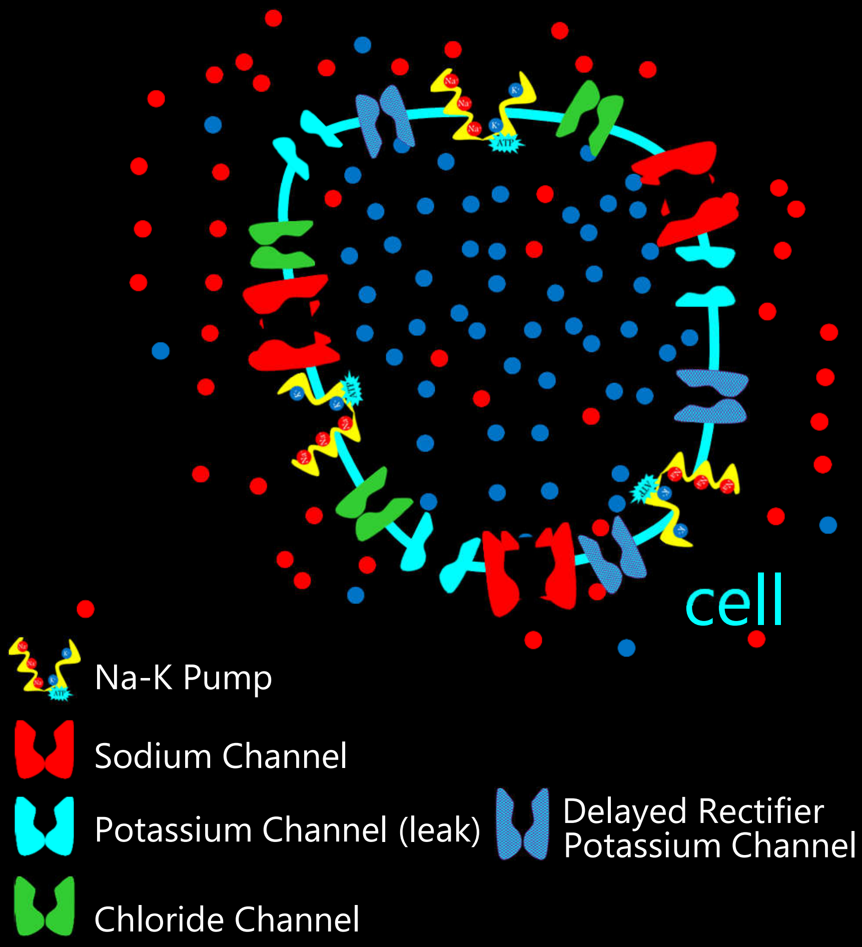
Vm—

Ion Channels & Cellular Electrophysiology



Membrane Potential

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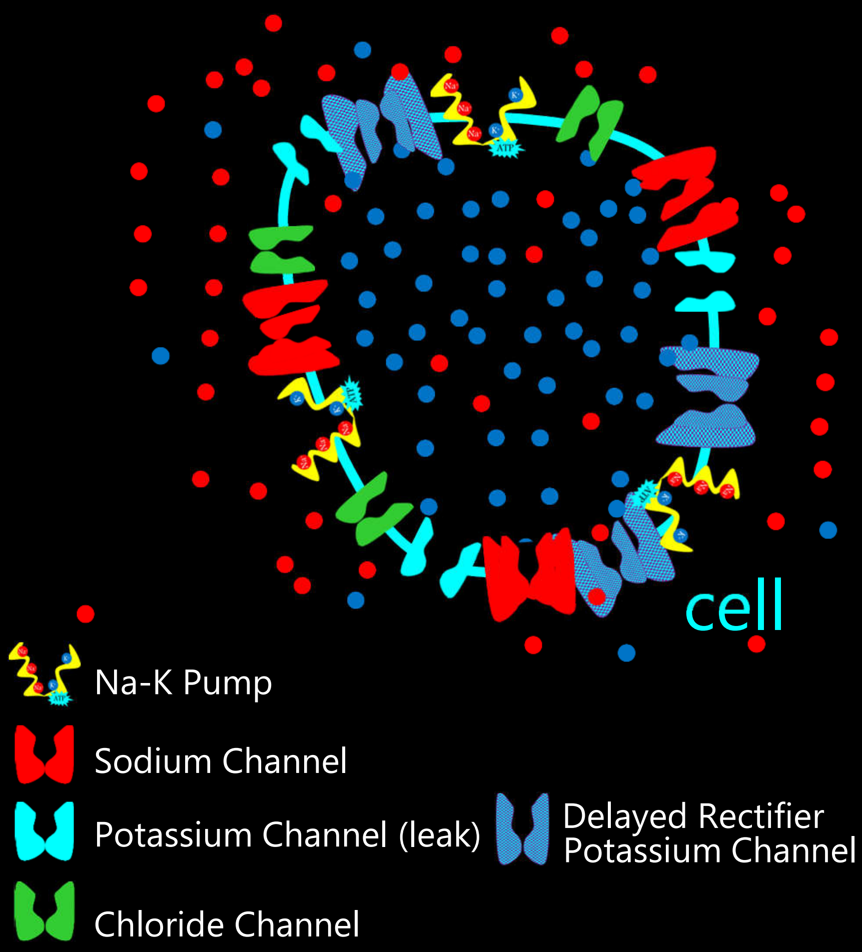
Vm—

Ion Channels & Cellular Electrophysiology



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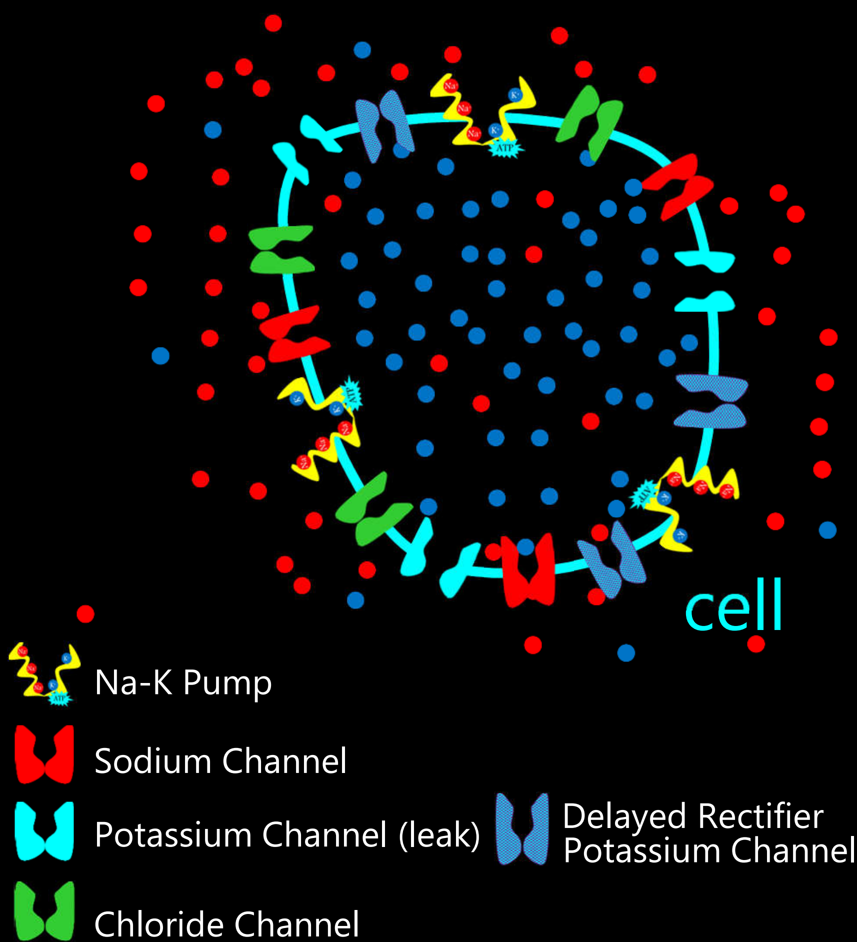
Vm—

action potential

Ion Channels & Cellular Electrophysiology



Membrane Potential

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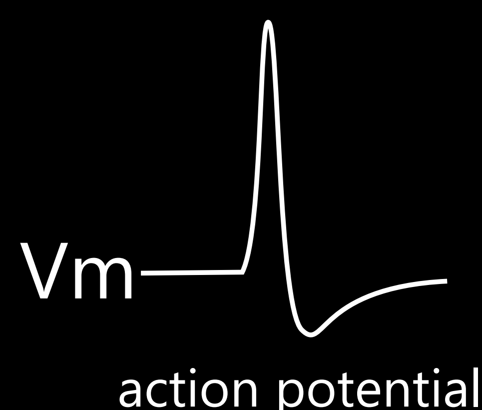
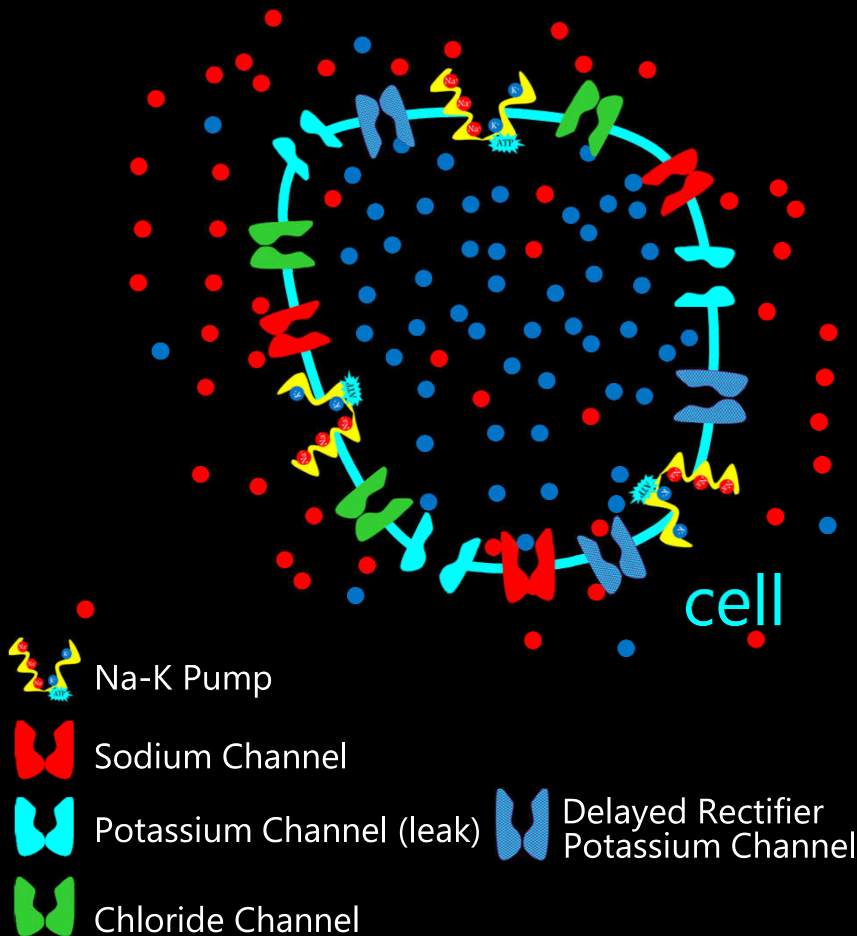


Ion Channels & Cellular Electrophysiology



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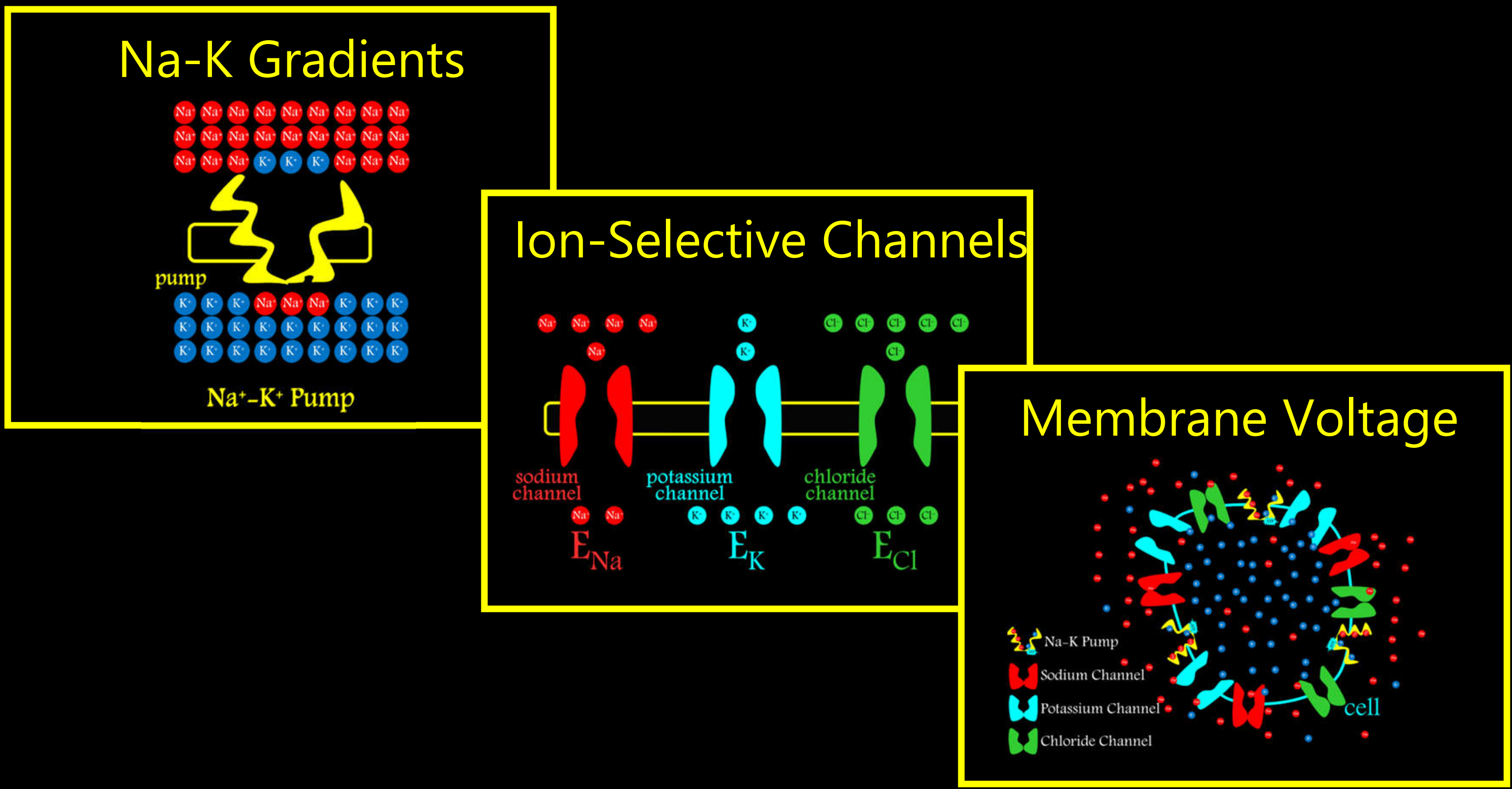

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Mark Beenhakker
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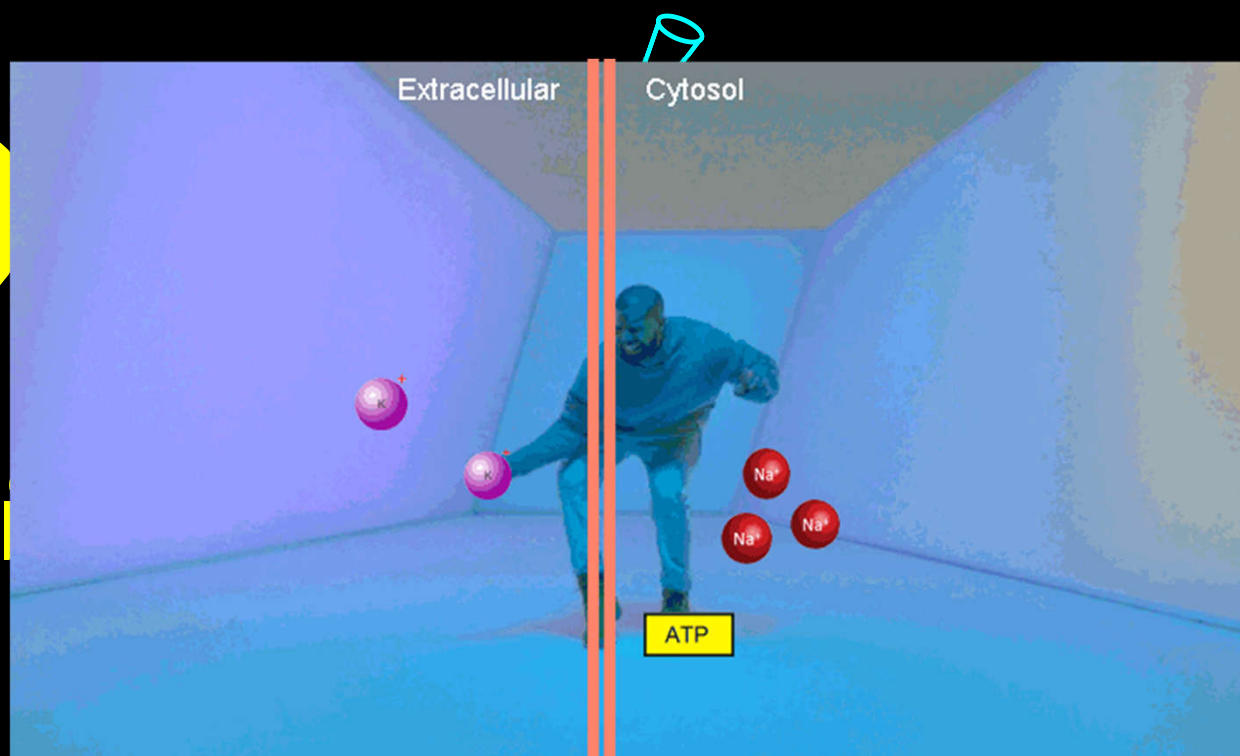

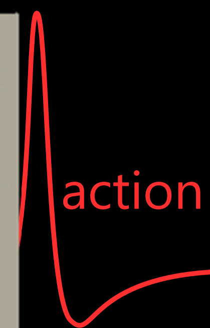

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