Bio 112 Handout for Physiology 3

This handout contains:
- Today's iClicker Questions
- Handouts for today's lecture

iClicker Question #23A - before lecture

Which of the following are true?

A. In an action potential, the Na^+ ions move **along** the axon.
B. In an action potential, Na^+ channels remain closed.
C. An action potential is when V_M becomes negative for a short time.
D. All of the above.
E. None of the above.

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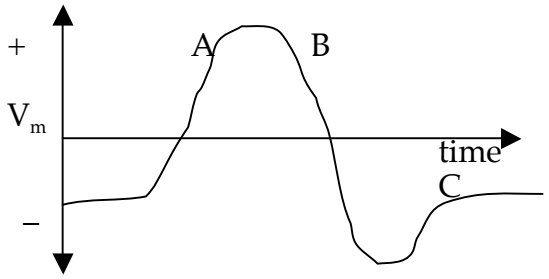
iClicker Question #23B - after lecture

Consider an action potential:



At which point(s) are the voltage-gated Na^+ channels open?

(A) A, B, and C.
(B) A and B only.
(C) B only.
(D) A only.
(E) none of the above.

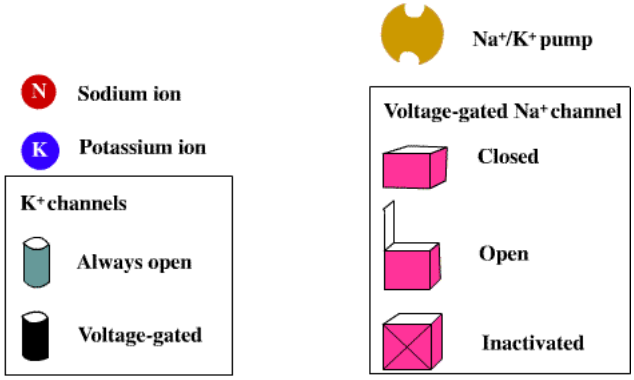
Beaming in your answers

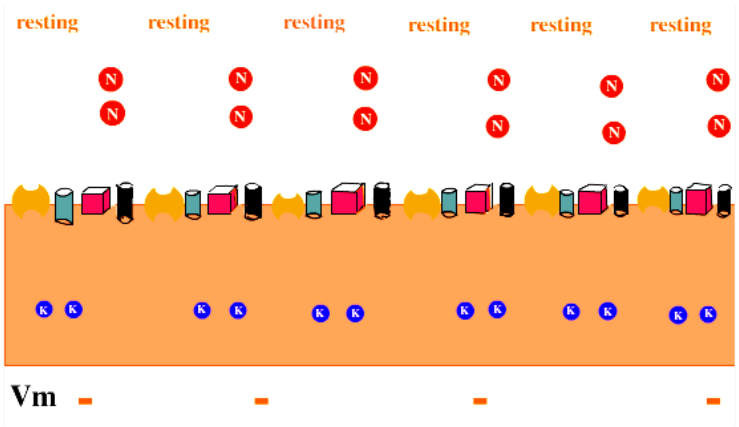
1. Figure out your answer and select the appropriate letter (A-E).
2. Turn on your iCliker by pressing the "ON/OFF" button; the blue "POWER" light should come on. If the red "LOW BATTERY" light comes on, you should replace your batteries soon.
3. Transmit your answer as follows:
   a. Press the button corresponding to the answer you've selected (A thru E).
   b. The "STATUS" light will flash green to indicate that your answer has been received. If the "STATUS" light flashed red, your answer was not received; you should re-send it until you get a green "STATUS" light.

Bio 112 Action Potentials

Shown below is a very short axon (the dendrites, cell body, and terminus are omitted for clarity).

Key:





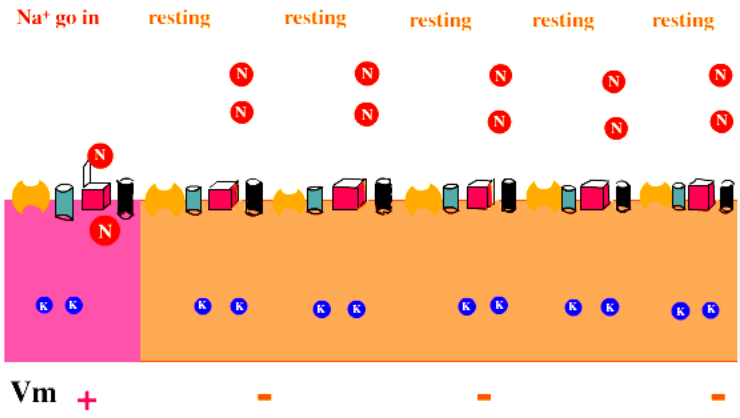
⇐ Inside cell: Na^+ low K^+ HIGH

(1) Resting state: Na^+/K^+ pump: running

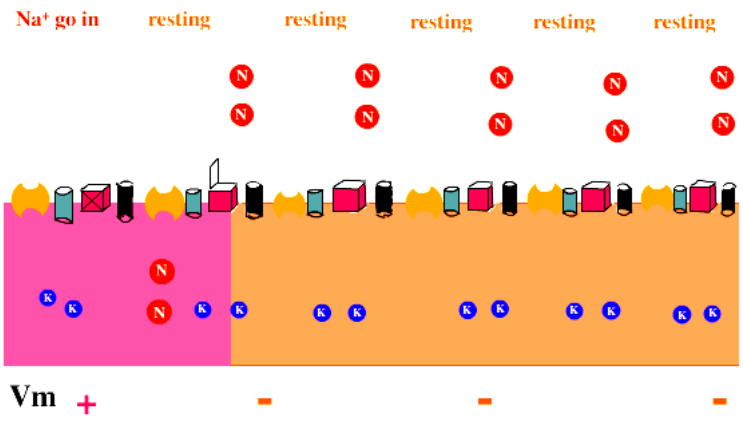
⇐ Outside cell: Na^+ HIGH
K^+ low

⇐ cell membrane: Na^+/K^+ pump: running
Na^+ channel closed
K^+ channel open (V-gated: closed)
⇒ K^+ leak out ⇒ V_m = -70mV

(2) First Na^+ channel opens.
⇒ Na^+ go in faster than K^+ are going out
⇒ V_m becomes + right near open channel



(3) A (+) V_m near the next Na^+ channel triggers that channel to open ⇒ V_m becomes + nearby

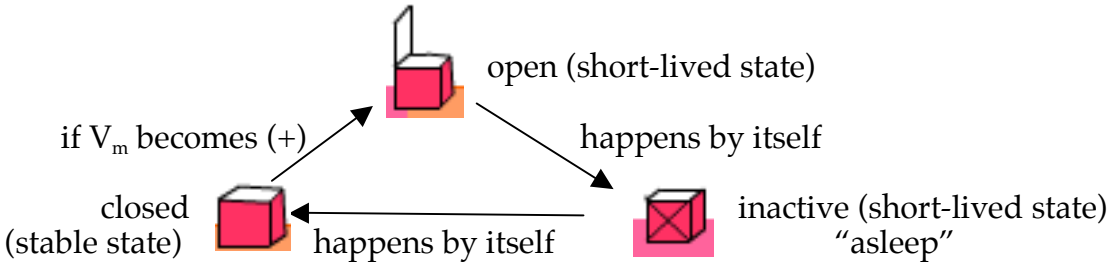


4) Wave of depolarization (V_m +) spreads along axon ⇒.
This wave of depolarization = **<u>an action potential</u>**

5) Problem: if Na^+ channels stay open when V_m is (+), then how do you send the next pulse?

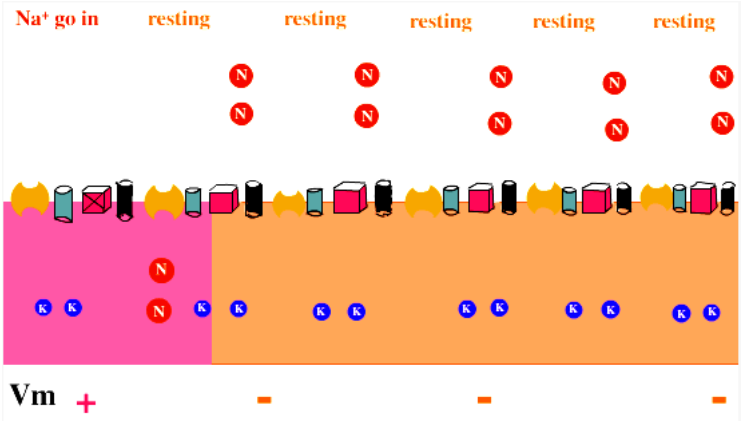
Answer: the Na^+ channel has an **<u>inactive</u>** state.

- After it has been open for about 0.001 seconds, it automatically closes & becomes inactive
  (closed no matter what V_m is)
- about 0.001 seconds after that, it becomes closed & ready to be opened again
  (by then, the membrane has re-polarized)

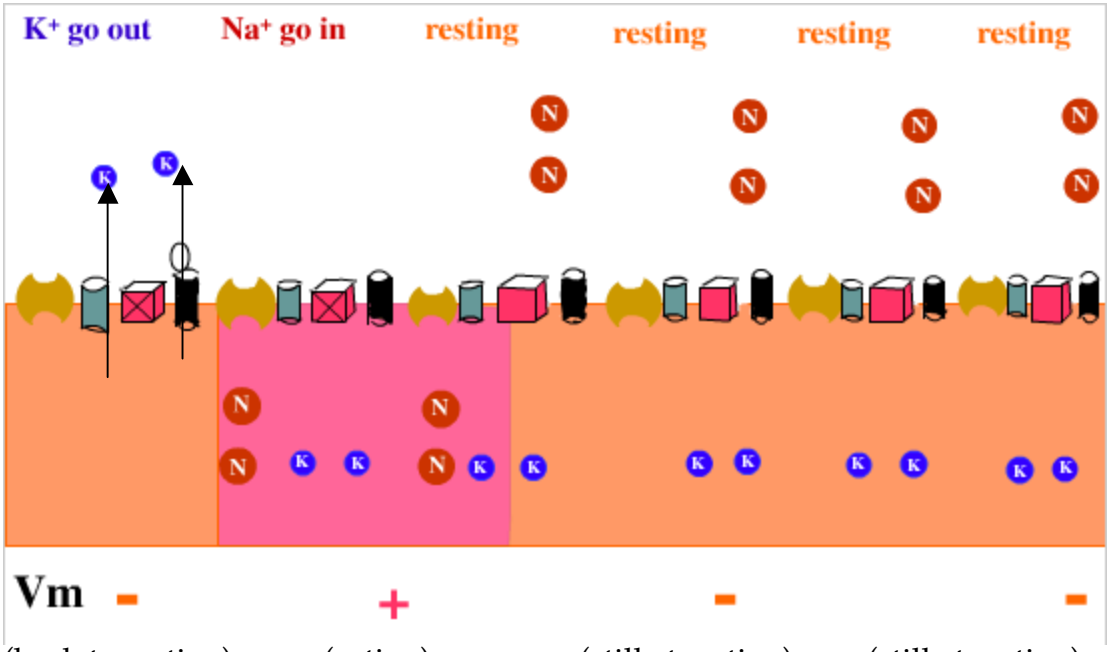


(6) How does this work? Here is an action potential moving ⇒ along the axon

The first Na^+ channel to open is the first to inactivate.

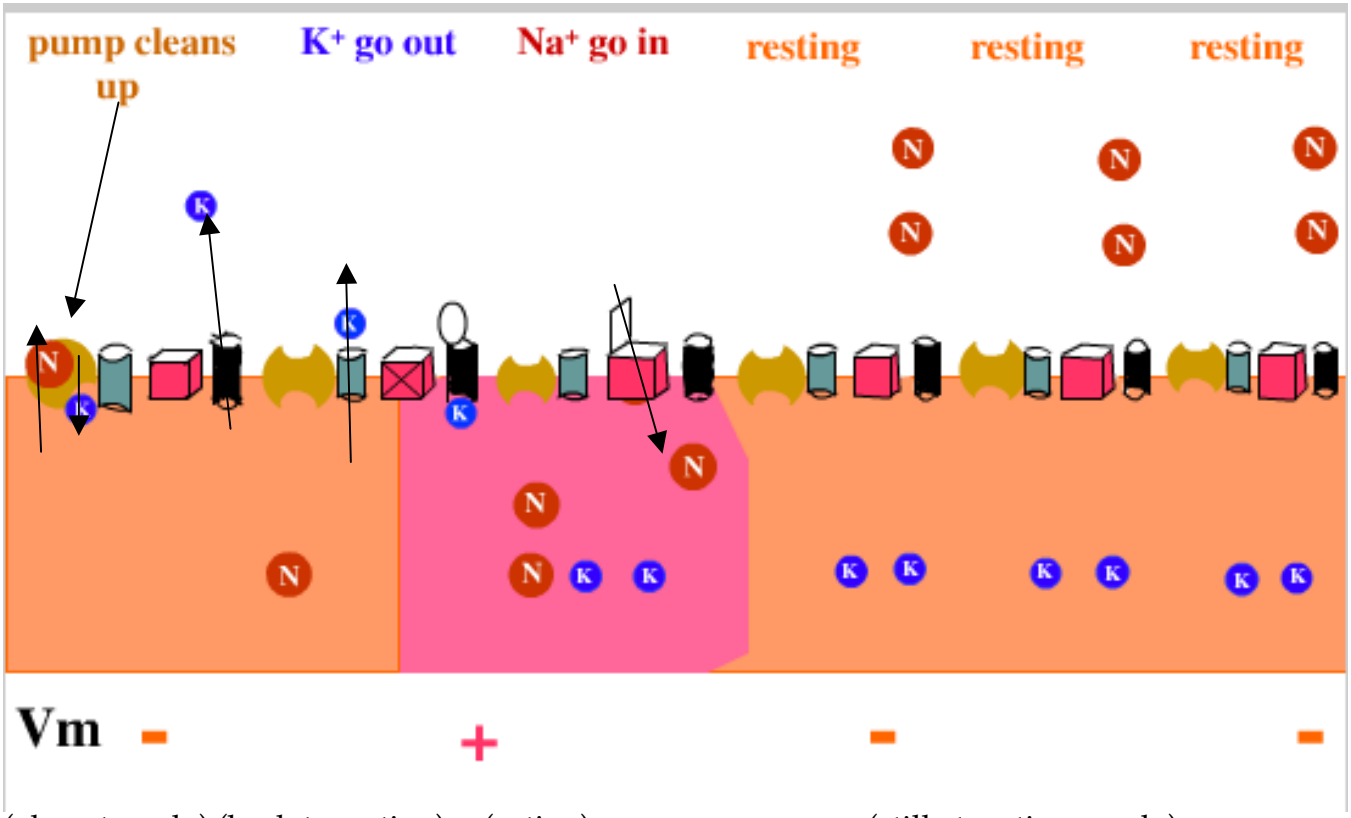


(7) How is the resting potential restored? Lots of K^+ rush out through K^+ channels (repelled by + charge inside) and neutralize the + charge inside. Also, voltage-gated K^+ channels open to allow faster K^+ out-flow.



(back to resting) (action) (still at resting) (still at resting)

(8) Finally, the Na^+/K^+ pump "cleans up the mess" by pumping the Na^+ back out and the K^+ back in.



(almost ready) (back to resting) (action) (still at resting; ready)

What is an action potential? A wave of depolarization going along an axon:

	AFTER		◄— DURING —►		BEFORE	
State	**ready**	**recharging**	**inactive**	**action**	**ready**	**ready**
V_m	–	–	changing	+	–	–
Na^+/K^+ pump	running	running a lot	running	running	running	running
K^+ channel	open	open	open	open	open	open
Na^+ channel	closed	closed	inactive	open	closed	closed
K^+ flow through pump	small in	large in	small in	small in	small in	small in
K^+ flow through channel	small out	small out	large out	small out	small out	small out
Na^+ flow through pump	small out	large out	small out	small out	small out	small out
Na^+ flow through channel	none	none	none	large in	none	none