Mechanisms of Transport

Learning objective 2.8.A Describe the processes that allow ions and other molecules to move across membranes.

Name: Date: Period:

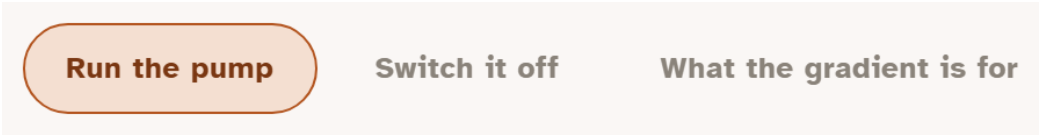
Use the tool **Three Out, Two In**. Work on the **Run the pump** tab for Parts 1 to 3, **Switch it off** for Part 4, and **What the gradient is for** for Part 5. The first time through, step through the cycle one stage at a time before you run ten cycles. Where a Part asks for a prediction, write the prediction before you use the tool to check it.

switch tab *scroll down* *predict first*

record from the tool *score yourself* *reset the tool*

The purple bar in the margin names the AP science practice a question uses.

Part 1 · Walk the cycle



Use the **Run the pump** tab. It is the one showing when the tool opens.

Step 1 is already showing. Press Next step six times to see the other six stages, and record what happens at each. Watch which side the pump opens to, and where the phosphate appears.

Step	**What happens**	**Opens to** *circle one*	**Ions held** *circle one*
1		inside / outside	3 Na^+ / 2 K^+ / none
2		inside / outside	3 Na^+ / 2 K^+ / none
3		inside / outside	3 Na^+ / 2 K^+ / none
4		inside / outside	3 Na^+ / 2 K^+ / none
5		inside / outside	3 Na^+ / 2 K^+ / none
6		inside / outside	3 Na^+ / 2 K^+ / none
7		inside / outside	3 Na^+ / 2 K^+ / none

1. (a) Identify the step at which ATP is hydrolyzed.

(b) Describe the effect of the phosphate group on the pump.

Part 2 · Count what one cycle moves

Stay on the **Run the pump** tab.

Press **Reset**, record the starting numbers, then press **Complete one cycle** once and record them again.

	Na^+ in	Na^+ out	K^+ in	K^+ out	ATP	Potential
At rest						
After 1 cycle						
Change						

2. Using the Change row of the Part 2 table, describe one cycle of the pump. Include the number of each ion moved, the direction each ion moves and the number of ATP molecules used.

3. At rest, sodium is more concentrated outside the cell and potassium is more concentrated inside. The pump moves sodium out and potassium in. Explain why each of these movements requires an input of energy.

Part 3 · Where the charge goes

Stay on the **Run the pump** tab.

Press Reset. Press Complete one cycle and fill in the 1 row, then press it four more times and fill in the 5 row. Press Reset again, press Run ten cycles and fill in the 10 row, then press Run ten cycles again and fill in the 20 row. Na^+ moved out is the Na^+ outside count minus 180; K^+ moved in is the K^+ inside count minus 180. Both ions carry a charge of +1.

Cycles	Na^+ moved out	K^+ moved in	ATP used	Pump's share of the potential
1				
5				
10				
20				

4. Calculate the net charge that leaves the cell in one cycle. Show your work.

5. (a) Explain how the pump contributes to the membrane potential.

(b) Identify the side of the membrane that becomes negative.

SP 4 · REPRESENTING AND DESCRIBING DATA

6. (a) Using the Part 2 table and the counts the tool shows after 20 cycles, calculate the total number of sodium ions, inside plus outside, at rest, after 1 cycle and after 20 cycles.

(b) Explain the pattern in these totals.

Part 4 · Stop paying and see what happens



Click the **Switch it off** tab at the top of the tool.

SP 6 · ARGUMENTATION

Predict the shape of the graph before you press anything. Then press Pump for 20 cycles and record the row, press Switch the pump off and let it leak, and record the last row when the lines stop falling.

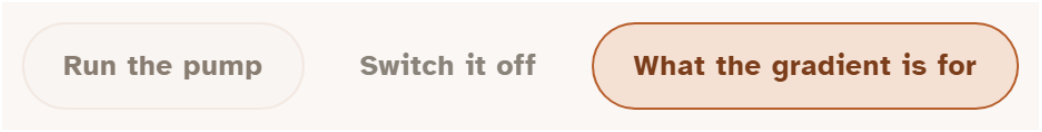
Stage	Na^+ gradient	K^+ gradient	ATP spent so far
At rest			
After 20 cycles of pumping			
After leaking for a long time			

7. Describe how the Na^+ gradient and the K^+ gradient change over time after the pump is switched off.

SP 1 · CONCEPT EXPLANATION

8. The ATP counter did not decrease while the gradients decayed. Explain why a cell must keep spending ATP on the pump to maintain its gradients.

Part 5 · What the gradient is for



Click the **What the gradient is for** tab at the top of the tool.

Step through the **Nerve impulses** card on the What the gradient is for tab, then read the other two entries and answer questions 9 to 11 in complete sentences.

SP 1 · CONCEPT EXPLANATION

9. Explain how a concentration gradient can act as a store of energy.

10. A cell moves glucose in against its concentration gradient by coupling the movement of glucose to the movement of sodium back into the cell. No ATP is used by this transport protein. Explain the source of the energy that moves the glucose.

SP 6 : ARGUMENTATION

11. Researchers block the sodium-potassium pumps of a neuron.
(a) Predict the effect of blocking the pumps on the ability of the neuron to fire repeatedly.

(b) Justify your prediction.

Part 6 · Learning check self-report

Scroll down to the **Learning check** at the bottom of the tool. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

Question	Points possible	Points I earned	Missed opportunities (what the rubric wanted that I left out)
1	2		
2	2		
3	2		
4	3		
Total	**9**		

What the model simplifies

The numbers are ion counts in a small model box, not concentrations in millimoles per liter. They are chosen so that each gradient runs the way a resting cell's does (sodium higher outside, potassium higher inside), while leaving the pump enough to work with.

The pump's share of the potential is shown as a plain count of net charges moved, not in millivolts. A real resting potential of about −70 mV is set mainly by potassium leaving through leak channels, with the pump's direct contribution a small part, and only a tiny fraction of the ions present ever cross. The two leak channels drawn on the first tab are there to show this; the potassium trickling through them is not counted on that tab, so the pump's arithmetic stays exact. The leak is counted on the second tab.

The pump stalls when the inside runs out of sodium. A real cell never reaches that point, because leak channels are letting sodium back in the whole time, which is exactly the situation the second tab shows.

The seven steps are the standard teaching sequence. The real conformational change is continuous, and the pump also has to release the phosphate and rebind ATP.