

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. Step through the cycle one stage at a time the first time round — do not jump straight to running ten cycles. Predicting: wherever a Part asks you to predict, write a specific number or word and one reason before you touch the tool, in the form “I think ... because ...”. A wrong prediction costs nothing; a prediction made after looking is not a prediction.

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

Run the pump

Switch it off

What the gradient is for

- 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 <i>circle one</i>	Ions held <i>circle one</i>
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. At which step is ATP hydrolyzed, and what does the phosphate do to 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. In one sentence, state what the pump moves, which way each ion goes, and how much ATP one cycle uses.

3. Sodium starts more concentrated outside, and the pump sends more of it out. Potassium starts more concentrated inside, and the pump brings more in. Explain what that means about the energy requirement of each movement.

Part 3 · Where the charge goes



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



Reset, then press **Run ten cycles**. 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. Work out the net charge that leaves the cell in one cycle. Show the arithmetic.

5. Explain how the pump contributes to the membrane potential, and state which side becomes negative.

6. Add the inside and outside counts of sodium at 1, 10 and 20 cycles. State what you notice and explain why it must be so.

Part 4 · Stop paying and see what happens

Run the pump

Switch it off

What the gradient is for

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

Pump for 20 cycles, then switch the pump off and let it leak. **Predict the shape of the graph before you press anything.**

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

7. Describe the shape of the two decay curves.

8. The ATP counter did not go back down while the gradients decayed. Explain what that tells you about what a cell is really buying when it spends ATP on the pump.

Part 5 · What the gradient is for

Run the pump

Switch it off

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 these in complete sentences.

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

10. A cell moves glucose in against its own concentration gradient by coupling it to sodium moving back in. No ATP is used at that transport protein. Explain where the energy for moving the glucose actually came from.

11. Predict what would happen to a neuron's ability to fire repeatedly if its sodium-potassium pumps were blocked. Justify your prediction.

Part 6 · Learning check self-report



Scroll down to the **Learning check** at the bottom of the tool. Type each answer in your own words, check it, and tick 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.