Name: _____   **Period:** _____   **Date:** _____

Open **peebedu.com** and navigate to **Sodium-Potassium Pump**. Click the **Start Pumping!** button to begin. Read the introduction popup, which describes the Na+/K+-ATPase pump: it transports 3 Na+ ions out and 2 K+ ions in per cycle, using 1 ATP molecule as an energy source.

Part 1 — Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Na+/K+ Pump Simulator as a scientific model.

M — Mode

What type of model is the Na+/K+ Pump Simulator? Describe how this computational simulation represents active transport across the plasma membrane. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about the sodium-potassium pump.

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A — Accuracy

(a) Identify two things this simulation represents **accurately** about the sodium-potassium pump. For each, name the specific simulation feature and explain what biological concept it demonstrates.

_____

_____

_____

(b) Identify two things this simulation **oversimplifies or leaves out** about active transport by the Na+/K+-ATPase. Consider what you cannot observe in the simulation that would be important for a complete molecular-level understanding of this pump.

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P — Purpose

What is the learning goal of this simulation? Explain how the Na+/K+ Pump Simulator is designed to help you understand why metabolic energy is required to move charged ions across the plasma membrane and how this movement establishes an electrochemical gradient. In your answer, connect at least one specific simulation feature to a biological function of the sodium-potassium pump.

P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Na+/K+ Pump Simulator. Explain why scientific models, including computational simulations, are revised as new evidence becomes available.

Small-Group Discussion

With your group, discuss the following:

- What are the strengths of this simulation as a model for active transport?
- What are its limitations?
- If you could add one feature to improve this simulation, what would it be and why?
- How does the simulation help you connect the concept of ATP hydrolysis to the establishment of an electrochemical gradient?

Part 2 — NGSS Questions

1.

> *Simulation Task: Complete one full pump cycle by dragging 3 Na+ ions from the intracellular space to the pump, adding 1 ATP molecule, then dragging 2 K+ ions from the extracellular space to the pump. Record the membrane potential before and after the cycle.*

Describe what happens during each step of one pump cycle. Explain why the cell needs to use energy from ATP to move sodium and potassium ions instead of allowing them to move on their own.

HS-LS1-3

2.

> *Simulation Task: Complete three full pump cycles. After each cycle, record the membrane potential from the data dashboard (it starts at 0 mV and changes by –5 mV per cycle).*

Explain why the inside of the cell becomes more negatively charged with each pump cycle. In your answer, describe how the unequal exchange of 3 Na+ ions out and 2 K+ ions in creates a charge difference across the membrane.

HS-LS1-3

3.

> *Simulation Task: Try to drag a Na+ ion directly through the membrane without using the pump protein. Then drag a Na+ ion to the pump and observe the difference. Note what happens when the ion reaches the pump's binding site.*

Explain why sodium and potassium ions cannot pass directly through the membrane on their own. Describe the role of the pump protein in allowing these charged ions to cross the membrane.

HS-LS1-3

4.

Simulation Task: During a pump cycle, observe what happens immediately after you add the ATP molecule. Watch the pump protein change shape and the phosphate group (P) attach. Then watch the pump return to its original shape after the K+ ions are released.

Describe the two different shapes the pump protein takes during one cycle. Explain how the energy released from breaking apart ATP causes the pump to change shape and move ions in a specific direction across the membrane.

HS-LS1-7

5.

Simulation Task: Complete five full pump cycles and observe the membrane potential reach −25 mV. Read the target value of −70 mV displayed on the data dashboard. Note how many ATP molecules you have used so far.

The simulation shows that reaching the target membrane potential of −70 mV requires many pump cycles and many ATP molecules. Explain why a cell must continuously run the sodium-potassium pump to maintain stable ion concentrations on each side of the membrane, even after the target potential is reached.

HS-LS1-3

6.

Simulation Task: Observe the arrangement of ions at the start of the simulation (Na+ concentrated inside, K+ concentrated outside) and after five pump cycles (Na+ building up outside, K+ building up inside). Note the membrane potential reading.

In the box below, draw a diagram of a cell membrane with the pump protein. Show the distribution of Na+ and K+ ions on both sides of the membrane after several pump cycles. Use arrows to indicate the direction each ion type is moved by the pump, and label which side is positively charged and which is negatively charged.

Draw your diagram here.

HS-LS1-7

7.

Simulation Task: Read the "Why It Matters" section from the introduction popup (click "View Introduction" to reopen it). Note the connection between the −70 mV resting potential and the ability of neurons to fire signals.

Nerve cells depend on the charge difference created by the sodium-potassium pump to send electrical signals throughout the body. Explain how the ion gradient established by the pump makes it possible for a nerve cell to rapidly transmit a signal, and predict what would happen to an organism's ability to sense and respond to its environment if the pump stopped working.

HS-LS1-2