

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.

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.

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 – Free Response Questions

Conceptual Analysis

Question 1 – Active Transport and Electrochemical Gradients

Simulation Task: Complete one full pump cycle by dragging 3 Na⁺ ions to the pump, adding 1 ATP molecule, then dragging 2 K⁺ ions to the pump. Observe the membrane potential readout before and after the cycle. Then complete two more cycles and record the membrane potential after each.

(A) (1 pt) **Describe** how the Na⁺/K⁺-ATPase uses metabolic energy from ATP to transport sodium and potassium ions across the plasma membrane against their concentration gradients.

(B) (1 pt) **Explain** why the asymmetric exchange of 3 Na⁺ ions out and 2 K⁺ ions in per pump cycle results in the inside of the cell becoming negatively charged relative to the outside.

(C) (1 pt) **Predict** what would happen to the membrane potential and ion concentrations if a cell's mitochondria were poisoned and could no longer produce ATP.

(D) (1 pt) **Justify** your prediction using the relationship between ATP availability and the ability of the Na⁺/K⁺-ATPase to maintain the electrochemical gradient across the plasma membrane.

Analyze Model / Visual Representation

Question 2 – Membrane Proteins and Ion Transport

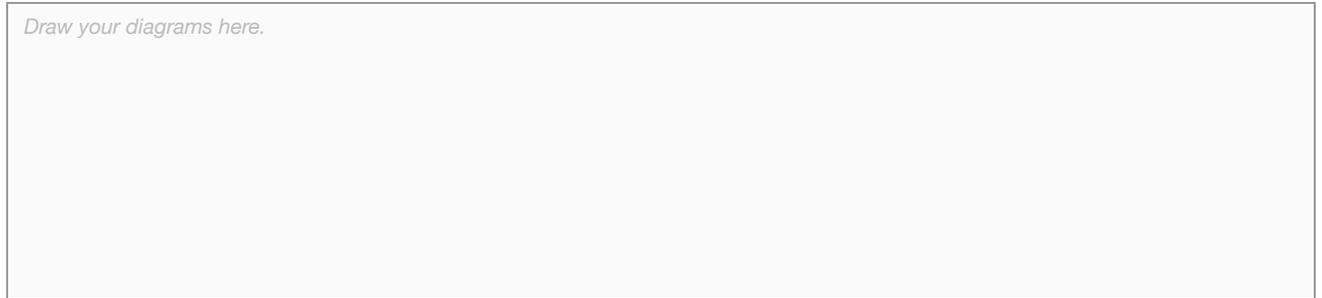
Simulation Task: Attempt to drag a Na⁺ ion directly through the membrane (not to the pump protein). Then drag a Na⁺ ion to the pump and observe what happens. Complete one full pump cycle and note the conformational change of the pump protein.

(A) (1 pt) **Describe** why charged ions such as Na⁺ and K⁺ require transport proteins to cross the plasma membrane rather than passing directly through the phospholipid bilayer.

(B) (1 pt) **Explain** the relationship between the conformational change of the Na⁺/K⁺-ATPase pump protein, the hydrolysis of ATP, and the directional movement of ions across the membrane.

(C) (1 pt) **Represent** the Na⁺/K⁺ pump cycle.

Draw your diagrams here.



(D) (1 pt) **Explain** how a mutation in the gene encoding the Na⁺/K⁺-ATPase pump protein could alter the protein's structure and reduce its transport function.

EK 2.6.A.1, EK 2.8.A.1