PEEBEDU

Powerhouse Mitochondria Simulator

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

> Open **peebedu.com** and navigate to **Powerhouse (Mitochondria Simulator)**. Click the **Start Game!** button to begin. Read the instructions popup, which describes how to use the Eat button to spawn glucose, the Breathe button to spawn O_2 and clear CO_2, and how to drag and drop molecules into reaction zones to trigger each stage of cellular respiration.

Part 1 — Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Powerhouse Mitochondria Simulator as a scientific model.

M — Mode

What type of model is the Powerhouse Mitochondria Simulator? Describe how this computational simulation represents cellular respiration. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about how cells extract energy from glucose.

A — Accuracy

(a) Identify two things this simulation represents **accurately** about cellular respiration. For each, name the specific simulation feature and explain what aspect of the metabolic pathway it demonstrates.

(b) Identify two things this simulation **oversimplifies or leaves out** about cellular respiration. Consider what you cannot observe in the simulation that would be important for a complete understanding of how mitochondria produce ATP.

P — Purpose

What is the learning goal of this simulation? Explain how the Powerhouse Mitochondria Simulator is designed to help you understand how cells break down glucose through a series of connected metabolic stages to produce ATP. In your answer, connect at least one specific simulation feature to a biological reason why cells need to produce ATP continuously.

P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Powerhouse Mitochondria 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 cellular respiration?
- 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 individual stages of cellular respiration to the overall goal of ATP production?

Part 2 — Free Response Questions

Conceptual Analysis

Question 1 — Electron Carriers and ATP Yield in Cellular Respiration

> *Simulation Task: Click "Eat" to spawn glucose. Drag one glucose molecule into the Glycolysis zone and click the zone to trigger the reaction. Observe the products that appear and note the ATP counter. Continue dragging products through Pyruvate Oxidation and the Krebs Cycle, triggering each reaction. Record the number of NADH, $FADH_2$, CO_2, and ATP produced at each stage.*

(A) (1 pt) **Describe** the role of NAD^+ and FAD as electron carriers in cellular respiration.

(B) (1 pt) **Explain** why the Krebs cycle produces more electron carriers (NADH and $FADH_2$) than ATP through substrate-level phosphorylation.

(C) (1 pt) **Predict** what would happen to a cell's total ATP production if a mutation in a mitochondrial gene caused the NADH dehydrogenase complex (Complex I of the ETC) to function at only 50% efficiency.

(D) (1 pt) **Justify** your prediction by explaining the connection between electron carrier oxidation in the electron transport chain, the proton gradient, and ATP synthesis by ATP synthase.

EK 3.5.B.1, 3.5.B.2, 3.5.B.3, 3.5.B.4

Analyze Model / Visual Representation

Question 2 — Oxygen as the Final Electron Acceptor

> *Simulation Task: After completing glycolysis, pyruvate oxidation, and the Krebs cycle for one glucose molecule, observe the NADH and $FADH_2$ molecules that have accumulated in the Oxidative Phosphorylation zone. Note the electron progress bar reading. Then click "Breathe" to spawn O_2, drag one O_2 molecule into the OxPhos zone, and trigger the reaction. Observe the product formed and the ATP counter change.*

(A) (1 pt) **Describe** the function of oxygen in oxidative phosphorylation.

(B) (1 pt) **Explain** why the simulation requires students to click "Breathe" before oxidative phosphorylation can proceed.

(C) (1 pt) **Represent** the flow of electrons and energy through the four stages of cellular respiration.

Draw your diagram here.

(D) (1 pt) **Explain** how a disruption in oxygen delivery to tissues (such as during ischemia caused by a blocked blood vessel) could lead to cell death.

EK 3.5.B.5