**PEEBEDU**

# Powerhouse Mitochondria Simulator

Unit 3: Cellular Energetics

**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 — NGSS Questions

**1.**

> *Simulation Task: Click "Eat" to spawn glucose molecules. Drag one glucose molecule into the Glycolysis zone and click the zone to trigger the reaction. Observe the products that appear and read the ATP counter.*

Describe what happens to a glucose molecule during glycolysis. In your answer, identify the products the simulation shows and explain why this first stage takes place in the cytoplasm rather than inside the mitochondrion.

HS-LS1-7

**2.**

> *Simulation Task: Drag the pyruvate molecules produced by glycolysis into the Pyruvate Oxidation zone and trigger the reaction. Then drag the resulting Acetyl-CoA molecules into the Krebs Cycle zone and trigger that reaction. Record the total number of NADH, $FADH_2$, and $CO_2$ molecules produced across both stages.*

Explain why the Krebs cycle produces many electron-carrier molecules (NADH and $FADH_2$) but only a small amount of ATP directly. Describe what role these electron carriers play in the overall process of releasing energy from food.

HS-LS1-7

**3.**

> *Simulation Task: After completing the Krebs cycle, observe the NADH and $FADH_2$ molecules that have accumulated in the Oxidative Phosphorylation zone and the electron progress bar. Click "Breathe" to spawn $O_2$, drag one $O_2$ molecule into the zone, and trigger the reaction. Watch the ATP counter jump and note the $H_2O$ produced.*

Explain the role of oxygen in the final stage of cellular respiration. Describe what happens to the electrons carried by NADH and $FADH_2$ and why the cell cannot continue producing large amounts of ATP without a steady supply of oxygen.

HS-LS1-7

**4.**

> *Simulation Task: Process one complete glucose molecule through all four stages (Glycolysis, Pyruvate Oxidation, Krebs Cycle, and Oxidative Phosphorylation). Record the total ATP shown on the counter after each stage is finished.*

Compare the amount of ATP produced during glycolysis and the Krebs cycle to the amount produced during oxidative phosphorylation. Explain why the final stage generates the greatest share of ATP and how the earlier stages contribute to this outcome.

HS-LS1-7

**5.**

> *Simulation Task: After triggering the Krebs cycle, observe the $CO_2$ molecules that appear in the game area. Click "Breathe" and notice that the $CO_2$ molecules are cleared from the cell while new $O_2$ molecules are spawned.*

Identify where $CO_2$ is released during cellular respiration and explain why it is considered a waste product. Describe how the simulation models the exchange of gases that occurs between a cell and its environment.

HS-LS1-7

**6.**

> *Simulation Task: Click "Store ATP & Finish" to view the summary screen. Review the total ATP count and the stages you completed. Then reset the game and look at the full layout showing all four reaction zones and the mitochondrion.*

In the box below, draw a diagram that traces the path of a glucose molecule through all four stages of cellular respiration. Label each stage, its location (cytoplasm or mitochondrion), and the key inputs and outputs at each stage. Use arrows to show the flow of matter from one stage to the next.

Draw your diagram here.

HS-LS1-7

**7.**

> *Simulation Task: Run through one full glucose cycle again. Pay attention to the $CO_2$ released during pyruvate oxidation and the Krebs cycle, and the $O_2$ consumed during oxidative phosphorylation. Think about where the glucose originally came from before the cell consumed it.*

Plants use carbon dioxide and water to build glucose during photosynthesis, and organisms break that glucose back down during cellular respiration, releasing carbon dioxide. Explain how these two processes form a cycle that moves carbon through living systems and the atmosphere. Describe what would happen to atmospheric carbon dioxide levels if one of these processes were significantly reduced.

HS-LS2-5