PEEBEDU

Cellular Energy and Thermodynamics

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

> Open **peebedu.com** and navigate to **Cellular Energy and Thermodynamics**. Click the **Start Exploring** button to begin. Read the introduction popup, which describes how cells use free energy to maintain order and how ATP couples exergonic and endergonic reactions.

Part 1 — Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Cellular Energy and Thermodynamics simulation as a scientific model.

M — Mode

What type of model is the Cellular Energy and Thermodynamics simulation? Describe how this computational simulation represents energy flow in living cells. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about cellular energy.

A — Accuracy

(a) Identify two things this simulation represents **accurately** about cellular energy and thermodynamics. For each, name the specific simulation feature and explain what principle of energy flow it demonstrates.

(b) Identify two things this simulation **oversimplifies or leaves out** about cellular energy and thermodynamics. Consider what you cannot observe in the simulation that would be important for a complete understanding of how cells manage energy.

P — Purpose

What is the learning goal of this simulation? Explain how the Cellular Energy and Thermodynamics simulation is designed to help you understand why living systems require a continuous input of free energy to maintain order and how cells use ATP to couple exergonic and endergonic reactions. In your answer, connect at least one specific simulation feature to a biological consequence of energy loss.

P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Cellular Energy and Thermodynamics simulation. 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 energy flow?
- 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 laws of thermodynamics to visible cellular consequences?

Part 2 — Free Response Questions

Conceptual Analysis

Question 1 — Free Energy and the Maintenance of Cellular Order

> *Simulation Task: Use the energy balance sliders to set cellular energy input to its maximum level and observe the cell. Then gradually reduce the energy input to zero and observe the cellular failure animation. Finally, use the restore energy feature to return the cell to its functioning state.*

(A) (1 pt) **Describe** the relationship between free energy input and the maintenance of cellular order.

(B) (1 pt) **Explain** why the cell in the simulation undergoes structural breakdown when energy input is reduced to zero.

(C) (1 pt) **Predict** what would happen to a multicellular organism's tissues if the supply of glucose to its cells were completely blocked for an extended period.

(D) (1 pt) **Justify** your prediction by explaining how the laws of thermodynamics require a continuous input of free energy for cells to maintain the ordered structures necessary for life.

EK 3.3.A.1

Analyze Model / Visual Representation

Question 2 — ATP Coupling of Exergonic and Endergonic Reactions

> *Simulation Task: Use the ATP Molecule Builder to build one ATP molecule from ADP and inorganic phosphate. Then break the ATP molecule and observe the energy released. Next, use the enzyme selection system to catalyze one step in the metabolic pathway and observe how the molecule counter tracks the energy transformation.*

(A) (1 pt) **Describe** the difference between exergonic and endergonic reactions in terms of free energy change (ΔG).

(B) (1 pt) **Explain** how ATP functions as the energy currency of the cell by coupling exergonic reactions to endergonic reactions.

(C) (1 pt) **Represent** the ATP cycle and energy coupling.

Draw your diagram here.

(D) (1 pt) **Explain** how a disruption in a metabolic pathway could reduce an organism's ATP production and, over generations, act as a selective pressure on a population.

EK 3.3.A.2, EK 3.3.A.3