

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 – NGSS Questions

1.

Simulation Task: Use the energy balance sliders to set cellular energy input to its maximum level. Observe the cell and read the molecule counter display showing ATP levels. Then gradually reduce the energy input to zero and watch the cellular failure animation unfold.

Describe how the cell changes as energy input decreases from maximum to zero. Using your observations, explain why cells need a constant supply of energy to maintain their organized structures and carry out life processes.

HS-LS1-7

2.

Simulation Task: Use the ATP Molecule Builder to build one ATP molecule from ADP and inorganic phosphate. Observe the energy that must be added during this process. Then break the ATP molecule and observe the energy that is released.

Explain how cells store energy by building ATP and release energy by breaking it apart. Describe what role this cycle plays in transferring energy from food molecules to the cellular processes that require it.

HS-LS1-7

3.

Simulation Task: Use the enzyme selection system to catalyze the steps of the metabolic pathway, starting from glucose. Follow each step through glycolysis, pyruvate processing, the citric acid cycle, and the electron transport chain. Watch the molecule counter track ATP production at each stage.

Describe how energy stored in a glucose molecule is transferred through a series of chemical reactions to produce ATP. Explain why energy is released in small, controlled steps rather than all at once, and how this benefits the cell.

HS-LS1-7

4.

Simulation Task: After reducing energy input to zero and observing the cellular failure animation (ion pump failure, membrane deterioration, protein breakdown), use the restore energy feature to return the cell to its functioning state. Compare the cell before failure and after restoration.

Explain why a cell naturally moves toward disorder when energy is no longer available. Describe how restoring energy input allows the cell to rebuild its organized structures, and explain what this demonstrates about the relationship between energy flow and the organization of living systems.

HS-LS1-7

5.

Simulation Task: Build and break several ATP molecules using the ATP Molecule Builder. Pay attention to the energy values displayed during each process. Notice that the energy released when ATP is broken is always less than the total energy originally stored in the food molecule.

Explain why the total amount of usable energy decreases each time energy is transferred from one molecule to another. Describe what happens to the portion of energy that is not captured in ATP and explain why no energy transfer in a cell is perfectly efficient.

HS-LS1-7

6.

Simulation Task: Observe the full metabolic pathway in the simulation, from glucose entering the cell through ATP production. Note how energy flows from food molecules through chemical reactions and into ATP, and how some energy is lost as heat at each step.

In the box below, draw a diagram that traces the flow of energy from a food molecule (such as glucose) through the cell. Show energy being transferred to ATP and then to a cellular process (such as active transport or muscle contraction). Include arrows showing where energy is lost as heat at each transfer. Label all parts of your diagram.

Draw your diagram here.

HS-LS2-3

7.

Simulation Task: Run the full simulation sequence: maximize energy input, catalyze the complete metabolic pathway from glucose to ATP, and observe the molecule counter showing carbon-containing molecules at each stage. Consider where the carbon atoms in glucose end up after cellular respiration is complete.

When cells break down glucose for energy, carbon atoms from that molecule are released as carbon dioxide. Explain how this process connects individual cells to the global carbon cycle. Describe how carbon atoms move from the atmosphere into living organisms and back again, and explain why this cycling of matter is essential for sustaining life in ecosystems.

HS-LS2-5