PEEBEDU

Endosymbiotic Theory Interactive (NGSS)

Name: ____________________ **Period:** ________ **Date:** ____________

Open **peebedu.com** and navigate to **Endosymbiotic Theory Interactive**. Click the **Launch Interactive** button to begin. In Level 0, observe the different prokaryotes and their metabolic inputs and outputs. Click on the prokaryote that consumes glucose and O_2 to produce ATP. Progress through the educational slides and quizzes, then continue through all four levels by following the on-screen instructions.

Part 1 — Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Endosymbiotic Theory Interactive as a scientific model.

M — Mode

What type of model is the Endosymbiotic Theory Interactive? Describe how this game-based simulation represents the process of endosymbiosis. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about the origin of eukaryotic organelles.

A — Accuracy

(a) Identify two things this simulation represents **accurately** about the endosymbiotic theory. For each, name the specific simulation feature and explain what aspect of endosymbiosis it demonstrates.

(b) Identify two things this simulation **oversimplifies or leaves out** about endosymbiosis. Consider what you cannot observe in the simulation that would be important for a complete understanding of how mitochondria and chloroplasts originated from free-living prokaryotes.

P — Purpose

What is the learning goal of this simulation? Explain how the Endosymbiotic Theory Interactive is designed to help you understand how membrane-bound organelles such as mitochondria and chloroplasts evolved from once free-living prokaryotic cells. In your answer, connect at least one specific simulation feature to the evidence that supports the endosymbiotic theory.

P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Endosymbiotic Theory Interactive. 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 endosymbiotic theory?
- What are its limitations?
- If you could add one feature to improve this simulation, what would it be and why?
- How does progressing through the levels help you understand the sequence of evolutionary events that led to eukaryotic cells?

Part 2 — NGSS Questions

1.

> *Simulation Task: Complete Level 0 by observing the different prokaryotes. Click on the aerobic prokaryote that consumes glucose and O_2 to produce ATP. After clicking, read the information screen comparing aerobic respiration (36 ATP per glucose) to fermentation (2 ATP per glucose).*

The simulation shows that aerobic prokaryotes produce 36 ATP per glucose molecule while anaerobic prokaryotes produce only 2 ATP. Explain how this difference in energy output would have given an ancient cell that engulfed an aerobic prokaryote a survival advantage over cells that relied only on fermentation.

HS-LS4-1

2.

> *Simulation Task: After engulfing the aerobic prokaryote in Level 1, read the "Evidence for Endosymbiotic Theory" info screen. Pay attention to the five pieces of evidence listed: own DNA, binary fission, double membrane, bacterial-like ribosomes, and phylogenetic similarity.*

Choose two pieces of evidence from the info screen and explain how each one supports the idea that mitochondria descended from free-living bacteria that were taken in by a larger cell long ago.

HS-LS4-1

3.

> *Simulation Task: In Level 2, collect oxygen and glucose molecules by moving your cell over them. Watch how the molecules travel to the mitochondrion inside your cell and are converted into ATP, CO_2, and H_2O.*

The simulation shows molecules entering the cell and being processed inside the mitochondrion. Explain how the double membrane surrounding the mitochondrion serves as evidence that an ancient cell engulfed a prokaryote, resulting in one membrane from the host cell and one from the engulfed organism.

HS-LS4-1

4.

> *Simulation Task: Complete Level 3 by engulfing a cyanobacterium in the sunlit zone. Read the "Origin of Chloroplasts" info screen that appears afterward, noting how the evidence for chloroplast origins mirrors the evidence for mitochondria.*

The simulation presents similar evidence for the origin of both mitochondria and chloroplasts (own circular DNA, double membrane, independent division, bacterial-like proteins). Explain what this pattern of shared evidence tells us about common ancestry and how scientists use it to support the idea that endosymbiosis happened more than once during the history of life.

HS-LS4-1

5.

> *Simulation Task: In Level 4, observe the complete eukaryotic cell with both mitochondria and chloroplasts. Watch how molecules cycle between the two organelles: chloroplasts produce glucose and O_2 in sunlight, and mitochondria use those molecules to produce ATP, CO_2, and H_2O.*

The simulation shows molecules being exchanged between chloroplasts and mitochondria inside a single cell. Describe this exchange and explain how the partnership between these two organelles allows the cell to capture light energy and convert it into usable chemical energy more efficiently than either organelle could alone.

HS-LS4-1

6.

> *Simulation Task: Compare the prokaryotic cells in Level 0 (no internal organelles) with the eukaryotic cell in Level 4 (containing mitochondria and chloroplasts). Note the differences in size, internal structure, and membrane organization.*

In the box below, draw a timeline diagram showing the key steps of endosymbiosis. Include: (1) an ancient anaerobic cell, (2) the engulfment of an aerobic prokaryote that becomes a mitochondrion, and (3) the later engulfment of a cyanobacterium that becomes a chloroplast. Label the double membranes on each organelle and indicate that each retains its own circular DNA.

Draw your timeline diagram here.

HS-LS4-1

7.

> *Simulation Task: Replay Level 3 and observe the cyanobacteria performing photosynthesis in the sunlit zone, converting CO_2 and H_2O into glucose and O_2. Then review the educational slides about the Great Oxidation Event, which describe how cyanobacteria transformed Earth's atmosphere.*

The simulation shows cyanobacteria releasing oxygen through photosynthesis. The educational slides explain that ancient cyanobacteria caused the Great Oxidation Event, which dramatically changed Earth's atmosphere. Explain how the evolution of photosynthesis in cyanobacteria and the later incorporation of these organisms into eukaryotic cells as chloroplasts influenced the flow of energy through living systems on Earth.

HS-LS1-5