PEEBEDU Unit 3: Cellular Energetics

Reaction Diagram Sandbox (NGSS)

Name: ____________________ **Period:** ________ **Date:** ______________

> Open **peebedu.com** and navigate to **Reaction Diagram Sandbox**. Click the **Start Drawing** button to begin. Read the introduction popup, which describes two interaction modes (Move and Assign), drawing tools for building reaction pathways, and key features including real-time energy calculations and solution checking.

Part 1 — Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Reaction Diagram Sandbox as a scientific model.

M — Mode

What type of model is the Reaction Diagram Sandbox? Describe how this computational simulation represents chemical reaction pathways. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about enzyme-catalyzed reactions and energy flow.

A — Accuracy

(a) Identify two things this simulation represents **accurately** about enzyme catalysis and reaction pathways. For each, name the specific simulation feature and explain what biological concept it demonstrates.

(b) Identify two things this simulation **oversimplifies or leaves out** about biochemical reaction pathways. Consider what you cannot observe in the simulation that would be important for a complete understanding of how enzymes catalyze reactions and how energy flows through metabolic pathways.

P — Purpose

What is the learning goal of this simulation? Explain how the Reaction Diagram Sandbox is designed to help you understand how enzymes lower activation energy to speed up biological reactions and how cells couple exergonic reactions with endergonic reactions to drive cellular processes. In your answer, connect at least one specific simulation feature to a biological example of why that concept matters for living organisms.

P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Reaction Diagram Sandbox. 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 enzyme catalysis and energy coupling?
- 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 concept of activation energy to the role of enzymes in metabolic pathways?

Part 2 — NGSS Questions

1.

> *Simulation Task: Drag Molecule A and Molecule B onto the canvas. Switch to Assign Mode and create the reaction A + B → C. Click Run Simulation and observe the energy diagram that appears, noting the energy level of the reactants compared to the products.*

Describe what happens to the overall energy of the system when A + B react to form C. Using the energy diagram in the simulation, explain whether this reaction releases energy to the surroundings or absorbs energy from the surroundings, and identify the evidence from the diagram that supports your answer.

HS-LS1-7

2.

> *Simulation Task: With the reaction A + B → C still on the canvas, observe the peak of the energy curve between reactants and products. This peak represents the activation energy. Note its height relative to the starting energy of the reactants.*

Explain what activation energy represents in a chemical reaction and why reactions do not happen instantly even when the products have less energy than the reactants. Describe how the height of the energy peak in the simulation relates to how easily a reaction can get started.

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3.

> *Simulation Task: Drag Enzyme E1 from the toolbox onto the reaction arrow for A + B → C. Click Run Simulation and compare the new energy diagram to the uncatalyzed version. Pay attention to how the height of the energy peak changes.*

Describe how adding Enzyme E1 to the reaction changes the energy diagram. Explain how enzymes speed up reactions in living cells by lowering the activation energy barrier rather than changing the overall energy difference between reactants and products.

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4.

> *Simulation Task: Clear the canvas and select the "6 Molecules – Metabolic Cycle" preset template from the dropdown menu. Click Run Simulation and observe how molecules flow through the pathway. Note which steps release energy and which steps require energy input.*

Explain how cells use energy-releasing reactions to power energy-requiring reactions within a metabolic pathway. Using what you observed in the metabolic cycle simulation, describe how the overall flow of energy through the pathway allows the cell to carry out processes that would not happen on their own.

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5.

> *Simulation Task: With the "6 Molecules – Metabolic Cycle" still loaded, switch to Assign Mode and add a negative feedback arrow from the final product back to an earlier enzyme-catalyzed step. Run the simulation again and observe how the rate of the pathway changes when the product accumulates.*

Describe how the negative feedback loop you added changes the behavior of the metabolic cycle. Explain why feedback regulation of enzyme activity is important for cells to maintain stable internal conditions and avoid wasting energy or resources.

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6.

> *Simulation Task: Clear the canvas. Build two separate reactions: one where the products have lower energy than the reactants (energy-releasing) and one where the products have higher energy than the reactants (energy-requiring). Run each one and compare their energy diagrams.*

In the box below, draw two energy diagrams side by side: one for an energy-releasing reaction and one for an energy-requiring reaction. Label the reactants, products, and activation energy in each diagram. Draw an arrow on each diagram showing whether the overall energy change is a decrease or an increase.

Draw your diagrams here.

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7.

> *Simulation Task: Select the "5 Molecules – Branched Pathway" preset template and click Run Simulation. Observe how a single starting molecule can be transformed through different branches, with each branch producing different products.*

Living organisms break down food molecules through branching metabolic pathways, releasing energy at multiple steps and producing various carbon-containing products. Using what you observed in the branched pathway simulation, explain how the energy stored in carbon-based molecules is transferred through a series of chemical reactions and why organisms depend on these stepwise energy transfers rather than releasing all the energy at once.

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