Name: _____ **Date:** _____

Section: _____

Aquarium Simulator Activity

Investigating Bacterial Nitrification: Enzyme Kinetics and Biogeochemistry

Phase 1: ENGAGE (10 minutes)

Getting Started: Open peebedu.com and navigate to Aquarium Simulator

Research Context: Read the introduction popup in the simulator, then consider this excerpt from *Martiny et al. (2021) Nature Reviews Microbiology*:

¿'Microbial communities drive Earth's biogeochemical cycles, yet predicting their responses to environmental perturbations remains challenging. In aquatic systems, the sequential oxidation of nitrogen compounds ($NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$) requires distinct microbial guilds with specific metabolic capabilities...'

Pre-Investigation Questions: Based on the reading, predict what will happen to ammonia, nitrite, and nitrate concentrations over time in the aquarium.

What role do bacteria play in transforming nitrogen compounds? _____

Phase 2: EXPLORE (15 minutes)

Systematic Investigation

Using the simulator controls, explore the nitrogen cycle:

Initial Setup: Add fish to start the nitrogen cycle

- Prediction: What will happen to nitrogen compounds? _____

Add Bacteria: Click to add nitrifying bacteria

- Prediction: How will this affect the nitrogen compounds? _____

Add Plants: Add aquatic plants to the system

- Prediction: What role will plants play? _____

Data Collection Table: Nitrogen Transformation

Pattern Check: Compare observations with a partner. What patterns do you both see? _____

Phase 3: EXPLAIN (10 minutes)

Pattern Analysis and Scientific Explanation

Graph your data: Create a line graph showing changes in NH_3, NO_2^-, and NO_3^- over time.

Identify Patterns (List at least 3):

- Pattern 1: _____

- Pattern 3: _____

Cause-and-Effect Relationships:

- When fish were added, what happened? Why? _____

- What triggers the conversion of NH_3 to NO_2^-? _____

Systems Thinking: Create a diagram showing:

- How organisms interact in the nitrogen cycle
- Which changes trigger other changes
- Any feedback loops you observed

CER Statement: Write a claim about the nitrogen cycle supported by your evidence.

Phase 4: ELABORATE (10 minutes)

Connecting to Human Impacts

Scenario: Agricultural runoff adds ammonia to a lake ecosystem.

Based on your observations, answer: What pattern of nitrogen transformations would you expect to see? _____ Why might excess nitrate lead to eutrophication? _____ How does this connect to EK 8.7.C.1 about human impacts on ecosystems? _____

Phase 5: EVALUATE (5 minutes)

Assessment Questions

Pattern Recognition: Describe two patterns you observed in the nitrogen cycle. For each pattern, explain what causes it. (4 pts)

Cause-and-Effect: If you add more fish to an established aquarium, predict the sequence of changes that would occur. Explain why each change triggers the next. (3 pts)

Systems Thinking: How do bacteria, plants, and fish interact in the nitrogen cycle? What would happen to the system if one component was removed? (3 pts)

Model Evaluation: Complete the Model Evaluation Form, focusing on which patterns the model shows well and which real-world complexities it simplifies.