Something is Fishy in the Nitrogen Cycle

Adapted from	https://petsintheclassroom.org/wp-content/uploads/2016/08/Goodney-6th-8th-Fish.pdf
Pet: **Fish**	**Class:** **6-8**

Brief Overview:
Students will set up a new aquarium and monitor the daily changes in ammonia, nitrite, nitrate, and pH levels. They will analyze their data to understand how bacterial activity affects these parameters and contributes to a healthy aquatic ecosystem.
This lesson could be adapted for other grades.

Essential Question
How do the levels of nitrogen compounds and pH change in a newly set-up aquarium, and how do these changes relate to the activity of bacteria and the health of the aquatic ecosystem?

Lesson Breakdown
Lesson 1: What is the NItrogen Cycle
Lesson 2: Setting the Stage
Lesson 3: Analyze it

Subjects
- ☑ Science
- ☑ ELA
- ☑ Math
- ☐ STEM
- ☐ Art
- ☐ Other

Stem Connections
Science:
Technology:
Engineering:
Math:

Performance Expectations/ Standards
NGSS
MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems**.**
MS-LS1-5: Use models to describe how matter moves through living systems and between living systems and the environment.
MS-ESS3-3: Apply scientific principles to explain the effects of resource availability on the growth and survival of a population.
MS-ETS1-4: Develop a model to describe and predict changes in a system caused by changing one or more components.

CCSS
ELA
W.6.8: Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and vivid language.
SL.7.5: Make an informative presentation, focusing on a topic, explaining key points, supporting claims with evidence, and responding to questions.
SL.8.1: Initiate and participate effectively in collaborative discussions on various topics, building on others' ideas and expressing their own clearly and persuasively.
L.6.6: Acquire and use accurately grade-appropriate general academic and domain-specific vocabulary.

Math
6.SP.B.5: Summarize numerical data sets in relation to their context
7.SP.A.1: Understand that statistics can be used to gain information about a population by examining a sample of the population;
8.SP.A.2: Know that straight lines are widely used to model relationships between two quantitative variables.

I CAN statements
Science:

- describe the nitrogen cycle and its stages (ammonification, nitrification, denitrification).
- explain the role of bacteria in each stage of the nitrogen cycle.
- monitor changes in ammonia, nitrite, nitrate, and pH levels in a newly set-up aquarium.
- analyze data to identify relationships between parameters and draw conclusions about the health of the aquatic ecosystem.
- explain how changes in water quality can affect aquarium inhabitants.
- predict the consequences of overfeeding or overcrowding on the nitrogen cycle and water quality.
- propose methods for maintaining water quality in an aquarium**.**

Math:

- collect and record data accurately and systematically.
- construct graphs to represent the changes in various parameters over time.
- calculate basic statistics (e.g., average, range) from my data.
- interpret graphical representations to identify trends and relationships**.**

ELA:

- communicate my findings through written reports, presentations, or discussions.
- use scientific vocabulary correctly and precisely.
- draw evidence from data to support my claims and conclusions.
- research different types of bacteria and their roles in the nitrogen

Materials

- Something is Fishy in the Nitrogen Cycle
- The Nitrogen Cycle Presentation
- Aquarium (10-20 gallons)
- Gravel, plants, aquarium decorations, fish
- Ammonia, nitrite, nitrate test kits
- Water sample cups of vials for collection
- Calculator
- Graphing paper

Teacher Background

The nitrogen cycle is a fundamental biogeochemical process occurring in all aquatic ecosystems, including your aquarium. It plays a crucial role in maintaining environmental stability by transforming nitrogenous waste products into forms usable by primary producers like plants. Understanding this cycle is essential for ensuring the health and longevity of your aquarium inhabitants.

Stage 1: Waste Production: Fish and other aquatic organisms generate nitrogenous waste, primarily in the form of ammonia. This highly toxic compound can rapidly accumulate in closed systems like aquariums, posing a major threat to fish health and survival.

Stage 2: Ammonia Oxidation: Fortunately, specialized aerobic bacteria known as nitrifiers come to the rescue. These microscopic heroes convert ammonia into the less toxic nitrite through a two-step process. First, ammonia-oxidizing bacteria (AOB) transform ammonia into nitrite.

Stage 3: Nitrite Oxidation: Nitrite, while less harmful than ammonia, remains detrimental to fish in high concentrations. Another group of nitrifiers, nitrite-oxidizing bacteria (NOB),

further detoxify the water by oxidizing nitrite into nitrate.

Stage 4: Nitrate Utilization: Nitrate, although the most stable form of nitrogen in the cycle, can still build up in aquariums without proper management. Thankfully, nitrate serves as a crucial nutrient for aquatic plants. They readily absorb nitrate, utilizing it for growth and development, helping to control its levels in the water column.

The Cycle Continues: This dynamic interplay between waste production, bacterial activity, and plant uptake constitutes the core of the nitrogen cycle in your aquarium. The cycle operates in a continuous loop, ensuring the efficient conversion of nitrogenous waste into forms beneficial to the ecosystem.

Maintaining Balance: Responsible aquarium management necessitates monitoring and managing nitrogen levels through practices like regular water changes, appropriate stocking densities, and responsible feeding regimes. Overfeeding or overcrowding can overwhelm the nitrifying bacteria, leading to ammonia and nitrite spikes detrimental to fish health.

Summary of the differences between nitrites and nitrates: Nitrites and nitrates are both important players in the nitrogen cycle, but they have some key differences:

Chemical Structure:

- Nitrites (NO_2) have only one nitrogen atom and two oxygen atoms. This gives them a higher negative charge and makes them more reactive and unstable.
- Nitrates (NO_3) have one nitrogen atom and three oxygen atoms. This additional oxygen stabilizes the molecule, making it less reactive and more water-soluble.

Toxicity:

- Nitrites: Extremely toxic to fish and aquatic life! Even low levels of nitrite can damage fish gills, impair oxygen uptake, and ultimately lead to death.
- Nitrates: Less toxic than nitrites, but still harmful in high concentrations. Elevated nitrate levels can promote algae growth and reduce oxygen levels in the water, creating stress and potential health problems for fish.

Role in the Nitrogen Cycle:

- Nitrites: An intermediate step in the nitrogen cycle. Ammonia-oxidizing bacteria convert ammonia into nitrite, which then serves as a substrate for further oxidation by nitrite-oxidizing bacteria.
- Nitrates: The end product of the nitrogen cycle in most aquatic environments. Plants readily absorb nitrates for growth and development, helping to prevent their accumulation in the water.

Management in Aquariums

- Nitrites: Closely monitor nitrite levels, especially in new aquariums where the

nitrifying bacteria haven't yet established themselves. Regular water changes, appropriate stocking densities, and responsible feeding are crucial to control nitrite buildup.
- Nitrates: While less urgent than nitrites, nitrate levels should also be monitored. Regular water changes and utilizing nitrate-absorbing plants help prevent excessive accumulation and maintain a healthy balance.

Testing Tips: Important Tips for Accurate Testing:

- Use a dedicated water sample cup or vial to avoid contamination.
- Follow the instructions provided with your specific test kit or meter carefully.
- Shake the water sample well before testing.
- Test the water immediately after collecting the sample, as ammonia levels can fluctuate quickly.

Testing Tips: Ammonia

Liquid Test Kits:

- These are popular and affordable options for home aquariums.
- They typically involve adding a few drops of test solution to a water sample in a vial or test tube.
- The solution reacts with the ammonia in the water and changes color based on the concentration.
- You then compare the color change to a chart included in the kit to determine the ammonia level.

Electronic Meters:

- These offer more precise readings and faster results compared to liquid kits.
- You dip the probe of the meter into the water sample, and the digital display shows the ammonia concentration directly.
- Some meters offer additional features like temperature and pH readings.
- Keep track of your test results over time to identify any trends or potential problems.

Interpreting the Results:

- Most liquid test kits and meters come with color charts or numerical scales to interpret the ammonia levels.
- Generally, anything above 0.5 ppm (parts per million) of ammonia is considered dangerous for most fish species.
- If your ammonia levels are too high, take immediate action to address the issue, such as performing a water change, reducing the feeding amount, or increasing aeration.

Testing Tips: Nitrates

Liquid Test Kits:

- Popular and widely available.
- Similar to ammonia testing, you add drops of test solution to a water sample in a vial/test tube.
- The solution reacts with nitrates in the water and changes color based on the concentration.
- Compare the color change to a chart provided in the kit to determine the nitrate level.
- Look for kits specifically designed for nitrates, as ammonia kits often test for both but have separate procedures and charts.

Electronic Meters:

- Offer high precision and quick readings.
- Similar to ammonia meters, you dip the probe into the water, and the display shows the nitrate concentration directly.
- Some meters offer additional features like temperature and pH readings.

Interpreting the Results:

- Test kit color charts and meter scales will guide you in interpreting nitrate levels.
- Generally, nitrate levels below 20 ppm are considered safe for most freshwater fish. Higher levels can promote algae growth and stress fish.

Lesson 1: What is the Nitrogen Cycle?		
Time	**Materials**	**Activity**
35 mins	The Nitrogen Cycle Presentation	Ask students what they know about nitrogen and the nitrogen cycle. Show the slide presentation and allow students to ask questions.
10 mins	Something is Fishy in the Nitrogen Cycle	On their worksheets, the students will make a model of the nitrogen cycle.

Lesson 2: Setting the Stage		
Time	**Materials**	**Activity**

25 mins	Aquarium, gravel, plants, air pump	Students will set-up the new aquarium with new gravel. Add live plants and an air pump.
20 mins	Something is Fishy in the Nitrogen Cycle	Students will be measuring the levels of ammonia, nitrite, and nitrate in the tank. Demonstrate the proper technique for testing the water before you add the fish in. Also demonstrate how to record the levels on their worksheets. Encourage the students to add subjective observations as well. They should note any changes in water clarity, fish behavior, or plant growth. **Classroom Management Tips** • Assign small groups to test the water each day so that every student has an opportunity to test. This will also reduce the amount of class time needed to collect the data. • Create a class spreadsheet that is shared with all the students and enter the data directly into the spreadsheet (or create a chart on your whiteboard and have the students record their results daily on that. (Take a picture regularly in case it gets accidentally erased!)

Lesson 3: Analyze It!		
Time	**Materials**	**Activity**
35 mins	Something is Fishy in the Nitrogen Cycle	Once students have collected the data for three weeks, have them calculate the averages for each week and then make a bar or line graph of those averages as well as the starting and values and the final values. (Note- Do not include the starting values in the week 1 average calculations.) Allow them time to complete the analysis questions.
10 mins		Conduct a class discussion to wrap up the experiment. What was the most important thing the students learned? Why do they think this was an important concept to master? How might this help them in other areas?

Differentiation

For students who need additional support:

- Have the students work in small groups to draw the nitrogen cycle, or conduct a classroom discussion.
- Pair the students who are less confident in taking measurements with students who are more confident, however, all students should have the opportunity to collect data, therefore hand over hand collection of the values may be required.
- Instead of having students create their own graphs, create a class graph on your whiteboard with all students getting a chance to contribute.

For students who need additional challenges:

- challenge them to research different types of bacteria involved in the nitrogen cycle and their specific roles.
- Have the students identify and test other potential influencers on the levels of nitrogen (ex, temperature, type of fish, amount of light)

Assessment

Criteria	4 Points	3 Points	2 Points	1 Point
Graph Creation				
Accurate Data Representation	All data points are plotted correctly and precisely on the graph.	Most data points are plotted accurately, with minor errors.	Some data points are plotted incorrectly or with significant errors.	Data points are plotted incorrectly or are missing.
Clear Labels and Titles:	Axes are labeled clearly and accurately, with units included. The graph has a descriptive title that conveys the main idea.	Axes are labeled, but there may be minor errors or missing units. The title is present but could be more informative.	Axes labels or titles are missing or inaccurate.	Axes and title are missing or severely misrepresent the data.

Analysis of Results				
Identification of Patterns and Trends:	Accurately identifies major patterns, trends, or relationships in the data.	Identifies some patterns or trends, but may miss or misinterpret some key points.	Identifies only basic patterns or trends, with limited understanding.	Misinterprets the data or fails to identify significant patterns.
Support with Evidence:	Provides specific evidence from the graph to support conclusions and interpretations.	Provides some evidence, but it may be incomplete or not fully support conclusions.	Provides limited evidence or relies on general observations without specific support.	Provides no evidence or misinterprets the data to support conclusions.
Explanation of Relationships:	Explains the relationships between variables clearly and accurately, using concepts and terminology relevant	Explains relationships somewhat, but explanations may be incomplete or lacking clarity.	Attempts to explain relationships, but explanations are superficial or inaccurate.	Fails to explain relationships or provides incorrect explanations.
Drawing Meaningful Conclusions:	Draws clear, logical, and meaningful conclusions based on the data and analysis.	Draws some conclusions, but they may be limited in scope or not fully supported by the evidence.	Draws weak or unsubstantiate d conclusions that are not well-supported by the data.	Draws incorrect or irrelevant conclusions that do not reflect the data.

Extension

- Test Different Aquariums (see: https://petsintheclassroom.org/wp-content/uploads/2015/08/Nitrogen-Cycle-in-the-Aquarium-Hilliman-6th-8th-Fish.pdf)
    - Students will complete a water test of 3 different aquariums and graph their results.
        - Aquarium 1: newly set up aquarium (less than a week)
        - Aquarium 2: aquarium that has been set up for less than a year
        - Aquarium 3: an aquarium that has been set up more than a year (you can usually consult your local pet store and get some of the water from their system). Students only need to collect the data once.
- Investigate the effects of overfeeding or overcrowding on the nitrogen cycle and water quality.
- Explore different methods for maintaining water quality in aquariums, such as water changes, filtration systems, and plant selection.