Nitrogen in Demand

Sequence of Lessons in Nutrient Cycling

By Rhett Buchanan

Grade Level: 7

Unit Overview: In this series of lessons, students will understand the critical importance of nitrogen in all food webs. First, students model the atomic structure of nitrogen atoms and identify nitrogen as an element found in all living organisms. Second, students play a game to learn how nitrogen is cycled between organisms and the environment. Third, students compare the nitrogen concentration in various agricultural fertilizers. Finally, students examine the effects of fertilizers on water quality by testing a local watershed; they will present their findings and recommendations to peers and/or local agencies.

MSBSD 7th Grade Science Standards Addressed
B2: Students will investigate how matter is transferred over time from one organism to others in the food web.
C14: Students will dramatize the relationships and interdependencies among the members of a food web.
also
State Performance Standards for 6-8: C1-SC3

Lesson 1: The Nitrogen Atom

Warm-up question: "Describe everything you know about atoms."

Learning sequence
1. Create a K-W-L chart to outline students' prior knowledge of atoms.

2. Introduce students to the Periodic Table of the Elements. Practice identifying the atomic number and the atomic mass by using the key for a particular version of the table.

3. Show students a simple model of an atom. Differentiate between the 2 regions of an atom (nucleus and electron cloud); explain that particles with mass (protons and neutrons) are located in the nucleus; explain that electrons have nearly zero mass.

4. Pass out poker chips to represent the 3 sub-atomic particles. Each type of particle should be a different color, and labeled with its charge: positive (+) for protons, negative (-) for electrons, and unlabeled (neutral) for neutrons.

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5. Model with students how to build a simple models for elements 1-10. For example, use the Periodic Table to find the atomic number for the element lithium (Li). An atom of lithium has 3 protons in its nucleus. Since its atomic mass (rounded to the nearest whole number) is 7, there must be 4 neutrons in its nucleus (3 protons + 4 neutrons = atomic mass of 7). Since the negatives must equal the positives, there need to be 3 electrons in the electron cloud.

Quick assessment: As students build each atom, ensure that they have included the correct number of each subatomic particle, and that the particles are placed in the correct location (nucleus for protons and neutrons, electron cloud for electrons.)

6. Discuss with students which elements they know to be common in everyday life (most will know oxygen as being needed by living organisms). Explain that carbon (C) and nitrogen (N) are two very important elements found in all living organisms, and that they will learn how nitrogen "cycles" between living organisms and their environment over the next few days.

Assessment: Short quiz in which students draw a simple model of various small atoms (up to Ne), using only information from the Periodic Table.

Lesson Two: The Nitrogen Cycle Game

Warm-up question: "Describe what is in the air around you."

1. Discuss student responses to the warm-up. Many will recognize that oxygen and carbon dioxide are present in the air, but fewer will know that the air around us is made up of more than 70% nitrogen.

2. Explain that nitrogen atoms in the air are paired up as N2, and this form of nitrogen is not usable by our bodies, or by many plants.

3. Ask students if they know of anything in their bodies that has nitrogen in it. Look for responses including DNA, protein, etc. Ask students: If our bodies have nitrogen in them, but the nitrogen in the air around us is not usable by our bodies, where do we get our nitrogen? Look for responses involving the word "eat" — we gain nitrogen by eating other organisms.

4. Draw a simple food web diagram specific to the local ecosystem; use common examples of organisms (such as grass, snowshoe hare, and lynx for Alaska). Label producers, primary consumers, and secondary consumers. Ask students how these organisms get nitrogen. Most will now recognize that consumers get nitrogen by eating plants…but how do producers access nitrogen? Briefly explain the symbiotic relationship of nitrogen-fixing bacteria in certain plants (alder, soybeans, peas). Explain that the upcoming game

will help students better understand how nitrogen cycles between living organisms and their environment.

Nitrogen Cycle Game
(Note: this game is modeled after a Project Wild activity to teach the water cycle; it has been modified for teaching the nitrogen cycle.)

Materials needed
4 large labeled sign boards for representing where nitrogen can be stored: atmosphere, nitrogen-fixing plants (beans, peas, alder), other plants (non-nitrogen fixers), animals, and soil. These will be taped to a stationary object (chair, desk) to mark a location in the game

4 large six-sided dice (a cubic cardboard box, reinforced with tape, works well). See the table (in file **Nitrogengame-diechart.pdf or .doc**) for side labeling information.

Game procedure:
1. Find a location with sufficient room to set up 4 stations. Each station needs room to have up to ¼ of the class in a single file line behind the station marker (chair, desk, etc.)
2. Place the large labeled die at the appropriate location.
3. Start by evenly distributing students at each of the 4 locations. Instruct students in the game procedure. Explain that each student is a particle of nitrogen. (You may want to have students create diagrams of nitrogen atoms to wear on their shirts). They will be following different possible paths of nitrogen in the atmosphere and the food web. The first student in line will roll the die. Whichever side is up explains where that student will go next. For example, if a student in the atmosphere rolls "taken up by an N-fixing plant," he or she then moves to the back of the line at the N-fixing plant station.
4. Allow the game to run for sufficient time (15-30 minutes). Expect that some stations will have longer lines than others; this is intended. For example, the line at the atmosphere station will generally be quite long. This will help students understand the critical role of nitrogen-fixing plants. You may want to give students tally cards to keep track of how many times they go through the line at each location.

Assessment: Students will complete a written Reflection. Some possible sentence starters/questions for this reflection include:

- The locations that seemed to hold nitrogen for long time periods were…….because…….
- Nitrogen-fixing plants play an important role because…..
- Decomposers play an important role because…..

Lesson 3: Fertile Soil and Nitrogen

Warm-up question: You are a farmer and your crops aren't doing so well. You have your soil tested, and it doesn't have enough nitrogen. What are your options?

Materials needed: Labels (or product specifications) for commonly available garden fertilizers. Make sure that each label clearly states the percentage of nitrogen, phosphorus, and potassium (such as 5-10-5) in that particular bag.

1. Discuss with students the answer to the warm-up. Many students will reference the game and plant nitrogen-fixing crops to increase nitrogen input into the soil. Other students may know that fertilizers contain nitrogen and can provide immediate improvement to the crop yield.

2. Explain that commercially available fertilizers contain concentrated amounts of nitrogen as well as other necessary soil nutrients (phosphorus, potassium) from the Periodic Table. Explain that students will be conducting a survey of commercial fertilizers to determine which contains the most nitrogen for the least amount of money.

3. Pass out product labels (or photocopies) of at least 3 different fertilizers. Make sure each label includes the total mass/weight and the cost of each bag.

4. Students are assigned the following tasks:

A. Calculate the actual mass of nitrogen compounds in each bag. For example, if a bag of 5-10-5 fertilizer weighs 10 pounds, it means that it has 5% nitrogen by weight. The calculation would then be: 10 lbs x 0.05 = 0.5 lbs

B. Calculate the cost per unit mass of nitrogen (such as dollars/lb or pennies/g) for each bag. For example, if the bag in the previous example costs $9.00, the cost per unit weight would be $9.00/0.5 lbs= $18.00/lb of nitrogen. Compare bags and find which has the best deal on concentrated nitrogen.

C. Students can report their findings in a Consumer Reports-styled analysis.

Extension: Allow students to research why fertilizer manufacturers sell different concentrations (such as lower concentrations for established lawns vs. higher concentrations for new lawns). They may also choose to investigate soil pH and ways to alter this soil factor.

Lesson 4: Too Much of a Good Thing?

Warm-up question: What would you expect to happen if a lot of fertilizer was accidentally dumped into a stream or lake?

Materials needed: water test kits that include measurements of ammonia, nitrite, and nitrate. (These are commonly available at pet supply stores in the aquarium section)

1. Discuss the answer to the warm-up question. Students often surmise that fish will be poisoned. Others may recognize that certain aquatic plants may experience rapid growth due to the fertilizer.

2. Discuss algae (plant-like single-celled organisms) as being a natural component of freshwater ecosystems. Explain that when large amounts of nitrogen (in the forms of fertilizers or untreated sewage) are added to an aquatic system, there is a significant growth of algae. These algae grow quickly and then may die. The bacteria that break down the dead algae use large amounts of oxygen in the decomposition process, which often results in the death of fish and other organisms due to oxygen starvation.

3. Obtain water samples from various local watersheds. Try to find at least one from a relatively pristine source, and another from a more polluted source. Slow moving streams or ponds near agricultural areas are a good bet for finding nitrogen-enriched water. You might also consider using water from a goldfish tank, which probably will show a very high level of nitrogen if you don't change the water often.

4. Explain that nitrogen can be present in different compounds. Dead organic matter containing nitrogen (such

as fish waste, decomposing plants) is first broken down by bacteria into ammonia. Other bacteria break ammonia down into nitrites, which are further broken down into nitrates.

5. Demonstrate the procedure for nitrogen water tests (based upon directions in the kit you bought). You will probably detect ammonia levels more easily, since it is the first stage in the decomposition process.

6. Students should report their findings in a poster form that can be displayed for others to see.

Extension: If high levels of nitrogen are found in a local watershed, you have a great opportunity for students to recommend a community action plan. Students should begin by using Google Earth to identify potential sources of nitrogen (golf courses, farm fields, industrial operations). Obtain water tests above and below various sites to determine any significant point-sources of this pollution. Students can debate the pros and cons of any action which you choose to take. Remember that any actions taken involve complex legal issues; be sure to consult your local Soil and Water Conservation District, state Department of Environmental Conservation or other local agency.

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