

Nutrient Cycling in the Arctic

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| Teacher: Rachel Rigenhagen | Unit: Environmental Chemistry |
| Grade/Course: 11/12; General Chemistry | Lesson Title: Nutrient cycling |
| NGSS Performance Expectation: | |
| Mater and Its Interactions; Ecosystems: Interactions, Energy & Dynamics; Earth's Systems & Human Activity | |
| Real World Phenomenon Addressed in the Lesson: The processes involved in nutrient cycling (photosynthesis, respiration and decomposition). | |
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| 3 Dimensions of Science | |
| Science & Engineering Practice(s) Used: Ask Questions. | |
| <ul style="list-style-type: none"> ● Develop and Use Models. ● Plan and Carry out Investigations. ● Analyze and Interpret Data. ● Use Mathematics and Computational Thinking. ● Construct Explanations. ● Engage in Argument from Evidence - including dialogue. ● Obtain, Evaluate, and Communicate Information. | |
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| Crosscutting Concept(s) Used: System & System Models; Matter & Energy Flow; Stability and Change | |
| <ul style="list-style-type: none"> - Defining a system and using models to represent it allows students to understand its boundaries, interactions, and how it functions. - Tracking the flow of energy and matter into, out of, and within a system helps in understanding its possibilities and limitations - This concept involves understanding a system's ability to maintain a constant state (stability) and the dynamic processes that cause alteration (change). | |
| Disciplinary Core Idea(s): Interactions, Energy and Dynamics; Biogeology; Energy, Technology, Science and Society | |
| <ul style="list-style-type: none"> - Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they | |

are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it. (HS-ESS2-7)
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) (secondary to HS-PS2-3) (secondary to HS-PS3-3) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

Background Information

Prior Student Knowledge: Key nutrients involved in cycling; carbon, nitrogen, and phosphorus

Possible Preconceptions/Misconceptions: Nutrient cycling doesn’t happen in the Arctic due to the cold climate conditions (“everything stays frozen”)

Content Information for Teacher:

- **Videos:** YouTube channels like CrashCourse or National Geographic.
 - [▶ The Hydrologic and Carbon Cycles: Always Recycle! - Crash Course Ecology #8](#)
 - [▶ Nitrogen & Phosphorus Cycles: Always Recycle! Part 2 - Crash Course Ecology #9](#)
 - [▶ 5 Human Impacts on the Environment: Crash Course Ecology #10](#)
 - [▶ Fritz Haber: Great Minds](#)

| 5E | Evidence of Use/Student Activity |
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| <p>Engagement</p> <ul style="list-style-type: none"> ● Capture attention ● Activate prior knowledge ● Connects to the real world phenomenon | <ol style="list-style-type: none"> 1. Hook: Start with a short video (3-5 minutes) showing various ecosystems and how nutrients are cycled within them. Discuss initial reactions and observations. <ol style="list-style-type: none"> a. ▶ Arctic Tundra Biome 2. Discussion: Ask students what they think nutrient cycling means. Write their ideas on the board. <ol style="list-style-type: none"> a. ▶ As Arctic warms, Indigenous communities ... |

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| <p>Exploration</p> <ul style="list-style-type: none"> • Test ideas and develop knowledge using explorations, investigations, experiments • For NGSS, provide an initial activity/lab that allows for investigation of real world phenomenon (ABC: Activity Before Content) | <ol style="list-style-type: none"> 1. Use Soil Test Kits to collect data on nitrogen and phosphorus in different soil types from various local locations 2. Presentation: Use slides to introduce key concepts: <ul style="list-style-type: none"> ○ What is Nutrient Cycling? Explain the flow of nutrients through biotic and abiotic components of ecosystems. ○ Key Nutrients: Introduce the carbon, nitrogen, and phosphorus cycles. <ul style="list-style-type: none"> ■ Carbon Cycle: Discuss photosynthesis, respiration, decomposition, and fossil fuel formation. ■ Nitrogen Cycle: Explain nitrogen fixation, nitrification, assimilation, and denitrification. ■ Phosphorus Cycle: Cover weathering of rocks, absorption by plants, and return to the soil through decomposition. 3. Diagrams: Show diagrams of each cycle and highlight the processes involved. |
| <p>Explanation</p> <ul style="list-style-type: none"> • Analyze data/information and construct explanations • Communicate understandings orally and in writing • Describe possible solutions | <ol style="list-style-type: none"> 1. Group Activity: Divide the class into small groups. Assign each group one of the nutrient cycles (carbon, nitrogen, phosphorus). <ul style="list-style-type: none"> ○ Carbon Cycle Lab ○ Nitrogen Cycle Game ○ Phosphorus Cycle Demonstration 2. Task: Each group will create a poster that illustrates their assigned nutrient cycle. They should include: <ul style="list-style-type: none"> ○ Key processes ○ Organisms involved ○ The importance of the cycle in the ecosystem ○ How human activities impact this cycle (e.g., pollution, agriculture) 3. Presentation Prep: Groups will prepare a short presentation (3-5 minutes) to explain their cycle to the class. |

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| <p>Extension</p> <ul style="list-style-type: none"> • Modify/refine procedures, prototypes, models, solutions, arguments, essays, etc. • Apply or practice in a new setting | <ol style="list-style-type: none"> 1. Find and compare data sets on nitrogen/phosphorus amounts to student data and Arctic data <ul style="list-style-type: none"> ○ https://datanuggets.org/2019/11/streams-as-sensors/ ○ https://projectbiodiversify.org/2022/03/15/arial-shogren/ ○ https://datanuggets.org/2023/09/which-tundra-plants-will-win-the-climate-change-race/ ○ https://datanuggets.org/2020/07/limit-by-limit/ 2. Writing Assignment: Have students write a reflection in their science journals addressing the following prompts: <ul style="list-style-type: none"> ○ Why are nutrient cycles essential for life on Earth? ○ What human activities do you think have the most significant impact on these cycles, and why? |
| <p>Evaluation</p> <ul style="list-style-type: none"> • Self-assess understanding of concepts • Demonstrate understanding of concepts through performance-based tasks • Reflect and/or revise answers or solutions to a complex question, issue, challenge, or real world problem | <ol style="list-style-type: none"> 1. Group Presentations: Each group presents their nutrient cycle poster to the class. Encourage questions and discussions after each presentation. 2. Evaluate group posters and presentations for understanding and creativity. 3. Review journal reflections for comprehension and insight. 4. Use exit tickets to gauge overall student understanding and address any lingering questions in the next class. |
| <p>Lesson Closure</p> <ul style="list-style-type: none"> • Summarize the lesson • Check for understanding via exit slip or exit ticket • Preview the next lesson | <ol style="list-style-type: none"> 1. Class Discussion: Recap the importance of nutrient cycling in maintaining ecosystem health. Discuss how understanding these cycles can help mitigate human impact. |

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| | <p>2. Exit Ticket: Have each student write down one thing they learned about nutrient cycling and one question they still have.</p> |
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Extensions

- **Field Trip:** Plan a visit to a local ecosystem (forest, wetlands, etc.) to observe nutrient cycling in action.
- **Research Project:** Assign students to investigate a specific human impact on one nutrient cycle and present their findings in a future class.