Teacher-to-Teacher
Video Series
for Secondary Educators

TITLE: Biogeochemical Cycles: Recycling Carbon and Nitrogen on Earth

PRIMARY SUBJECT AREA: Science

GRADE LEVEL: 9-12

OVERVIEW: Students will work in groups to construct flow diagrams that investigate and explain the processes of the carbon and nitrogen cycles. Students will place symbols or pictures in a logical sequence, connect them with arrows to show directionality, and add simple text to clarify the cycles. They will compare and contrast diagrams from other class groups, texts, and the Internet and modify and improve their group diagrams. Students will write a summary of the cycles based on their flow diagrams. Each group will present its final diagram to the class. Students will also analyze graphs and other visual images that present data related to the cycles in order to investigate human impact on the carbon and nitrogen cycles.

Proposed outcomes are that students will organize information in a meaningful way, summarize the information, and interpret flow diagrams. Students will demonstrate an understanding of photosynthesis, respiration, decomposition, fossil fuel formation, carbon dioxide, biogeochemical processes, plankton, bacteria, and plants and animals in the context of the carbon cycle. Concepts from the nitrogen cycle include nitrogen fixation, denitrification, decomposition, fertilizers, nitrogen gas, ammonia, nitrate ions, nitrite ions, proteins, and nucleic acids, and the role of legumes and other plants, bacteria, and animals, Students will discuss the impact of human activities on both cycles including eutrophication, global warming, greenhouse gases, hypoxia, nonpoint source pollutants, phytoplankton, and the Gulf of Mexico dead zone. The science benchmarks addressed in this activity focus on understanding the significance of nutrient cycling to organisms and ecosystems, knowing how to interpret data and models, and understanding the importance of environmental awareness and action. Technology will be used to research Internet resources, construct the flow diagram, and access graphs and cyclic flow diagrams.

APPROXIMATE DURATION: four 50-minute class periods

LOUISIANA CONTENT STANDARDS:
http://www/DOE/assessment/standards/SCIENCE/pdf

Science as Inquiry
Benchmark:

SIB-A4 formulating and revising scientific explanations and models using logic and evidence.

SI GLE:

7. Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)

Life Science
Benchmark:

LS-H-D1 illustrating the biogeochemical cycles and explaining their importance.

LS GLE:

Biology GLE 23. Illustrate the flow of carbon, nitrogen, and water through an ecosystem (LS-H-D1) (SE-H-A6)

Earth and Space Science
Benchmark:

ESS-H-B1 illustrating how stable chemical atoms or elements are recycled through the solid earth, oceans, atmosphere, and organisms.

ESS GLE:

Earth Science GLE 13. Explain how stable elements and atoms are recycled during natural geologic processes (ESS-H-B1)

Science in the Environment
Benchmark:

SE-H-D2 analyzing how individuals are capable of reducing and reversing their impact on the environment through thinking, planning, education, collaboration, and action.

ES GLE:

Environmental Science GLE 25. Discuss how education and collaboration can affect the prevention and control of a selected pollutant (SE-H-D2) (SE-H-D3)

EDUCATIONAL TECHNOLOGY GUIDELINES:

Technology Productivity Tools

Students use productivity tools to work collaboratively in developing technology-rich, authentic, student centered products.

INTERDISCIPLINARY CONNECTIONS:

ELA-4 -H4 speaking and listening for a variety of audiences and purposes
ELA-7-H1 using comprehension strategies in contexts

D-7-H making inferences from data that are organized in charts, tables, and graphs.

OBJECTIVES:

1. The student will organize information in a meaningful sequence (cyclic flow diagram) to explain the carbon and nitrogen cycles.
2. The student will analyze diagrams of the carbon and nitrogen cycles and draw conclusions about these processes.
3. The student will analyze data displayed in graphs and maps that is related to changes in global carbon dioxide levels, global phytoplankton growth, and the size of the Gulf of Mexico dead zone and make predictions about human effects on the carbon and nitrogen cycles.
4. The student will propose action plans to lessen the negative effects of human impact on the carbon and nitrogen cycles.

LESSON MATERIALS AND RESOURCES:

butcher paper
magazines
scissors
glue or tape
References that contain flow diagrams and explanations of the carbon and nitrogen cycles
Calculator

TECHNOLOGY TOOLS AND MATERIALS:

Hardware: Internet access

Software: Word processing program such as Microsoft Word, Inspiration software or other program to organize information

Web site: NASA Earth Observatory. (2002). The carbon cycle. [On-line]. Available: www://earthobservatory.nasa.gov/Library/CarbonCycle.

BACKGROUND INFORMATION:

The carbon and nitrogen cycles are usually studied during a larger study of ecology. Prior to the lesson students should be able to construct and analyze flow diagrams and use them to explain spatial or time relationships between objects and events. Specifically, students should understand how flow diagrams are used to explain science processes, for example the flow of energy through a food web. Students should have experience interpreting graphs and drawing conclusions and making predictions from data. This activity will enable them to improve these skills.

Students should have prior knowledge of basic ecology concepts including the complex interactions between biological, physical, and chemical (living and nonliving) factors that make up ecosystems. A study of energy flow through ecosystems usually precedes a study of the cycling of matter (nutrients). Prior to the lesson students should understand concepts including ecology, renewable and nonrenewable resources, environment, nutrient, energy, carbohydrate, protein, nucleic acid, producer, autotroph, consumer, heterotroph, photosynthesis, respiration, and decomposition. A prior understanding of the fundamentals of biological chemistry is helpful but not imperative.

LESSON PROCEDURES:

PROCEDURE

1. Each cycle is studied separately; first the carbon cycle and then the nitrogen cycle. Following the study of the nitrogen cycle comparisons are made between both cycles and human impact on the cycles is investigated. Before class students should actively read the section on the carbon and nitrogen cycles in the text by reading one time for an overview, then reading again for details. During the second reading comprehension strategies such as outlining the main ideas and writing questions in the left-hand margin, constructing a concept map, or paraphrasing main concepts can be used. Student responses can be emailed to the teacher prior to class or hard copies can be collected at the beginning of class.
2. To introduce the lesson and start students thinking the teacher can lead a class discussion reviewing the water cycle, which was studied in middle school.
3. Direct student teams consisting of two students to a variety of web sites and instruct them to select one diagram of the cycle being studied to view and analyze. These images can also be scanned and duplicated as handouts or put on the school network, school web page or Blackboard for students to access. During the analysis student teams should break down the entire cycle into its subcategories and write a written description of what is happening in each one and why (Student Worksheet 1). During a class discussion ask teams to share their findings and ideas.
4. Following the discussion instruct each student to convert the information presented in the selected diagram into a written summary that explains the process of the cycle.
5. Instruct students to list the criteria to be used in evaluating a successful cyclic flow diagram. These criteria will be used to evaluate diagrams that they will construct. Ask the students to finalize a class list of criteria during class discussion (Attachment 2).
6. Students work in groups to collect pictures, symbols, 3-dimensional objects, or images from magazines or the Internet that represent objects and events in the cycle.
7. Group members organize the information into a cyclic flow diagram by sequencing the symbols in spatial order and using arrows to show the movement of carbon or nitrogen through each respective cycle. They may use Inspiration to complete this diagram.
8. Students add labels or text that contain a minimum of words to explain each step of the cycle.
9. Group members create a symbol (e.g., ∅, ϑ) to represent human impacts on the cycle that have negative effects. They also create a different symbol to represent human impacts on the cycle that have positive effects. They identify sequences in each cycle that are affected by human impact and insert these symbols into the cycle at the appropriate places.
10. Finally each group will present its completed cyclic flow diagram to the class using presentation strategies including PowerPoint, posters, or overhead transparencies. Instruct the students to work individually to complete Student Worksheet 2. Data about the carbon and nitrogen cycles is presented in different forms and the student interprets the data to draw conclusions and make predictions.

ASSESSMENT PROCEDURES:

Reading comprehension prior to the learning activity should be assessed by evaluating the student strategies [e.g., notes, concept map, outline]

Participation in class discussions is ongoing and a tally sheet made from the class roll can be used. Use a + to indicate a positive response and a – for a negative response. A student who does not participate in the discussion will have no mark by her name.

Collaboration skills can be assessed by having students record their contributions to the group in a daily work log and/or complete guided self and peer evaluations (Attachment 1) during and at the completion of the activity.

Student interpretations (analysis) of diagrams should be evaluated. Students use a simple checklist (Attachment 2) that can then be assessed by the teacher.

Group presentations should be evaluated (Attachment 3)

ACCOMMODATIONS/MODIFICATIONS:

N/A

REPRODICIBLE MATERIALS:

Attachment 1 – Sample self and peer evaluation criteria
Attachment 2 – Sample diagram criteria
Attachment 3 – Evaluation of Group Projects
Student Worksheet 1 – Guide to Analyzing Cyclic Flow Diagrams
Student Worksheet 2 – Analyzing Human Impact on the Carbon & Nitrogen cycles

EXPLORATION AND EXTENSION:

Students research current scientific research on global warming and develop an argument for or against whether global warming is actually occurring. They present their argument before a Congressional committee made up of their peers.

Students research and report on the projected effects of global warming in Louisiana.

Students research the Gulf of Mexico Dead Zone; its causes and effects and write an editorial calling for action.

Students design and carry out an experiment to test the effects of increased nitrogen on the growth of fast plants (terrestrial environment) or phytoplankton (aquatic or marine environment).

Students model a greenhouse and gather data on temperature changes over time. (http://seawifs.gsfc.nasa.gov/SEAWIFS/LIVING_OCEAN/TEACHER5.html)

LESSON DEVELOPMENT RESOURCES:

BSCS. (2002). BSCS biology: An ecological approach. Colorado Springs, CO.

Miller, K. R., & Levine, J. (2002). Biology. Upper Saddle River, NJ: Prentice Hall
Ducks Unlimited (2002). [On-line].
Available: http://www.ducks.org/news/deadzone.asp

EPA Office of Water, (2002). Mississippi River Basin . [On-line].
Available: http://www.epa.gov/msbasin/mexico.htm
NOAA. (2002). Global Carbon Cycle. [On-line].
Available: www.ogp.noaa.gov/mpe/gcc

USA Today. (2002). Gulf of Mexico Dead Zone. [On-line].
Available: http://www.usatoday.com/news/healthscience/science/enviro/2001-07-27-deadzone-gulf-of-mexico.htm

Louisiana Public Broadcasting. (2002). Enviro-Tacklebox. [On-line].

Available: http://www.envirotacklebox.org

NASA. (2002). Nitrogen Cycle. [On-line].
Available: http://ltpwww.gsfc.nasa.gov/globe/NFTG/nitrocyc.htm

Think Quest. (2002). Chemical Carousel: A trip around the carbon cycle. [On-line]. Available: www.thinkquest.org/library

ThinkQuest. (2002). Nitrogen Cycle. [On-line].
Available: http://thinkquest.org/11353/nitrogen.htm

NASA. (2002), The Carbon Cycle. [On-line].
Available: http://earthobservatory.nasa.gov/Library/CarbonCycle/NASAEarthObservatory

NASA. (2002). The Ocean Carbon Cycle. [On-line].
Available: http://seawifs.gsfc.nasa.gov/SEAWIFS/LIVING_OCEAN?Carbon_cycle.jpe

REFLECTIONS:

The approximate duration is estimated and students must be allowed enough time to develop the flow diagrams on their own. Different learning styles are addressed when students choose their medium for the diagram.

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Attachment 1

COLLABORATION SKILLS

SELF & PEER EVALUATION FORM

PROJECT TITLE:_____

GROUP MEMBERS:_____

Please rate your contribution to the group and evaluate the group on a scale of 1 – 10 with 10 being the highest.

INDIVIDUAL EVALUATION: Name_____

____1. Following teacher's instructions

____2. Asking meaningful questions

____3. Contributing ideas and information

____4. Helping the group stay on task

____5. Contributing materials

____6. Asking for help when needed

____7. Sharing responsibilities

____8. Respecting others

____9. Explaining things to others

___10. Doing things on time

____11. Doing my best

I could improve on_____

I rank my contributions to the group as_____.

GROUP EVALUATION:

____1. Following teacher's instructions

____2. Asking meaningful questions

____3. Contributing ideas and information

____4. Staying on task and meeting deadlines

____5. Sharing responsibilities

____6. Respecting others

____7. Explaining things to others

____8. Solving problems within the group

____9. Consistent effort

___10. Producing a quality product

I rank our group's efforts at working together as_____

PEER EVALUATION:

Rank each member of your group on a scale of 1 – 10 and cite specific reasons why you evaluated each person's contribution to the group that way.

_____

_____

_____

_____

_____

_____

_____

Attachment 2

Assessment Criteria for Diagrams

NAME _____PERIOD_____DATE_____

Diagram Title _____Diagram Type_____

Diagram Description _____

Diagram Source _____

Content:

____ accurate information

____ clarity of information

____ enhances understanding of the concept or process

____ correct order or sequencing

Images:

____ visually pleasing

____ appropriate size

____ enhance understanding

____ directionality

____ creative

____ clear (focused)

____ effective use of color and/or contrast

____ components within images are consistent in design when moving from image to image (ex – chromosomes are always the same design when more than one cell is shown)

Text:

____ readable

____ key terms highlighted

____ minimum of words, phrases, or sentences

____ easy to comprehend

____ meaningful connections between words, phrases, or sentences

____ enhances understanding

____ meaningful positioning of words, labels, headings, or subheadings

Attachment 3

Assessment for Project Presentations

Evaluator_____ PERIOD_____ DATE_____

Topic _____ Group Members _____

_____

Description of
Model_____

_____

_____

Content:

____ accurate information

____ clarity of information

____ enhances understanding of the concept or process

____ correct order (sequencing)

____ appropriate resources used

_____ sufficient amount of detail

Project:

_____follows directions

____enhances understanding of the concept or process

_____accurately represents concept or process

____ presents information clearly

_____labeled accurately

____appropriate use of materials

_____uses reasonable scale

____ shows all necessary components

_____visually pleasing (e. g., neatness, color)

_____accomplished its purpose (goal)

_____creative or novel approach

Student Explanation/Presentation

____ adequate amount of preparation and research

_____maintained audience interest

____speaking skills (posture, eye contact)

_____clarity of explanation

____ able to explain in own words

_____used appropriate examples

____able to apply concepts to novel situations

_____able to answer audience questions

_____references cited correctly

_____appropriate use of time

Student Worksheet 1

Directions for analyzing flow diagrams of the carbon cycle and nitrogen cycle.

Search the Internet or printed resources to find a cyclic flow diagram of the cycle. Select a diagram that you think does an excellent job of explaining the processes represented in the diagram. Choose one that is easy to understand. Use the questions below to guide you.

1. Does the diagram help you understand the goal of the cycle? In other words does it make sense?

2. Is the diagram simple enough or do you think it is too complicated to understand?

3. Is the diagram well labeled? Do you understand what the text in the labels means?

4. Are there arrows that show what direction the carbon is moving in?

5. If chemical symbols are used do you understand what they represent? Would words be better to use?

6. Can you start anywhere in the cycle or is there one starting point? You should be able to start at any point.

7. How many subcategories can you identify in the cycle? For example, in the carbon cycle the movement of carbon dioxide from the atmosphere to plants during photosynthesis is a subcategory. Burning fossil fuels to release carbon dioxide from organic compounds back into the atmosphere is another category.

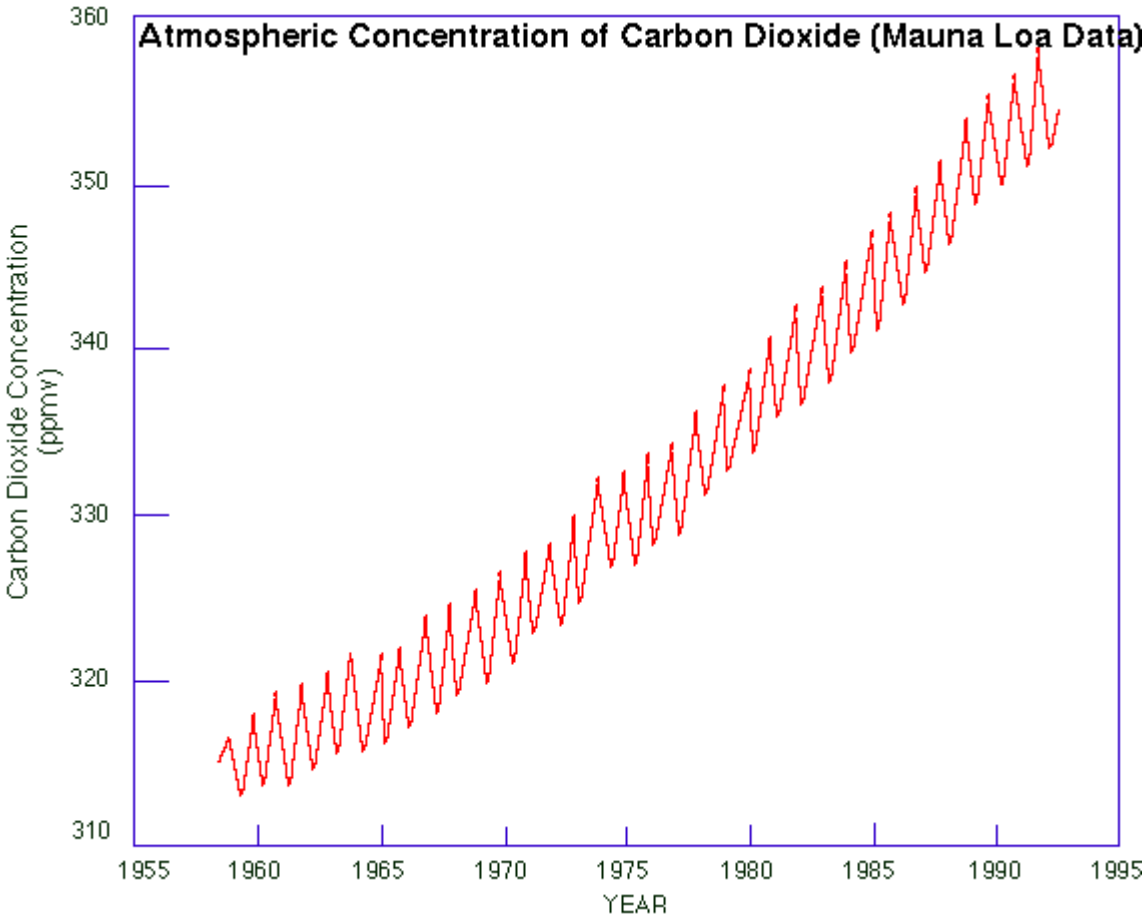
8. Can you interpret the symbols and describe what is happening in each subcategory?

Student Worksheet 2

What is the Human Impact on the Carbon and Nitrogen Cycles?

Directions: Study the graphs and maps below that provide data on changes in the carbon and nitrogen cycles. Answer the questions about these changes to learn more about human impact on the carbon and nitrogen cycle.

Carbon Cycle Data



NASA SEAWIFS PROJECT
http://seawifs.gsfc.nasa.gov/SEAWIFS/LIVING_OCEAN/mauna_loa_co2.gif

A. Regular measurements of carbon dioxide levels in the atmosphere were begun in 1958.
   1. Describe the overall trend in carbon dioxide levels that has occurred since then.

      _____

   2. Find the percent change in maximum carbon dioxide concentration from 1960 to 1990. Show your calculations in the space below. Circle your answer.

      _____

3. Natural increases and decreases in carbon dioxide concentration are shown to occur in a somewhat regular pattern of seasonal changes throughout the years measured. What are some possible biological causes of the increases in carbon dioxide? During what season would you expect carbon dioxide to increase?

_____

4. When would you expect carbon dioxide levels to decrease during the year? What are some possible biological causes of the decreases?

_____

5. In what ways do you think humans put carbon dioxide into the atmosphere and take it out of the atmosphere?

_____

_____

B. Access the long-term data of atmospheric carbon dioxide obtained from Antarctic ice cores at the NASA Earth Observatory Web site.
http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html.

1. How many years does the data represent?

_____

2. In your own words explain how carbon dioxide levels correlate with the ice ages.

_____

3. Are human activities currently increasing or decreasing the carbon dioxide concentration in the atmosphere? Explain your answer.

_____

4. Explain why an increase in atmospheric carbon dioxide levels increases global temperatures and may lead to global warming.

_____

C. Study the NASA satellite map of the global biosphere shown at NASA Earth Observatory: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle5.html

1. Compare the differences in chlorophyll a concentrations on land and in the oceans. What does chlorophyll a indirectly measure?

   _____

   _____

2. What areas of the world have higher chlorophyll a concentrations? What are some possible reasons for these higher levels?

   _____

   _____

3. Propose how scientists might use the information in this map.

   _____

Nitrogen Cycle Data

Examine the maps showing the Mississippi River watershed and the Gulf of Mexico Dead Zone (Ohio State University.
Gulf of Mexico Hypoxia http://www.acs.ohio-state.edu/units/research/archive/hypoxia.jpg and
Ducks Unlimited http://www.ducks.org .

1. A proposed explanation of the causes of the dead zone is that nitrogen-rich fertilizers wash into the Gulf of Mexico by way of the Mississippi River. What states in the watershed are farming states where large amounts of fertilizers are used?

   _____

   _____

2. Which map do you think gives more information about the source of the nitrogen that causes the dead zone? Why?

   _____

   _____

3. Explain how increases in nitrogen can cause hypoxia or loss of oxygen in a body of water such as the Gulf of Mexico.

   _____

   _____

4. Fertilizer is a non-point source pollutant. Give reasons why this is true.

_____

_____

5. The dead zone is shown to be off the coast of Louisiana where it directly kills marine organisms such as fish; an economic resource. What effects do you think the dead zone have on other states? Do you think it could possibly affect countries other than the United States? Explain your answer.

_____

_____

_____

6. Brainstorm actions that you think could be taken to lessen the negative impact that humans have on the (a) carbon and (b) nitrogen cycles.