



Lesson #3

Biogeochemical Cycles

Objective:

- The learner will demonstrate comprehension of the energy sources of various cycles by completing mini stories.
- The learner will demonstrate analysis of words by defining individual word parts and combining them to form definitions.
- The learner will demonstrate synthesis of a cycle by researching the cycle and creating a cartoon depicting that cycle.

National Science Education Standards:

UCP 1, PS 3, LS 3, ESS 2, ESS 3, ST 1, HNS 2

Benchmarks:

3A, 3B, 4B, 4D, 4E, 5A, 5E, 8C, 11A, 11C, 12D

Materials:

Handout sheet
Paper for cartoon (8 ½ X 11)
Colored pencils
Books about various cycles (or computer access for students to research)

Background:

Our earth has a long history. To understand the processes occurring on and in our earth now we must think back to the earth's origins. In this lesson, students will be asked about the formation of oxygen in the atmosphere. As plants began to grow and carry out photosynthesis, our atmosphere received oxygen as a waste from the plants. The production of oxygen by plants during photosynthesis is still happening today. The cycling of oxygen and carbon dioxide through our atmosphere are examples of biogeochemical cycles. It is through these and other cycles that the earth supplies the necessary chemicals for life to exist.

Biogeochemical cycles will be an important part of upcoming lessons. It is important to understand that many things in science occur in cycles. By studying these cycles, scientists can better understand the world around us. Although these lessons will involve many different biogeochemical cycles, the iron cycle will be particularly important to your work.

Iron can exist in many states. In particular, iron can be in the 2+ or 3+ states. This means that there are more protons (2 more or 3 more) in the iron atom than there are electrons. When iron (symbol Fe) is changed from Fe^{2+} to Fe^{3+} , the atom is losing an electron. When iron is changing from Fe^{3+} to Fe^{2+} , it is gaining an electron. Bacteria help to make these changes by removing or adding electrons to the iron. Aerobic bacteria (bacteria that need oxygen to survive) oxidize iron which changes the Fe^{2+} into Fe^{3+} . Some anaerobic bacteria (those that do not need oxygen or can not survive with oxygen) reduce the bacteria from Fe^{3+} into Fe^{2+} . In addition there are other non-living things, such as chemicals, which can also help to change the iron.



So why all this moving around of electrons? Simple, it gives the bacteria energy. There is energy in the bonds holding electrons to the atom. By moving some of these electrons around, the bacteria are actually using the iron as a source of energy. Remember, these are chemical reactions taking place.

Preparation:

There is very little preparation for this activity. A sample cartoon should be created to show students the size and format you would like them to use in their cartoons. Students will be researching cycles (this does not need to be in-depth research) and will need books or internet access. The following are some of the suggested cycles which you may want to have students research: oxygen, nitrogen, phosphorus, carbon, water, sulfur, as well as various life cycles.

Warm-Up:

Discuss the concept of cycles. What are cycles? What makes something a cycle? Name some cycles. (This may include scientific cycles as well as things like bicycles. Accept all answers and allow students to explain how the cycle works.)

Procedures:

1. After students have briefly discussed the cycles that they are aware of, encourage them to think specifically about scientific cycles.
2. Hand out the attached sheet to the students. Ask them to fill in their definition of a cycle. Ask students, "What does a cycle need to keep going?" Encourage students to come up with possible answers.
3. Students will read the two "mini stories" and complete the two questions that complete each story. You may want to have students work on these in pairs depending on the needs of your students.
4. Discuss the story endings as a class. Students should have indicated that photosynthesis was responsible for the plants releasing oxygen. Students should then indicate that the earth is very hot inside. Both of these stories involve energy. Energy from the sun is needed for photosynthesis (which allowed for the presence of oxygen on the earth) and energy from the earth (geothermal energy) provided the heat to create the black smokers.

Big idea: Cycles need energy!

5. Students should give their definitions for bio, geo, and chemical. Discuss these briefly. Ask students what a biogeochemical cycle is. Students should respond that it is a cycle involving both biological and geological components as well as chemical reactions.
6. Students will then read the information about biogeochemical cycles. They will also read about some of the specific aspects of the iron cycle. Allow students to read on their own, and then discuss as a class.
7. Assign each student a cycle (see the suggestion list in the preparation section) or allow them to pick a cycle of their own with your approval. Students will research the parts of that cycle and create a cartoon depicting the stages in that cycle. Encourage students to be creative and turn the components of their cycle into characters. Students should use the cartoon section on the handout to guide them in their research and creation of the



cartoon. It is important that you give students any specific directions as to how you would like to have the cartoon paper set up.

Variations and Follow-Up Activities:

For the research component of this activity students can use class books, library books, or internet resources. The following activities in this module can serve as excellent follow-up to this lesson.

Assessments:

Students can be informally assessed during this activity in the many individual and small group portions as well as during the class discussions. Much of this assessment can be conducted while walking around the room while students are working.

The cartoons which students create will also provide an opportunity for assessment.

Observations:

If your students have not had experience in creating scientifically accurate diagrams, it may be helpful to give students a simple diagram and label it together as a class. Reinforce the proper way of using and creating a scientific diagram. Consider discussing the use of straight lines which do not cross, printing instead of writing in cursive, and giving every diagram a title. This may seem like it takes extra time in the beginning of the lesson, but these skills are essential to accurate diagrams and will help you to avoid problems with your students diagrams later on. My students had already been given instruction in creating diagrams, so I found it helpful to review the basic diagram rules before beginning.

When creating the cycles, my students found it helpful to refer back to the geothermal vents from earlier in the lesson. The students were able to see this as a natural tie-in.

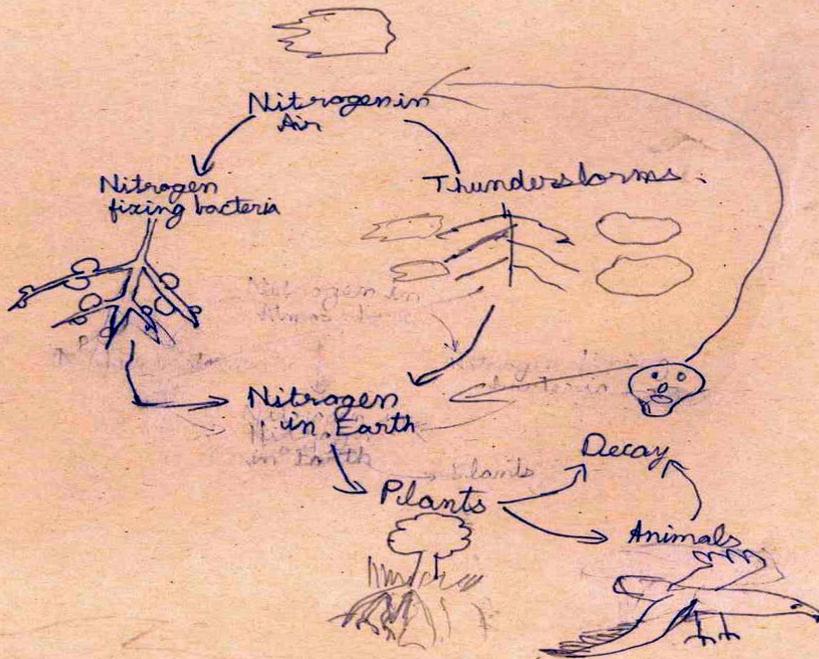
I caution you in having students diagram the iron cycle. While that is the cycle we will be studying, it is rather difficult for most students to understand. If you have a student who is particularly interested, he or she may be able to create a diagram for the iron cycle. The purpose of working on these various cycles is to help students to understand cycles rather than to understand the iron cycle in particular. That will come later. My students needed to focus on the big ideas here instead of the intricacies of the iron cycle. Students should understand that cycles need energy and that the energy flows through the cycle. Once this is understood, aspects of the iron cycle will be easier to comprehend. I found that my students didn't understand the iron cycle as well as they understood that energy flows through cycles and then connected that idea to the lessons involving the iron cycle at work as a battery in the bottle.

Encourage creativity in your students' cycles. While this is a scientific endeavor, students should be given the freedom to be creative in their work. Many of my students named a particular aspect of their cycle and then used that "character" as a way to describe the cycle to other students. While it may be interesting to learn about the nitrogen cycle, for many students it is more interesting to follow the adventures of Nicky Nitrogen.

The following page gives examples of students work.



Nitrogen Cycle





Name _____

Date _____

Biogeochemical Cycles

Biogeochemical cycles will be an important part of upcoming lessons. It is important to understand that many things in science occur in cycles. By studying these cycles, scientists can better understand the world around us. In this activity you will be looking at cycles and how they are similar and different.

Define a Cycle - _____

You finish the story:

The activities occurring in hydrothermal vents require oxygen. Oxygen was not originally present in the earth's early atmosphere. It was released into the atmosphere once plants began to grow. Why? _____

Other than water, what did these plants need to carry out that process? _____

Hot water under the ocean floor dissolves minerals from the surrounding rocks. When this water comes out at hydrothermal vents, bacteria use these minerals as a source of energy. What heats the water under the ocean floor? _____

What are both of these sources giving to the hydrothermal vent? _____

Defining Biogeochemical cycles.

Bio - _____

Geo - _____

Chemical - _____



Although these lessons will involve many biogeochemical cycles, the iron cycle will be very important to your work. Iron can exist in many states. In particular, iron can be in the 2+ or 3+ states. This means that there are more protons (2 more or 3 more) in the iron atom than there are electrons. When iron (symbol Fe) is changed from Fe^{2+} to Fe^{3+} , the atom is losing an electron. When iron is changing from Fe^{3+} to Fe^{2+} , it is gaining an electron. Bacteria help to make these changes by removing or adding electrons. Some aerobic bacteria (bacteria that need oxygen to survive) oxidize iron by removing an electron which changes the Fe^{2+} into Fe^{3+} . Some anaerobic bacteria (those that do not need oxygen or can not survive with oxygen) reduce the iron from Fe^{3+} into Fe^{2+} by adding an electron. In addition there are other non-living things, such as chemicals, which can help to change the iron. You will learn more about the iron cycle in later lessons.

So why all this moving around of electrons? Simple, it gives the bacteria energy. There is energy in the bonds holding electrons to the atom. When the electrons are added or removed, some of the energy is released. By moving some of these electrons around, the bacteria are actually using the iron as a source of energy. Remember, these are chemical reactions taking place.

Cycle Cartoon - Attach your cartoon to this paper.

Name of cycle _____

Important parts of the cycle

Describe the actions taking place in your cartoon. Include sources of energy!
