CO2 LEARNING CENTER

Book Three Lesson Plan

The Magic Mirror:

Reflections on Recycling

This lesson plan was produced by the CO_2 Learning Center, a project of the CO_2 Coalition

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The Magic Mirror: Reflections on Recycling

The Magic Mirror is the third in a planned series of informative and entertaining books for students on various aspects of science made available through the CO_2 Learning Center. Students will learn about how the Earth naturally recycles all of the substances on the planet and how the carbon dioxide cycle is a critical part of this recycling.

The Magic Mirror tells of another adventure in the lives of Sophia, Ariana, and Elyssa, the three young sisters whom we have already met. This time, as they go about their recycling chores, their friendly scientist neighbor Mr. Gordon helps them to learn that Mother Nature is the most important recycler of all. Natural and man-made processes eventually bring plants and animals back to the miracle molecule, carbon dioxide, so that new life can emerge.

> *"Sometimes it takes a little magical reflection to see the wonders of nature. In this delightful story, three sisters discover how the cycles of life are made possible by the miracle molecule, carbon dioxide. An entertaining look into the scientific realities of life on Earth for children of any age." -- Payne Kilbourn*
>
> Payne Kilbourn is now an independent consultant and writer after 28 years in the U.S. Navy Submarine Service and eight years in business. He retired from the Navy as a Captain.

The CO_2 Learning Center lesson plans were created by Dr. Sharon Camp. Dr. Camp received a B.S. in Geology from the University of Georgia and a Ph.D. in Analytical Chemistry from Georgia Tech. She has 20 years' experience teaching high school, including Earth Science, Biology, Chemistry, Physics, and AP Environmental Science. She is currently a reader for the yearly national AP Environmental Science exam.

Table of Contents

A note about our lesson plans:

Our CO_2 Learning Center lesson plans all have the same format, which includes learning standards from the Next Generation Science Standards (NGSS), student learning objectives, background information on the science concepts covered in the book or video, suggested activities including labs to enrich the lesson and reinforce use of the scientific method, and formative and summative questions. The NGSS are the standards on which most public-school systems have based their curriculum.

We do not necessarily endorse the NGSS but have included the relevant standards for circumstances in which a teacher is required to use them. The lesson plans contain everything that a teacher might be required to submit in a formal lesson plan to a school administrator or science department head. This lesson plan was created for the CO_2 Coalition's CO_2 Learning Center by Sharon Camp, Ph.D. Analytical Chemistry; B.S., Geology, using Next Generation Science Standards (NGSS).

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Understanding NGSS:

LS: Life Science
PS: Physical Science
ES: Earth Science

1-5 indicates standard for grade level (1-first grade, 2-second grade, 3-third grade, 4-fourth grade, 5-fifth grade)

MS: Middle School

Please note that only the parts of the outline that are relevant to this lesson have been included. If LS1.C or PS3.D *(example from this lesson) is shown, these NGSS segments were included as relevant to this lesson for Life Science and Physical Science.*

Lesson Plan: Book Three
Grades K-8

Next Generation Science Standards (NGSS) Learning Objectives:

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.]

- **LS1.C: Organization for Matter and Energy Flow in Organisms:** Plants, algae (including phytoplankton) and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- **PS3.D: Energy in Chemical Processes and Everyday Life:** The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.]

- **LS1.C: Organization for Matter and Energy Flow in Organisms:** Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
- **PS3.D: Energy in Chemical Processes and Everyday Life:** Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials as this matter moves through an organism. (PS – Physical Science)

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems and on defining the boundaries of the system.]

- **Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Source: https://www.nextgenscience.org

Student Learning Goals

After reading the book, students will be able to:

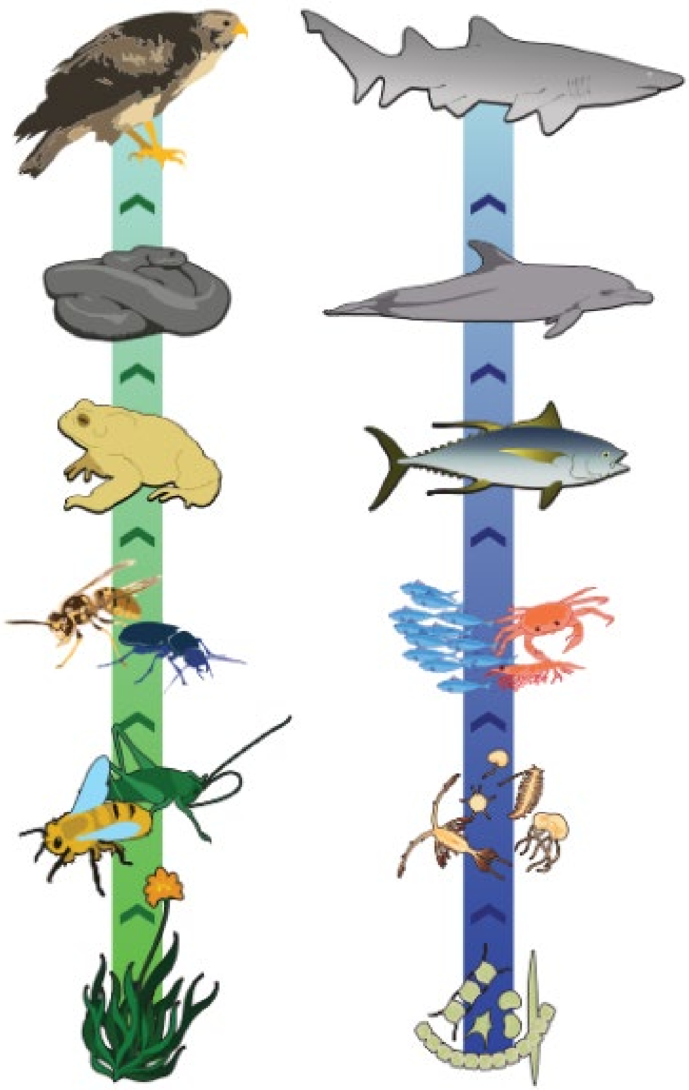
1) Explain what recycling is.
2) Explain what a decomposer is and describe its position in the food chain.
3) Explain how carbon dioxide is created after an animal eats another animal or plant.
4) Explain how forest fires release carbon dioxide into the atmosphere.
5) Explain how fossil fuels formed and why they are considered to be fossils.
6) Name three ways plants and animals can be recycled back into carbon dioxide.

Background Information

When most people think of recycling, they think of taking materials, such as those listed by the girls in the story, to a bin where it is taken to another location and sorted according to material type. These sorted materials are then sold to industries who will either melt them down to make more of the same (steel and aluminum cans, for example), or engineer it into a similar or even a different product (plastics used to make carpets and clothing, for example). Most everyone understands that the purposes of recycling are to reduce the amount of waste produced and to make our natural resources last longer. Very few people understand that Mother Nature is constantly recycling all materials. As the photograph of Earth from space demonstrates[1], Earth is a closed system (in other words, does not receive extra materials from any external source), everything that is on Earth must be reused to allow the continuance of life on the planet.

Everything on the planet is recycled, living and nonliving materials alike. The rock cycle describes the processes by which rocks of all different kinds can be recycled into another type of rock repeatedly. Cycles called biogeochemical cycles describe how elements such as oxygen, nitrogen, sulfur, and, of course, carbon are constantly recycled. The term biogeochemical refers to how air, life, water, and soil are all involved in the recycling of Earth's materials.

The purpose of *The Magic Mirror* is to explain that all living things are broken down into their component parts (carbon dioxide and water) so that these parts can be used to make more living things. The two primary processes by which this recycling occurs are photosynthesis and cellular respiration, which have been discussed in depth in the lesson plans for the prior two books, *Once Upon a Time* and *Simon the Solar Powered Cat.*



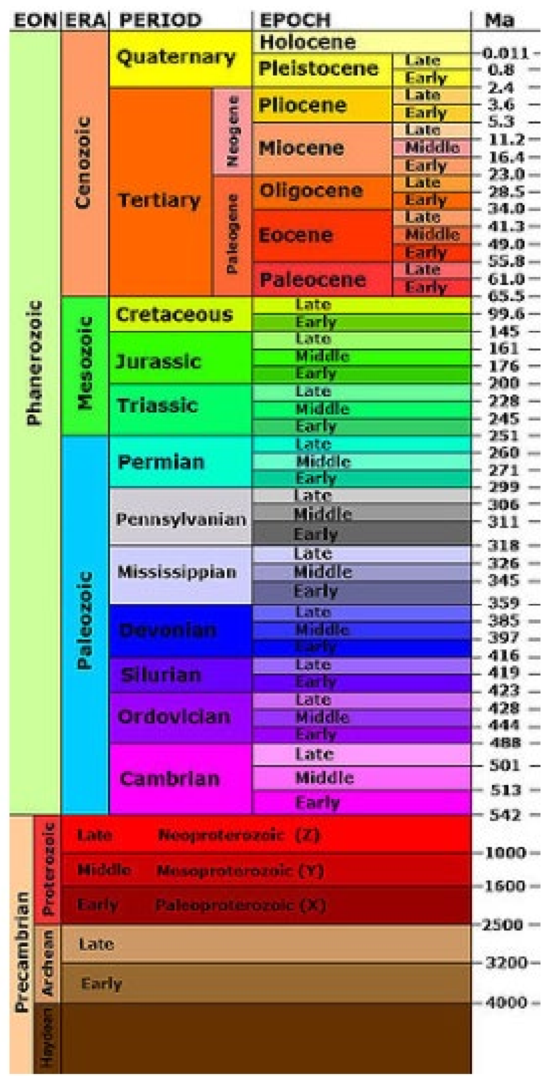
In a simplified food chain, such as the one displayed in the image to the left[2], the source of the energy is the producer (an organism that undergoes photosynthesis to produce its own food). Please note that the source of energy for the producer is the Sun.

The producer is eaten by primary consumers, which are eaten by secondary consumers and so on, until the top predator caps the food chain. Along the way, each organism releases carbon dioxide and water into the atmosphere as it breathes. This carbon dioxide is then available for other producers to use in photosynthesis. Therefore, every organism that is consumed is broken down completely. The consumer uses the energy and nutrients it obtains from its food to continue to live, and carbon dioxide and water are released to the atmosphere as waste products of cellular respiration. The waste products are then available for producers to start the cycle all over again. This way, all the materials necessary for life are recycled so that waste products become resources.

But what happens to the top predators when they die? They also will be recycled, but this time it will be by a huge group of other organisms known as decomposers. This group can include animals that eat dead animals, such as vultures and crows. But it also includes flies, worms, bacteria and fungi. These decomposers will finish the job of breaking down the dead organism into its component parts, and they all will release carbon dioxide and water into the atmosphere. The decomposition of dead organisms and the subsequent release of carbon dioxide into the atmosphere is a critical part of the carbon cycle.

Forest fires accelerate the process of recycling, because two of the main substances released in a fire are carbon dioxide and water. When forests have periodic fires, the brush and invasive plants on the surrounding ground are destroyed, reducing competition for the existing trees and other native plants that have adapted to fire in the forest. The photo above is an example of a controlled burn that removes the brush on the ground.[3]The brush is burned or combusted, which is a chemical term that refers to a rapid chemical reaction whereby a fuel combines with oxygen in the air and releases carbon dioxide, water, and energy. A spark or other source of energy is necessary to start rapid combustion.

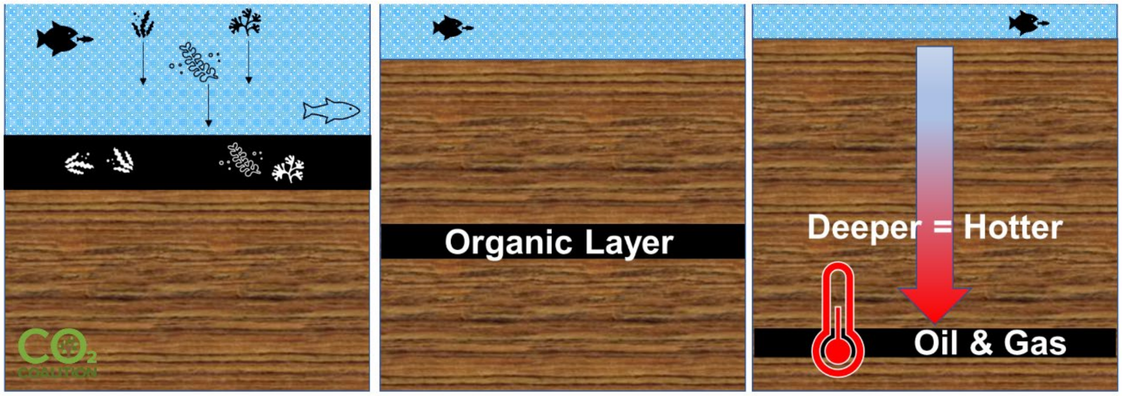
Burning fossil fuels also releases carbon dioxide into the air, but how do they form and why are they considered to be fossils? According to the United States Geological Survey, coal deposits in the U.S. range in age from Pennsylvanian to Eocene.[4] (see photo right[5]). This means coal deposits formed as early as 318 million years ago and as late as 34 million years ago.



Coal specifically is composed of the remains of plants that died millions of years ago that were compacted and metamorphosed by high heat and pressure as illustrated in the picture below.

Coal is literally made of fossilized plants, hence the name fossil fuel. These plant remains have been protected from decomposition for hundreds of millions of years.

Because coal has stored energy obtained from the Sun, this stored solar energy is released when coal is burned. Carbon dioxide is a waste product of the combustion of coal.



Organic-rich sediments accumulate on ocean floor **Organic-rich layer is buried deeply** **Heat converts organics to oil & gas**

Oil, like coal, is also formed from the fossils of dead organisms, except these organisms lived in shallow seas that existed millions of years ago. Small sea organisms called plankton die and fall to the bottom of the sea. There they are covered with sand and other sediments and buried. The pressure from the overlying layers of sediment compresses and metamorphoses the organisms to form oil.

Therefore, the book explains three ways that living things on the planet are naturally recycled. The first way is by direct consumption of a living or dead organism, by which the consumer uses cellular respiration to take the energy content from the food and release carbon dioxide and water as waste products. Organisms such as fungi and bacteria will take whatever is left behind by the consumers and gradually break the materials down into their component parts, which include carbon dioxide and water. The second way is rapidly by the combustion, or burning, of plants such as trees. Wildfires rapidly recycle plants into carbon dioxide and water.

And finally, plants and small plankton have been fossilized to form coal and oil. These materials have stored the energy that the organisms contained before they died and, therefore, release the energy when they are burned. All of these pathways are included in the carbon cycle, which describes how carbon is recycled through the air, the water, some rocks and fossils, and the living things on Earth.

References

1. NASA/Apollo 17 crew; taken by either Harrison Schmitt or Ron Evans, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:The_Earth_seen_from_Apollo_17.jpg
2. Picture of food chains from LadyofHats, CC0, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Simplified_food_chain.svg
3. Burning tree image, https://pixabay.com/photos/control-burning-prescription-tree-53614/

4. John, Nelson W. Coal deposits of the United States. International Journal of Coal Geology, Vol. 8, International Journal of Coal Geology, 1987, USGS Publication No. 70014217
5. Geologic Time Scale from United States Geological Survey, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Geologic_time_scale.jpg

Suggested Activities

1) Find a food chain in your backyard or park:

Young children may have a better understanding of a food chain after looking for one in their backyard or neighborhood park. A simple food chain can start with a plant that has leaves that have been partially eaten, as shown in the picture to the right. Start with the leaf and ask the student what may have happened to it to make the holes in it.

Eventually the student will guess a bug. If you can find bugs, ask the student what that bug might eat. From there, you can ask questions about what might eat the bug. Leading the child through the steps of the food chain, and having the student find organisms that might fit into the food chain, will help the student understand interrelationships among the organisms. You may also want to ask the student about why plants and bugs get eaten and where the energy comes from that the plant uses to live. Have the student draw out a food chain that includes the organisms seen during your walk.

Older students will also benefit from searching for food chains in a backyard or park but won't need as much direction as younger students. Have the students take pictures of the different organisms in their food chains and make a visual display with the pictures. The pictures and display should have names and descriptions of the organisms in their food chain, along with a diagram that shows energy flow through the food chain (see the example in the discussion above). Challenge them by asking them to find more than one food chain and combine them to form a food web. Photo credit: Insect damage on leaf. MukherjeeApratim, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0, Wikimedia Commons

2) Find decomposers in your backyard or park:

Again, for young children, decomposers might make more sense if they have an opportunity to see them. Even though watching a crow or vulture eat carrion is not pleasant, the student has probably seen one of the two eating a dead animal alongside the road while they were riding in a car.

Decomposers can also be seen easily in a decomposing log, if you can find one. These logs will probably have ants and beetles in them, and they may also have visible fungi, which will appear as thin filaments throughout the wood or mushrooms and other types of fungi growing on the bark.

The log will probably be full of holes and tunnels as well. Again, ask the student questions about what the bugs are eating, how they can tell (what is the evidence), and project what will happen to the log sometime in the future (it will completely disappear). Then ask the student what would happen if there were no decomposers and all the dead branches, plants, and trees stayed forever.

This thought experiment may help them understand the critical role that decomposers play in recycling plants and animals back to their raw materials so that the materials can be used again to make new life. Be sure to have them include decomposers in their food chain. Photo credit: Rotting log. https://pixabay.com/photos/fungus-fungi-mushroom-nature-5359943/

3) Some ecosystems have evolved to require fire for them to survive:

The southeastern United States used to be covered with longleaf pine forests, but over-harvesting and fire suppression have reduced the acreage covered by these great trees to a small percentage of what they once were. Longleaf pine forests can only exist with fire, which can occur in the southeast frequently because of lightning. The tree is adapted to survive fire that hugs the surface of the ground, which kills competing hardwoods and invasive plants. The wiregrass grows back, flowers, and goes to seed after a fire, helping to renew the landscape. In the west, there are many kinds of plants and trees that require fire for their cones to open. The cones of the giant sequoias must have the heat from a fire

before they can open and release their seeds. There are many other examples as well. Students can do research on examples of plants that need fire, and they should be required to present their research to the class or submit it in a paper. What happens in the long term to a forest when fire is suppressed? Is fire suppression good or bad for the ecosystem? Grasslands and rangelands are dependent on fire for their continued existence. Explain how grasslands are adapted to periodic fires. What happens to a grassland when fire has been suppressed for many years? Support your position with data and references. (Please remember that Wikipedia is NOT a source.) Photo source: Longleaf pine forest. bobistraveling, CC BY 2.0, https://creativecommons.org/licenses/by/2.0>, Wikimedia Commons

Formative and Summative Questions

1) At the beginning of the story, the girls brag about how they recycle paper, plastic, cans, and glass. What does it mean when materials are recycled? Pick one material that can be recycled and compare and contrast that to how earth's systems recycle materials.
2) What is a decomposer, and how is it different from a consumer? Where on the food chain do decomposers fit?
3) How is carbon dioxide created after an animal eats another animal or plant? By what process is carbon dioxide used by plants to make food?
4) When forests burn, carbon dioxide is released. Explain how this is a way in which carbon dioxide is recycled.
5) Give two examples of fossil fuels. Why are they considered to be fossils? How are they an example of how the Earth recycles carbon dioxide? Why do they release carbon dioxide when they are burned?
6) List three ways plants and animals can be recycled back into carbon dioxide.

Sharon R. Camp, Ph.D., Analytical Chemistry; B.S., Geology

What is the CO_2 Coalition?

The CO_2 Coalition was established in 2015 as a 501(c)(3) for the purpose of educating thought leaders, policy makers, and the public about the important contribution made by carbon dioxide to our lives and the economy.

The CO_2 Coalition is a group of the top scientists, engineers and energy experts who study and report on the important contribution made by carbon dioxide to our lives and the economy.

Learn more at CO2Coalition.org and CO2LearningCenter.com.