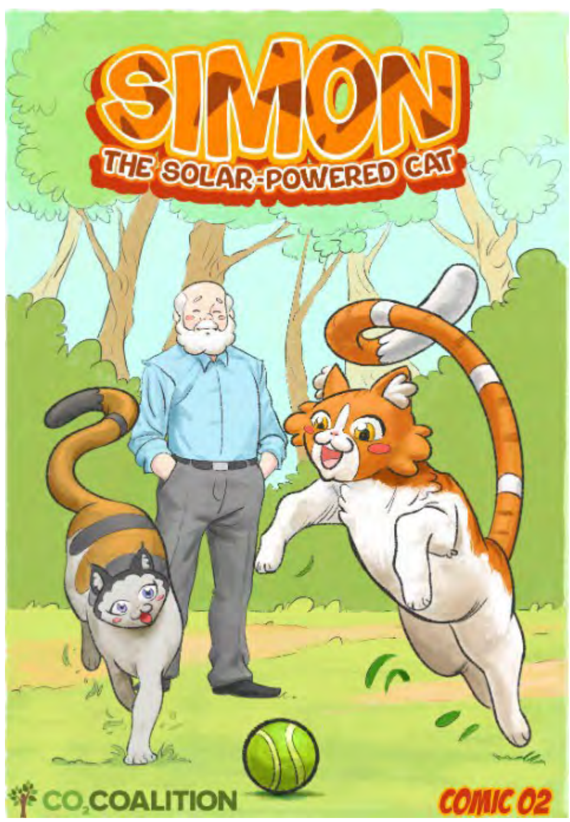
CO₂ LEARNING CENTER

# Book Two Lesson Plan

# *Simon the Solar-Powered Cat*




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


# Book Two Lesson Plan

## *Simon the Solar-Powered Cat*

*Simon the Solar-Powered Cat* is the second 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 the Sun's critical role in sustaining life on Earth and how carbon dioxide and photosynthesis are critical to this process.

The story is told through the adventures of three young girls who live on a tree farm in Oregon. They learn from their kindly neighbor, a scientist, that a process called photosynthesis enables plants to combine sunlight, water, and carbon dioxide to create the calories that all plants and animals need to live and grow. A byproduct of that process is the oxygen that animals also require. These are the fundamental ingredients for life on Earth.

> *"Simon the Solar-Powered Cat is a charming story that teaches that the basis for life on Earth is the miracle molecule carbon dioxide. Without it, virtually all life would die. The demonization of carbon dioxide in many of our schools makes the proper teaching of the gas's role in converting solar energy to plant food critically important. This wonderful book allows readers to make the necessary connections to see why all plants and animals are solar-powered."*
>
> -- Dr. Sharon Camp, Ph.D. Analytical Chemistry

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.A *and* PS3.D *(example from this lesson) are shown, these NGSS segments were included as relevant to this lesson for Life Science and Physical Science.*

# Lesson Plan: Book Two

Grades K-8

## Student Learning Goals

After reading *Simon the Solar-Powered Cat*, students will be able to:

1) Explain that carbon dioxide is found in the air in very small amounts using a model (see activity #3)
2) Explain that one source of carbon dioxide is from people and animals breathing
3) Explain that dry ice is frozen carbon dioxide, and describe its appearance
4) Explain that plants use carbon dioxide to make food, and that animals eat plants to get their food
5) Explain that all living things are made of carbon that comes from the carbon dioxide in the air and describe the process by which living things obtain carbon (Aquatic organisms also need carbon dioxide, and in the oceans most of the $CO_2$ is absorbed from the atmosphere)
6) Describe what the earth would look like if there were no carbon dioxide in the air
7) Explain why carbon dioxide was described as "the miracle molecule" in the book

## Background Information

Book Two follows the $CO_2$ Learning Center's Book One, *Once Upon a Time*, where Mr. Gordon and the family of girls who live next door are first introduced. The first book explains to readers what carbon dioxide is and why it is important, and the second book continues the story by explaining just how solar energy is harnessed by plants, which supply energy for life for almost every living organism on Earth. (There are bacteria in deep ocean vents that get their energy from the vents, and these bacteria are the source of food energy in those environments. These organisms are beyond the scope of this lesson.)

Organisms are divided into two very broad categories, which are producers and consumers. As the terms imply, producers are able to produce their own food source, which they do using photosynthesis. Consumers get their food directly from producers. The order in which the energy flows is called a food chain. A food web is composed of two or more food chains. In drawing a food chain, the source of energy is always the Sun because the producers get their energy directly from the Sun. Producers include every organism that contains the pigment chlorophyll, which stores energy from the Sun. These organisms include terrestrial plants, aquatic plants, algae, and even some bacteria called cyanobacteria. For the food chain illustrated in this book, the producer is corn.

Consumers are organisms that get their energy by eating other organisms because they are unable to make glucose like plants. Primary consumers eat only plants. Secondary consumers eat primary consumers, tertiary consumers eat secondary consumers, and so forth. Top, or apex, predators are usually fifth-level consumers. This is where the food chain ends because any consumers above this level cannot physically consume enough animals to survive (First Law of Thermodynamics). Each time energy is transferred from one position on the food chain to the next, only 10% of the total energy is passed along. After transfers through five levels, there is no energy left to pass along.

A food chain that includes Simon is shown below:

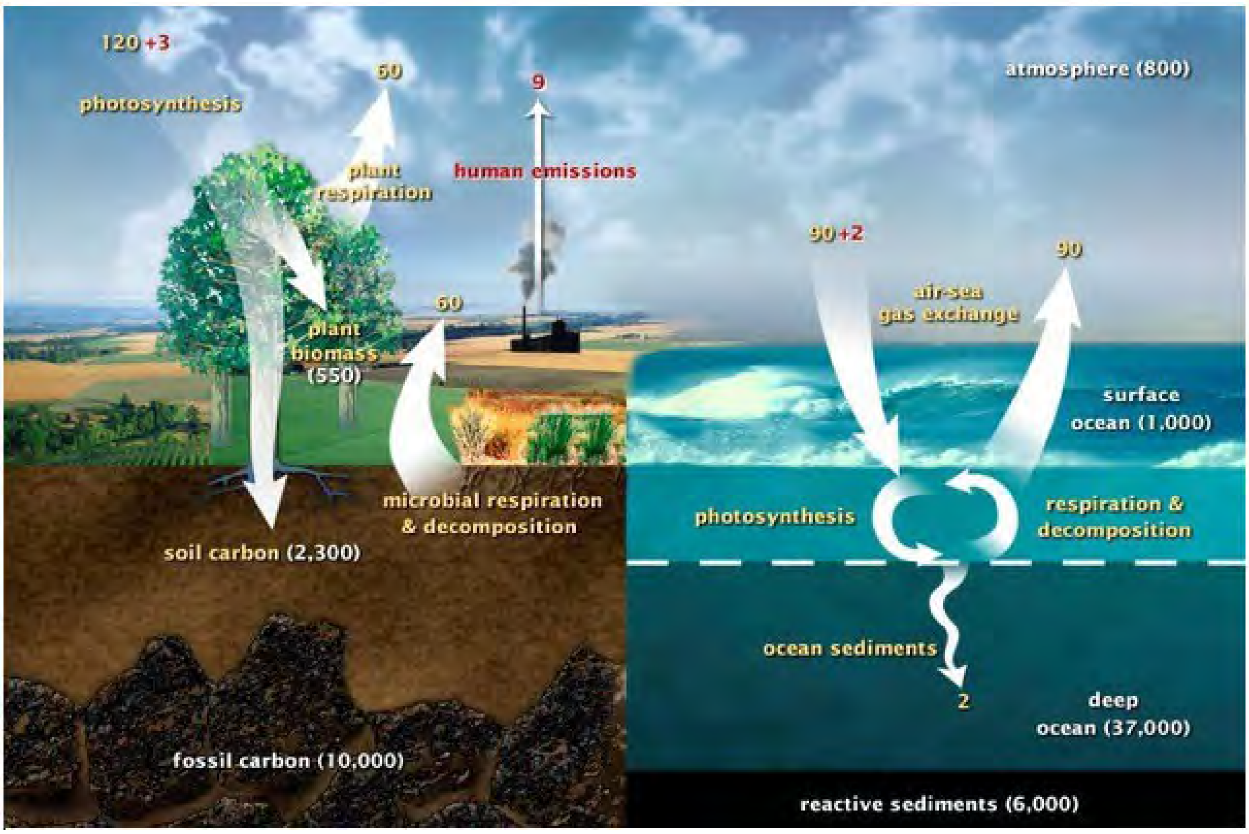
The arrows point in the direction of the flow of energy. Since the Sun is the source of the energy, the arrows point from left to right. In this example, the corn plant is the producer, the chicken is the primary consumer, and Simon is the secondary consumer.

As explained in Once Upon a Time, photosynthesis is a chemical reaction that occurs in plants or any organism with chlorophyll. Chlorophyll is a primary absorber of light and the donor of an excited electron that contributes to the electron transport chain that makes ATP, which is the molecule in which the energy from the Sun is stored. The electron from the chlorophyll molecule is replenished by the water-splitting complex in the light reaction. The reaction occurs when energy from the Sun is absorbed by the chlorophyll. Carbon dioxide enters the plants through special pores in the leaves called stomata, and water enters the plant through the roots and the leaves.

Photosynthesis occurs in plant organelles called chloroplasts that are contained in living cells, and the product of this reaction is glucose, with oxygen produced as a byproduct or waste product. The oxygen actually comes from the water splitting portion of the light reaction part of photosynthesis. Water molecules are split to capture electrons that go to replenish depleted chlorophyll molecules. The oxygen from the water molecule is released from this reaction into the atmosphere as a waste product. The product glucose is a type of simple sugar. The oxygen is released into the air, and the sugar is stored for later use by the plant to grow and reproduce.

When animals eat plants, they eat the original glucose and the many sugars, fats, starches, proteins, and cellulose that the plant makes from the glucose. This gives them the energy and substance to grow and reproduce. When the glucose or derivative compounds are broken down in a reaction called cellular respiration (not to be confused with breathing), oxygen and glucose are broken down to produce carbon dioxide, water, and energy. Cellular respiration is the reverse of photosynthesis. Every organism, including plants, undergoes cellular respiration and releases carbon dioxide. Even though the book does not discuss cellular respiration, it is helpful to know that carbon dioxide is released from many different sources, including all producers, all consumers, the weathering of rocks that have minerals made of carbon compounds called carbonates, and burning organic materials such as wood and fossil fuels. We release carbon dioxide every time we exhale.

Carbon cycles through living and nonliving things in a process called the carbon cycle. One small part of the carbon cycle is reflected in a food chain. The cycle, however, is much more complicated. An understanding of the full carbon cycle is beyond the scope of this book, but an illustration of the many reservoirs of carbon is included below, as well as the estimated flows between reservoirs. The human contribution of CO2 to the atmosphere from burning fossil fuels, manufacturing cement, and breathing is about 10 gigatons of carbon per year. One gigaton (1 Gt) is a billion metric tons, or 10exp12 kilograms, or 10exp15 grams. Natural flows are, in total, about twenty times larger than the human contribution.




Numbers are gigatons of carbon/year. Source: NASA's Earth Observatory

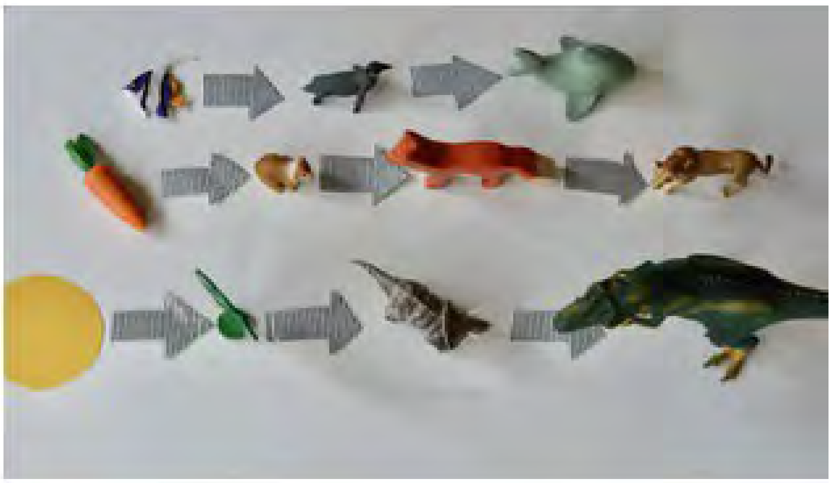
Food energy is measured in kilocalories (AKA calories). Food energy is measured in an interesting way: food is put into a device called a calorimeter, which will contain the energy released, and then the food is ignited and burned! The amount of heat energy that is given off by the burning food is measured in kilocalories.

## Suggested Activities

The Internet is full of fun and creative ideas on how to teach about food webs and chains. The problem with most of these, however, is that they leave out the most important concept, which is that sunlight powers life through carbon dioxide and water. Almost all these activities can be adapted to demonstrate how important the Sun is by simply adding the extra step of including the

Sun in the food chain or food web. Another major fact discussed in this book is the importance of carbon dioxide to all living things. With these major concepts in mind, here are some examples of food chain activities that will help students understand that life depends on both the Sun and the existence of carbon dioxide. These suggested activities are good for students in grades K-4, but grades 5-8 should have practice using the scientific method.

1. Collect plastic animal and plant toys from around the house and create a food chain or web using these animals. Be sure each chain starts with the Sun and includes a producer of some kind. Aquatic food chains should be encouraged.



*Source: Easy Food Chains for Kids, Sparks Science: https://www.science-sparks.com/simple-food-chains/#:~:text=All%20energy%20comes%20from%20the,further%20up%20the%20food%20chain.*

2. Have students go outside and take pictures of plant leaves and animals and connect them into a food chain by either printing out the pictures and gluing them to a poster or creating a poster using their digital pictures. A couple of free online poster programs are:
   a) https://www.adobe.com/express/create/poster?sdid=SYBNLY5J&mv=search&ef_id=Cj0KCQjw2MWVBhCQARIsAIjbwoO6tyPj6YLP1Nq2oLlBSo70pDjDgcuzW9CPhshDfOCdgx4q7xCAbdQaApeYEALw_wcB:G:s&s_kwcid=AL!3085!3!569697610559!e!!g!!poster%20design%20online%20free!15566817516!133997429471
   b) https://www.canva.com/create/posters/
   c) https://www.postermywall.com/index.php/l/online-poster-maker

3. A fun experiment to do with older students is a calorimeter experiment using paper clips, simple food items, and an empty aluminum drink can.

If a ring stand is not available, it can be purchased at this website: https://www.homesciencetools.com/chemistry/lab-equipment/ring-stand-clamps- supports/

The lab from Carolina Biological Supply can be found here: https://www.carolina.com/teacher-resources/Interactive/food-calorimetry+/tr23949.tr. A hard copy of the lab can be found at the end of this lesson plan.

4. Critical Thinking: Chlorophyll is a green pigment and is found in producers. But what about plants whose leaves are not green? How do they produce energy from the Sun? Some examples of plants with leaves that are not green include several varieties of Japanese maples, copper beeches, and purple plum trees, although there are others. Divide the students into groups and have each group of students come up with possible explanations (hypotheses) as to why plants without green leaves can still photosynthesize. Instruct each group of students to devise an experiment to test their hypothesis. If possible, have the students perform their experiments to determine whether or not their hypotheses were supported or rejected. Each group should give a presentation to the class that describes their hypothesis, their experimental design, their results including data they collected, and their conclusion. Leaves have a mixture of different pigments.

Normally, these pigments are hidden by chlorophyll, but they become more obvious in fall when the chlorophyll breaks down and reveals the beautiful colors of the other pigments in the leaves.

A process called chromatography can be used to separate the mixture of pigments in a leaf. A simple experiment can be found here: https://www.thoughtco.com/do-paper-chromatography- with-leaves-602235#:~:text=In%20paper%20chromatography%2C%20pigments%20may,to%20release%20t heir%20pigment%20molecules.

If you wish to introduce this concept to the students before giving them a chance to design their experiments, they can also do the same chromatography activity with a pen that has water- soluble ink, such as a Paper Mate™ Flair felt-tip. (Be sure to substitute water as the solvent.) Once the students have been introduced to the concept of chromatography, they can research to determine how it can be applied to separating leaf pigments.

## Formative and Summative Questions

1. How do animals get the energy they need to survive?
2. How do plants get their food and energy?
3. What is a food chain? Give an example of a simple food chain by drawing a picture of all of the “links in the chain and draw arrows to show how energy flows through the chain.
4. Explain what photosynthesis is.
5. All life forms on Earth contain carbon. Give a simple example of how carbon, in the form of carbon dioxide, goes from the air and becomes part of an animal’s body. Explain how carbon dioxide goes back into the air from the animal.
6. Simon is described as a “solar-powered cat” in the title of this book. Why is Simon solar-powered?
7. Explain how sunlight provides the energy that powers life through carbon dioxide and water.

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

## Next Generation Science Standards (NGSS) Learning Objectives

**K-LS (Life Science) 1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.** [Clarification Statement: Examples of patterns could include that animals need to take in food, but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

- **LS1.C: Organization for Matter and Energy Flow in Organisms.** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water, $CO_2$ and light to live and grow.

**5-PS (Primary School) 3-1. Use models to describe that energy in animals’ food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun.** [Clarification Statement: Examples of models could include diagrams, and flow charts.]

- **PS3.D: Energy in Chemical Processes and Everyday Life** The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).
- **LS1.C: Organization for Matter and Energy Flow in Organisms** Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary)

**5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.** [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

- **LS2.A: Interdependent Relationships in Ecosystems** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants' parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil.

  Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
- **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

**MS (Middle School) -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.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

- **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. (secondary)

**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 as this matter moves through an organism.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.]

[Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

- **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. (secondary)

*Source:* https://www.nextgenscience.org


## What is the CO2 Coalition?

The $CO_2$ Coalition was established in 2015 as a 501(c)(3) for the purpose of educating thought leaders, policymakers, 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 CO2LearningCenter.com and CO2Coalition.org.**