Study Guide for
Photosynthesis
Living Sunlight
May 3-4, 2012

Portions of this guide written by Jennifer Daly for Youth in Arts
Extended Lessons for Grades 1-4 written by Rebecca Burgess for Youth in Arts
Reading guide, experiments, references and activity sheets
from Living Sunlight study guide by Molly Bang, Sally Sisson, Jim Green & Penny Chisholm

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California Curriculum Standards and Performing Arts Field Trips

California’s Visual and Performing Arts (VAPA) framework for students’ learning about the arts is divided into five strands. Following are ideas for relating each strand to a performing arts field trip.

1.0 Artistic Perception

Students perceive and respond to art, using increasingly sophisticated vocabulary and concepts.

Take time before and after the performance to discuss the experience. Ask children to re-enact scenes or reproduce movements, tones or rhythms. Use study guide to review vocabulary or key concepts.

2.0 Creative Expression

Students use various media to express meaning and intent in original works of art.

Attending a performance can inspire children to create their own art. Youth in Arts provides instruction in visual art, music, dance, theater and new media in your classroom. To learn more, call 415-457-4878.

3.0 Historical and Cultural Context

Students analyze the relationship between the arts and diverse cultures of the past and present.

Use maps, photos and stories to learn about places and people associated with the art form. Ask for observations about language, costumes, etc. Where was the performance set? How do you know?

4.0 Aesthetic Valuing

Students critically assess and derive meaning from arts experiences.

Ask students to respond to the performance, challenging them to go beyond words like “good” or “interesting”. How did sounds, movements or lines of dialogue create a mood or send a message?

5.0 Connections, Relationships and Applications

Students apply arts learning across subject areas and with respect to their own lives.

Read books related to the performance. Develop projects using the art form (i.e. puppetry) to explore academic concepts. Discuss the arts profession. How do performers learn their skills?
Children learn best from a performing arts experience when they know what to expect. Following is background information about the performance you will see, including information on the performers and the art form they will present.

**PHOTOSYNTHESIS—LIVING SUNLIGHT: SYNOPSIS**

Students Ted, Kinu and Dulce are preparing for a test on photosynthesis, led by their teacher, Ms. Drizzle. None of the children are convinced they will ever use the knowledge Ms. Drizzle is trying to impart (“Photosynthesis? What Do I Care?”).

Suddenly, the students and Ms. Drizzle are transported to a magical land, where plants dance in the sunlight and all the processes of plant science are visible to the eye. They meet Flora, their guide, and are dazzled to be able to actually see the sun’s photons (“Energy for Everyone”). Still, they soon are hungry and really just want to get home to their “more interesting” activities. Flora tells them the key will be to find the “Four Fs” to get “everything they need.”

They set out and soon come to a remarkable farm where they can actually see photosynthesis in action (“H2O, Don’t You Know?”) The farmer, Olivia, explains all the wonderful things we have in our lives, thanks largely to plants and photosynthesis (“Plants, Amazing Plants”).

With three of the Four Fs revealed, the kids manage to make their way back to their school garden, where discover the fourth and final key and learn the end result of photosynthesis (“Sugar!”). They have a new respect for all plants do (“Photosynthesis? I Really Do Care!”) and better understand how living things on earth depend on one another (“Life Keeps Circling Around”).

**THE BOOK: LIVING SUNLIGHT**

*Photosynthesis—Living Sunlight* is based on the book *Living Sunlight: How Plants Bring the Earth to Life* by Molly Bang and Penny Chisholm. Although the picture book appears at first glance to be for young children, it actually offers a clear explanation of how photosynthesis works, including a detailed and illustrated glossary. A detailed read-through lesson is provided in the activity pages of this study guide, to maximize children’s understanding of the book before or after the performance. In addition to building on concepts from the book, the show incorporates text in song lyrics and Molly’s beautiful illustrations in the scenic design.

**THE COMPANY: YOUTH IN ARTS**

The leading arts education nonprofit in the North Bay, Youth in Arts offers students experiences and instruction in the visual and performing arts and enriches the community with cultural events. Founded in 1970, Youth in Arts believes a child’s balanced development must include the arts.

Youth in Arts staff includes artists in music, theater, dance and visual arts. In addition, the organization contracts with over 50 Mentor Artists to provide programs throughout the Bay Area. *Photosynthesis—Living Sunlight* is a new production written and staged by Youth in Arts.
Artists can help us think about science, understand scientific concepts, and come up with new ideas for things we want to learn about and study. Visual artists like Molly Bang can create pictures that help us imagine things too tiny for us to see, like atoms and molecules. Her book Living Sunlight was carefully illustrated, working with scientists, to “show” photosynthesis, a process that happens inside of plants, which we can not see with our own eyes.

Performing artists, like the company from Youth in Arts, use their bodies, instruments, voices and imaginations to portray scientific concepts on stage. This is another way of helping us “see” things in our minds that we can not see in the real world with our eyes.

This performance explores basic scientific concepts involved in photosynthesis and uses dance, music and dramatization to help explain and illustrate these ideas. Illustrations from Molly Bang’s book are also incorporated in the show. The goal is not for elementary students to walk away with a complete scientific understanding of photosynthesis (which is actually very complicated chemistry and biology suited to advanced graduate study). Rather, we hope students will begin to understand the process and be open to learning more as they advance in their studies. Most importantly, we hope they come away with an appreciation for how important photosynthesis is to all of us. Photosynthesis makes our food, the air we breathe and most of the material goods in our lives. It is completely essential to human life.

We have provided a range of pre- and/or post-performance activities with this guide, to help you and your students extend your exploration of photosynthesis. Following are some of the scientific concepts addressed in the play, which you may want to review in discussion before or after the show, or as you complete other lessons.

Photosynthesis is a natural process through which green, leafy plants absorb sunlight, water and gases and then produce food energy inside their cells. All animals on earth depend on this food energy, either eating plants directly or eating animals that eat plants.

An atom is a tiny, tiny bit of something, so tiny you can not see it (except with a very fancy and powerful kind of microscope). There are many different kinds of atoms on earth. In fact, everything around us is made up of a whole bunch of different kinds of atoms (and so are we!)

Hydrogen, Oxygen and Carbon are the names for three special kinds of atoms involved in photosynthesis (there are lots of other ones, too, but these three are very important). Oxygen is also something that humans need very much. We need oxygen to breathe!

A molecule is a combination of atoms. Each molecule has a chemical “recipe” that tells you how many atoms of each kind it has. For example, H2O is the “recipe” for one molecule of water. That means each water molecule has two Hydrogen atoms and one Oxygen atom. Molecules are very tiny. There are quintillions of molecules in just one drop of water.

Carbon Dioxide is another kind of molecule. Its “recipe” is CO2 (one Carbon atom and two
Humans make carbon dioxide molecules in our bodies, but we do not need them, so we breathe them out. Every time you breathe out, you breathe out lots and lots of carbon dioxide molecules. Plants need these carbon dioxide molecules for photosynthesis.

Electrons are parts of an atom, even tinier than the atom itself. As these tiny electrons move and “jump” from atom to atom and from molecule to molecule, they help form and break apart molecules and change one kind of chemical into a different kind of chemical. We can not see electrons, so the work they do moving around can seem like magic. But it is really science!

Chlorophyll is the chemical in plants that makes them green. It is also the chemical that absorbs energy from the sun and starts the process of photosynthesis.

Glucose is a kind of sugar made by plants. That is the purpose of photosynthesis, to make glucose. Glucose is food energy. We can also call this food energy carbohydrates. The plants use the food energy to grow themselves—but we also need it. All our energy comes from eating carbohydrates.

The Four Fs are the important basic things that plants provide through photosynthesis: Flora (all the beautiful and useful plantlife around us), Fiber (materials to make our clothing and other things we need), Fuel (to power our lives) and Food (to eat, for our life energy!)

FOLLOW-UP LESSONS

Activities around photosynthesis for grades 1-4 have been developed for this study guide for Youth in Arts by artist, author and environmental educator Rebecca Burgess.

Rebecca is a textile artist who works with natural plant materials to create and color fabric. She has also curated Youth in Arts current gallery exhibit “Farm Fresh Fashion” running through June 1 at the YIA Gallery in downtown San Rafael. If you would like to arrange a free guided visit to the exhibit with a hands-on art activity for your students, contact yia@youthinarts.org or 415-457-4878.

Review materials for the book Living Sunglight created by Molly Bang and co-authors are also provided in the following pages. This includes a detailed reading guide for sharing the book with students. Again, while the book may look like something for “little kids” the science in it is quite complicated and looking carefully at the illustrations can help students of all ages better understand photosynthesis. With older students, you may want to talk less about the “story” of the book and more about the choices the artist made. How did she represent the sun’s energy? How did she represent CO2? Why did she make some things larger than other things?

Additional activities and online references provided by Molly Bang and co-authors are also included for older elementary and middle school students.
Carbon in the atmosphere can become too much, keeping the carbon cycle in balance is important for our climate.

Decaying Organisms are made of carbon that once came from the air!

Taking stored carbon from fossil fuels

Grassroots contain carbon, when the grass is eaten above ground, the roots are released in the soil

Grass regenerates and is ready for grazing, the carbon will be sequestered again when the animals return

Strategically grazed animals promote CO2 sequestration in the soils

Grass ready to be grazed

CO2 enters the leaf

Soil Respiration, CO2 is released into the atmosphere

Photosynthesis (Sun energy powers carbon cycle)

SUNLIGHT (PHOTON ENERGY)

BIOSPHERE

CO2 CYCLE

SOIL ORGANIC MATTER

LITHOSPHERE

Oceans absorb CO2 from the atmosphere, carbon is used to build the shells of marine organisms

Roots are made of carbon that once came from the air!

Grassroots contain carbon, when the grass is eaten above ground, the roots are released in the soil

Taking stored carbon from fossil fuels

Fossil Carbon

Lesson 1 Page 1

INTRO

From Student To Sun

Where Does My Energy Come From?
What are these lessons about?

The lessons in this study guide are designed to connect student’s personal physical energy to its original source—the sun, and carry that connection into a deeper understanding of human material culture. Two foundational natural cycles, namely photosynthesis and the carbon cycle are responsible for all life on earth, and learning about these two core cycles early on is an essential platform for enhancing human decision-making processes towards the creation of a sustainable society.

The first of these cycles--photosynthesis is a process only plants can partake in that allows them to be ‘fed by sunlight’ as they convert photons (light energy), into chemical energy (sugars). The energy provided through photosynthesis is what drives the earth’s carbon cycle. Whereby carbon dioxide from the earth’s atmosphere is absorbed by plants and transformed (with the addition of water)—into carbohydrates. Our biosphere (the place where we humans exist, between sky and soil, including all living and dead organisms not yet converted into soil organic matter) is one of earth’s carbon pools, where carbon exists in the form of carbohydrates. We generally think about carbohydrates as something we eat, but they also create very beneficial sources for fiber and fuel. Carbohydrates have the potential to supply humans with sustainable sources of food, fuel and fiber, and can be likened to ‘fresh forms of carbon’, manifesting within plant life during the earth’s annual seasonal growing cycles. Modern society has become increasingly dependent upon a more ancient and less renewable form of carbon—fossil carbon, which comes from our deepest carbon pool- our lithosphere. This source of carbon is often burned and refined to create gasoline for our cars, plastic for our clothes, dyes, bottles, bags, and thousands of other objects we humans use. Fossil carbon is part of the earth’s storage system, and can be likened to a bank account that we humans are on our way to depleting at the cost of our climate. Helping students to become familiar with the fundamental cycles (first two lessons) and then giving them the opportunity to chart their own material culture (third lesson) in relation to the ‘fresh carbon’ concept is a crucial step towards developing an ecologically literate generation capable of addressing the fundamental shifts we must make from a fossil fuel based culture, and into a biosphere based one.

These lessons are designed to meet strategic developmental goals for children ages six through eight, as well as meeting current C.A. state educational standards, including the those put forth by the most recent Education for the Environment Initiative; these lessons also meet The U.S. Partnership for Education for Sustainable Development—put forth by a collaboration between the United States and the United Nations.
Using the EEI
Living Sunlight sets a foundation acknowledging core principles: EEI

Principle I
The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

As a basis for understanding this principle:
- Concept A. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.
- Concept B. Students need to know that the ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.
- Concept C. Students need to know that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems

U.S. Partnership for Education for Sustainable Development:
United Nations
Grades K-4
Ecological Systems 2.2

Visual & Performing Arts
1st Grade: 1.1
2nd Grade: 1.1
3rd Grade: 3.2
4th Grade: 2.4
Asking students questions about their own physical experiences is an immediate way of cultivating interest and personal connection to a lesson topic.

**Ask the class:** “What is your energy like today? Are you feeling like you want to move fast, are you feeling like moving slow, or somewhere in between?”

**Student Responses often include:** “I feel like moving fast!” or “I’m sleepy, I have just a little energy.”

Invite two students, (Student A with ‘excess energy’, and Student B with ‘sleepy energy’) to share how they feel with the class. Ask both students to show you how they move when they are feeling ‘sleepy’, or how they move when they are feeling ‘fast’.

**Ask the class:** “What would Student B need to have more energy like Student A?”

**Ask the class:** “Can everyone get up and move their body- what gave you the energy to move your body like that?”

**Student Responses often include:** “My arms and legs!” “I went to bed on time” and hopefully something along the lines of “My breakfast,” if any student has a food related answer, you can confirm that, “Yes! food does provide you energy.”

The next series of questions track the student back to their own food sources:

**Ask the class:** “What do you like to eat that gives you energy?”

Draw a picture of a student on the board as you ask this question.

(Continue to next page)
Choose one animal (meat based food source- egg, or meat) and
One plant based food source (berries, beet, carrot, oatmeal, rice, or
beans are examples)

Draw a picture of the two food sources you’ve chosen from those offered,
on the board next to the person. Draw one ‘energy arrow’ from the food to
the person. (See drawing below as an example.)

Ask Students: “Where does the “berry” (or whatever plant based food you’ve
chosen) get its energy from?”

Student Responses often include: “the plant”, “from the water”, “from the soil”
Answer: The berry does get its energy from the plant.
Draw a berry bush and one ‘energy arrow’ from the berry to the plant.
(For teacher reference the plant’s physical material structure came 100% from carbon dioxide and nitrogen from the earth’s atmosphere—the plant did not build itself from minerals from the soil, as many tend to think. The energy used to convert carbon dioxide into carbon comes from the energy that the plant derives from the sun. More on this in the next lesson)

**Ask Students:** “What part of the plant brings in the energy?”

**Student Responses often include:** “the roots, the leaves, the stems”

Confirm for students that it is the leaf that brings in the energy. **Draw a leaf** and connect it to the plant with one ‘energy arrow’.

**Ask Students:** “Where does the leaf get its energy from?”

**Student Responses often include:** “from the soil,” “from water,” “from the sun.”

**Possible Teacher Response:** “The plant could not live without soil and water, that is true, and yet it’s energy comes from a special place—someone mentioned this place—can you tell me again?”

**Student Responses are most often:** “From the Sun!”

**Draw the sun and the final energy line from the leaf to the sun**

Confirm for students that all plants make their food from sunlight. This is something we animals cannot do. We too are made of the sun’s energy, but we receive it from the plant life on our earth. In this way we are all made of sunlight, some of the sunlight is very fresh—like that which is in a berry, apple or other plant-based food source, some of the sunlight is not as fresh and took longer to become something that we humans use or eat—like a bag of chips or a chicken nugget (which took more sun energy to produce and a much longer time frame). We can also find varying degrees of fresh sunlight in other things we humans use—like fuel, and the fiber for our clothes. (That’s for the next lesson!)
Art Activity: Indoor version

This activity can also be used as an assessment tool for teachers to see if the lesson has provided the foundation for students to create their own ‘energy tracking drawing’.

Have students work in small groups of 3 to 4. Choose one student to bring a small item from their lunch for the group to do a ‘track the energy’ process with. If the food is packaged, ask students to focus on the food inside the packaging (tracking the packaging can be followed up within the next lesson).

Ask students to work together to think about where the food item comes from, and have students draw the different stages of energy transfer. Each student can work on their own drawing, or the team can work on one large piece of paper.

Ask Students: “You are going to eat lunch at some point today, and this food you are looking at will give you energy to move your body, talk, think, and have fun—Can you draw for me how you eating your lunch connects you to the sun?”

If students need guidance you can remind them:
- Draw a person (start with the eater)
- What plant or animal did the chosen food come from?
  Can you draw that?
- If it came from an animal- what did the animal eat to get their energy?
- If it came from a plant- what part of the plant was used to capture the sun’s energy?
- Finish the chain by having students draw the sun!

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It can be very nice to have students get up in front of class and report back to the other groups what food they chose to draw, and explain their thinking... this gives the children an opportunity to speak publicly and integrate what they have learned.

**Energy Tracking--Taking it further:** The energy track-back is generally oversimplified for young children, because many of the foods in children’s lunches do not simply track back straight to the sun that easily. The energy it really takes for an apple to get to a child’s lunch is dependent upon many other inputs.

**Example:** An apple eaten in the spring or summer is often from the southern hemisphere, it travelled using jet and diesel fuel to get to North American grocery stores. The apple orchard is likely managed by workers who drive using gasoline to get to their jobs, the fertilizers, pesticides, and herbicides that most apples receive (only .9% of the world’s agriculture is organic) are made from petroleum. Once the apple arrives into the U.S. it is transported using diesel trucks, and once at the grocery store is kept fresh with ambient cool temperatures, most of which are generated from electricity from coal burning powerplants. As you can see an apple may derive from the sun’s energy, but how it is managed once it enters our human system of food and arrives in a child's lunch, requires many fossil fuel inputs. We will address fossil fuels and their connection to the carbon cycle in the following lessons.
Art Activity: Outdoor version

Taking students outdoors is the most immediate way to expose them to the process of photosynthesis!

Plant life is so good at capturing energy that humans have recently learned to mimic the way leaves grow on trees as inspiration for the way they organize and place solar panels: This technique was developed by a 13 year old boy—and is a wonderful story to share with students before taking them outside to observe trees and plants!

Drawing Activity:

(Inspired by the Boy who created solar panel placement designs 30% more efficient by watching what trees do!)

Have students work in small groups of 3 to 4. Each group observes the plants on campus, and takes a moment to watch how the plant is structured. Does the plant have many small leaves covering its branches, or does it have fewer large leaves covering its branches? Have children collect a sampling of 4 to 5 leaves from plants on campus (gently taking leaves from plants with an abundance of them). Have student groups work together to draw the leaves they see, trying to mimic the colors, shapes and sizes of the leaf.

Discussion Questions:

What are the differences in the leaves?
Why do you think the leaves are so different from plant to plant?
What makes this leaf good at collecting the sun’s energy?

For teacher reference: Often plants with large leaves are from deciduous trees and annual plants—both of these types of plants put a lot of energy into creating ‘big solar collectors’ a.k.a. leaves because they are capturing as much of the sun’s energy as they can for only five or six months of the year. The evergreen plants, and many perennial species have smaller leaf structures so that they can endure year round weather conditions, they are generally harder species—think of the difference between a Redwood tree and a Maple tree, or the difference between an evergreen shrub, and a tulip.
Once students have connected to the fact that their personal energy derives from the sun, and have tracked back to the ‘solar collectors’ known as leaves, the next step is to connect how plants take carbon dioxide from our air, and transform it into their very own physical structure—this lesson supports students understanding that all plants are created from thin air that comes from, in part, the carbon dioxide that we exhale. Most children learn about the oxygen and carbon dioxide balance between humans and plants, this lesson takes it one step further to describe how plants are actually using that carbon dioxide, and what benefits we humans receive from this elegant process!

Using a potted plant to refer to during this lesson will help students connect to the reality of what is being asked in the question and answer period.

**Student & Teacher Question and Answer:**

**Ask the class:** Does this plant breathe? What does this plant breathe in, and what does it breathe out?

**Student Responses:** If students are already aware that plants take in carbon dioxide and expel oxygen, you can move on to the next question. If students don’t know how this works- draw the leaf on the board, and include an arrow pointing towards the base of the leaf (that’s where the stomata absorbs the CO2) with the words **carbon dioxide** (CO2), and an arrow leaving the plant with the word **oxygen** attached to the arrow.

![Diagram of a leaf with oxygen and carbon dioxide labels]

**Ask Students to:** Inhale... and exhale, what does your body use when it breathes in? What does it let go of when you breathe out?
Out of Thin Air!

Emphasize for students that their bodies are using oxygen and they are exhaling carbon dioxide, the plants are using our carbon dioxide, and giving us oxygen. This is one way that we are working with plants!

**Ask Students:** “How do plants do this?” Does the plant have a nose? What does it use to breathe?

Pointing to the leaf on the potted plant—turn the underside of the leaf towards the class, “This leaf has tiny holes, like many tiny noses which we cannot see, these holes are called stoma and many holes together are called stomata, and this is where the plant is breathing in carbon dioxide.”

**Ask Students:** “Where does the plant get its energy to breathe?”

**Students Responses:** Students will hopefully use their prior knowledge and connection to the last lesson, and let you know, “the sun gives the leaf its energy!”

**Ask Students:** “What is one thing we do to help this plant stay healthy, what do we pour into the soil of our potted plants?”

**Student Responses:** Often students are clear that we add “water.”

**Ask Students:** “What material does the plant use to build itself, what is this plant made out of?”

**Student Responses:** Often include “soil, water, and maybe even air.”

Confirm for students that the plant is using sun for energy, and water comes through the roots and into the leaves—and air comes in through the stomata. What the plant uses to build itself comes from the air. It is the carbon in the carbon dioxide that the plant uses to create its structure. In this way the plant is being built out of thin air! Some scientists call this ‘making mass out of gas.’

(Continue to next page)
Ask Students: “If the plant is using carbon from carbon dioxide to build itself, do you think we'll ever run out of carbon dioxide?”

Confirm for students that all the carbon on our earth is in a fixed amount, no more will ever come or leave our planet (other than in the form of a meteor or space ship).

Ask Students: “If no more carbon is coming to our earth, how do the plants keep getting enough to build themselves? How do they not run out?”

Answer: Carbon keeps moving around our planet, and it looks different at different times in different places. We never run out because it keeps moving around our earth, through what are known as five carbon pools. When it is needed to build plants, it is always available, (the carbon map on the front of this study guide can be used to reference the 5 pools of carbon).

For teacher reference.
Carbon is in different forms when it is in different phases of the carbon cycle.
In our atmosphere it is in the from of carbon dioxide
In our biosphere it is in the form of carbohydrates
In our soils it is in the form of carbon
In our lithosphere it is in the form of fossil carbon
In our oceans it is in the form of calcium carbonate

Ask Students: “Do you think humans are part of how this carbon moves around the planet- are we a part of the carbon cycle?”

Student Responses: Sometimes include ‘breathing’ and that is true!

Confirm for students that we are also a part of the carbon cycle when we eat a plant or when we eat an animal that eats a plant, when we put on clothes made from plants and animals, and when we get in the car to drive somewhere with fuel in our car that comes from very old (30 million year old) plants and animals. Everything we eat, wear, and fuel our cars with is made of some form of carbon. Some of that carbon is cycling through the carbon pools quickly, and some has been stored for a very long time (fossil carbon is an example of this).
Out of Thin Air!

With Students in small groups- ask students to work together to draw how these plants are made out of thin air. This will help them understand a fundamentally important part of the carbon cycle—the transfer of atmospheric carbon to biosphere-based carbon. The other carbon transfers could be delved into at another time. This particular transfer of carbon is so fundamental to human needs, it is very important for students to understand that this is where our food, fuel, and fiber come from.

Art Activity: Draw the ‘Plant out of Thin air Process’

Students can do this in small groups or individually, teachers can model this on the board and have students mirror their process, or students can get into small groups and attempt to draw the process as they remember learning it:

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For teacher reference—the internal workings of the leaf include these processes:
- The sun's energy is absorbed by chlorophyll and other pigments such as carotenoids.
- The energy is used to break apart water within the leaf, into an oxygen atom and a hydrogen ion.
- As the leaf absorbs CO2 from the atmosphere, oxygen combines and is released (that is the oxygen in our atmosphere), carbon from carbon dioxide is combined with hydrogen (from the broken water molecule), via something called the Calvin cycle to create carbohydrates.
- It is these carbohydrates, which create everything we humans rely upon—food, fiber, and fuel.
Now that we’ve brought to light that we are all a part of the carbon cycle through breathing, eating, wearing clothes, driving in cars, and using any and everything in our biosphere, we can begin to chart our use of carbon... “Is it fresh, or is it old?”

For Teacher Reference: From the last lesson we know that there is a fixed amount of carbon on our planet, with the exception of spaceships or meteors—no carbon comes or goes. Carbon exists in different forms depending on which ‘carbon pool’ it is in. There are five carbon pools on earth, and from the last lessons we know it transforms from carbon dioxide into carbohydrates when it moves from the atmospheric pool, to our biosphere. When plants take in carbon dioxide from the air, and transform it into a carbohydrate they essentially are making ‘mass out of gas.’ That ‘mass’ is material that humans use—some of it food, some of it fiber, and even fuel can be made from this mass. The activity below is a way to help students understand if their carbon comes from the biosphere or if it comes from a deeper and older source known as the lithosphere. Using the ‘carbon-meter’ drawing has the potential to move beyond one lesson plan, and even become a weekly or daily activity for students to do as a way to assess and analyze the world around them as it relates to carbon.

Using the carbon cycle map in the front of this lesson plan is a great way to share with students what the carbon cycle looks like.

**Student and Teacher Question and Answer:**

**To test prior knowledge, ask students:** “What do plants use to build themselves?” You can point to the atmosphere on the carbon cycle map as a reminder that plants build themselves from carbon dioxide that comes from the air.

If you feel your class is ready for the big word (carbohydrate), then confirm for students that once the carbon dioxide moves into the plant, the carbon becomes known as a **carbohydrate**. Refer to the carbon cycle map to point out where the biosphere is—the place where all the carbohydrates exist (grasses, trees, apples on the tree).
Ask Students: “Where does the carbon go when parts of the plant die and are no longer growing?”

Ask Students: “Where does the carbon go when an animal eats the plant? What do animals do when they eat a lot, where does the carbon go?”

Confirm for students that when plants die, and when animals poop, carbon returns to the earth, and becomes soil. (Referring to the carbon cycle map—point out the soils).

The soil is another one of earth’s carbon pools, and it is a place that is very healthy for carbon to be. Carbon in our soils means that soil is rich and black, it is a place that plants like to grow in. More plants growing means more carbon dioxide gets taken out of the atmosphere to build more plants. The more plants dying and more animals pooping—the cycle begins to grow carbon rich soils!

For teacher reference: Soils are a potentially very important carbon sink—a place on the earth where carbon could reside to create benefit, instead of detriment.

- A 1% increase in the organic matter in our soils gives the soil an ability to hold approximately 27,000 gallons of additional water per acre!
- When animals graze the grasslands in a strategic way, the roots of the grasses slough off and release their carbon into the soil, (grazing animals and grasslands have co-evolved and have sequestered carbon in earth’s soils over many millions of years.)
- A .016% increase in soil organic matter in the world’s grasslands has the ability to Reverse global warming

Ask Students: Where does carbon go that is really old, after many layers of soil and dirt grow on top... what happens to it?

Confirm for students that the old carbon (all the old dead plants and animals—dead dinosaurs included, become fossil carbon). Fossil carbon can take 640 million years to make! It is really old carbon, and it is part of the earth’s natural energy storage system. (Refer to the fossil carbon on the map- it resides in a carbon pool called the lithosphere).
How Fresh is Your Carbon?

**Ask Students:** “Do you know what we call this old carbon?”

Confirm that this form of carbon is called fossil carbon.

**Ask Students:** “Do you know what we use fossil carbon for?”

Confirm for students that we use fossil carbon for gasoline, for fertilizer, for all forms of plastic that go into computers, bags and toys, we also use fossil carbon for dye color, for fleece jackets, and stretchy clothes (spandex).

**Ask students:** “How do you think we make a fleece jacket out of old fossil carbon?”

Confirm for students that we have to heat the old fossil carbon and when it heats up we separate it into parts, we take some parts for fertilizer for plants, plastic for our clothes, some is used for gasoline to fuel our cars, and some for dyes and other materials.

**Ask Students:** “When we heat and burn fossil carbon to make our cars go, or when we burn it to make the factory run, where does that old carbon go?”

Confirm for students by using the image of the factory on the carbon cycle map—the fossil carbon returns to the atmosphere.

**Ask Students:** “What do you think the carbon becomes when it goes back to the atmosphere?”

Confirm for students it returns to the air, and becomes carbon dioxide again.

We need to burn a lot of fossil carbon to keep our lives going at school and at home, and because of this, there is a lot of carbon dioxide in our air, so much that it is no longer healthy for our earth, (you can choose to, or not to discuss climate change at this point.)

**Ask Students:** “Do you think humans could use a fresher source of carbon, (not such an old source) for their clothes, fuel, and fertilizer to raise their food?”
How Fresh is Your Carbon?

Where might we get a fresher source of carbon? (Pointing to the carbon cycle map to help students refer to a visual)

Confirm and remind students that there are fresh sources of carbon in our biosphere called carbohydrates and these carbohydrates can supply our food, fuel and fiber (the three F's). These carbohydrates are in plants. Plants are always taking carbon dioxide out of the atmosphere and using it to build themselves. When they decay, the carbon they have stored goes into the dirt to make good soil for more plants. The plants re-grow every year, making more carbohydrates by taking more carbon dioxide out of the atmosphere—it is a constantly renewing and fresh carbon cycle!

**For teacher reference:** Carbon dioxide is a resource for plants, we humans have utilized so much stored fossil carbon that there is now too much in the atmosphere. However, the more we can support utilizing fresh forms of carbon for our daily lives, the more we will begin to see carbon dioxide as a resource, and not an unhealthy molecule. There is just too much of it in the wrong place at the moment. We as a global community, starting in every classroom can begin to make choices towards eating, dressing, and fueling our lives with fresh carbon, and return balance to our carbon cycle.

**Ask students:** “Can you tell me an example of a food that is made from fresh carbon?”

Example: fruits, vegetables, and fresh meat. Old carbon comes into the food system through packaging, shipping, and fertilizer.

**Ask students:** “Can you tell me an example of clothing that is made from fresh carbon?”

Examples: 100% natural fibers like cotton, linen, or wool clothes (dyes are an exception and the color is from fossil carbon, unless it is a plant-dyed garment).

**Ask students:** “Can you give me an example of fuel that is made from fresh carbon or even a fuel that doesn’t come from carbon?”

Example: The sun that fuels solar panels, wind energy, bio-fuel (made from carbon), and ethanol (made from carbon).

**Ask students:** “Can you tell me how we can fertilize our plants with fresh carbon?”

Example: Compost! (a combination of green waste, food waste, and animal manure if you have it will make the best compost).
How Fresh is Your Carbon?

**Art Activity:**
As individuals, have students use the ‘carbon-meter’ below as a model for their own drawing—this is helpful to having all the students create the correct color scheme. This meter shows a slice of our earth, from the atmosphere down to the old carbon storage system in our earth’s crust.

Once students have sketched their own carbon-meter they can work in small groups or as individuals to chart some of the things they eat, wear, and how they got to school.

**Example:** If the choose a cotton T-shirt, they can draw the T-shirt, and then a line from this drawing, to where the cotton comes from. To start, we know the T-shirt comes from cotton that comes from the biosphere (one line of connection), and that might be where students begin. To further the conversation, ask them to draw a line of connection from the color of the shirt to where the think the dye comes from (second line of connection to the source of the dye). Then you may ask students how the shirt got from the cotton farm, to the factories, and then to the store, (third line of connection to the fuel source).

**In a group:** The class as a whole can work on coloring a large carbon-meter that can be used by the class for weekly or daily activity. Examples of use: Choose a student or a small group of students to choose an item that one of them is wearing, or has in their lunch, or that is a familiar object that they all like and draw it on small piece of paper, and have them cut it out so it can be pinned or taped next to the carbon meter. Ask students to come in front of the class to point to the part of the earth the item is from. Using twine or yarn the teacher can pin a direct line connecting the item to its source. Over time, a collection of items will be mapped and students will begin to see visually how fresh their carbon is, in relation to the material culture in their daily lives.
How Fresh is Your Carbon?
This guide was almost finished when Nutmeg Media asked if they could make a DVD of the book. Penny and Molly happily agreed, and the DVD Nutmeg made is great! It also includes some comments by Penny and Molly about how they made decisions as they worked on the book. If you decide to include the DVD in your lesson about photosynthesis, we suggest that you show it at this point, after the discussion above and before you read the book as in the dialogue below.

Reading the Book: Suggested Questions and Comments

For older readers, we suggest three goals. The first and most basic is to be able to follow the movement of energy from the sun, to plants, to the animals that have eaten the plants. In Living Sunlight, the energy is shown sometimes as little yellow dots, sometimes as a glowing yellow halo around the molecule or plant or animal that contains it, sometimes as a swirling starburst within an animal or plant. The second goal is to grasp some of the details of photosynthesis, e.g., the splitting of water, the release of oxygen, and the incorporation of carbon dioxide. The third goal is to learn something about respiration—the reverse of photosynthesis—and the cycling of carbon between plants and animals.

Title page
What’s the title of this book? Living Sunlight
Down at the bottom it says, “How plants bring the Earth to life?” Does anyone know what that is called? The subtitle. Subtitles give us a clue about the subject of a book.
Who wrote the book? Molly Bang and Penny Chisholm
Who made the pictures for the book? Molly Bang. How do you know?

Now look at the picture. What do you see? A child and a tree... sitting on a ball.
What’s the ball? The Earth. And what’s all around the Earth? Space.
And what are all these little yellow dots? They show the light energy coming from the sun.
Do you think there are REALLY little yellow dots coming from the sun?
No, not really, but Molly Bang had to show the sunlight-energy somehow. So she showed the sunlight-energy as waves of little yellow dots.
As we read, let’s watch the yellow dots...

pp 6-7 (child on swing)
(very quietly) Can everybody feel how warm you are? Do you feel your heart pumping? Do you feel your energy?
Where is the sunlight-energy in this picture?
What’s inside the child on the swing? Yes! Little yellow dots.
Hmm...how can there be light inside of us?
What do you see in this picture? The huge sun…the tiny Earth. (Note: The sun is bigger than one million Earths all put together!)

(As you read each phrase ask the children to point to the picture that illustrates what you have just read…) I warm your land (point) and seas (point), etc. With each picture, where are the yellow dots of sunlight-energy? What are the four things that the sunlight-energy is doing? Warming the land. Warming the seas. Melting the glaciers. Making the wind.

Yes, and it does even more than that! I wonder what?

(Note: It’s hard to say what the yellow dots in the fourth rectangle, the wind picture, are doing. Nevertheless, the sun does create wind by heating air near the surface of the Earth. The warm air rises and pulls in air around it, creating winds. There’s more about sunlight energy and wind in Molly’s book, My Light.)

Where are the dots of sunlight-energy now? In the child, the bear, the fish, the tree, the plants, etc. How does it get there? (The children don’t know yet.)

What’s different about the illustrations inside the four rectangles? They show things that are happening inside the leaves or roots of the green plant. These are things that are far too small to see without a microscope or even too small to see with a microscope.

Ask students to find the sentence in the text that describes what’s happening in each of the rectangles.

Rectangle 1. Plants suck up water—H₂O—from the Earth.
Rectangle 2. In daylight, green plans catch my energy with their chlorophyll.
Rectangle 3. Plans use my energy to break apart the water—break the H₂O into H and O₂, hydrogen and oxygen.
Rectangle 4. But as plants break apart the water, they trap my energy as little packets.
Ask students to describe what’s happening to the sunlight energy in each rectangle.

**Rectangle 1. Nothing.**
**Rectangle 2. The chlorophyll is capturing the sunlight energy.**
**Rectangle 3. The plant is using the captured energy to break apart water molecules.**
**Rectangle 4. The sunlight energy is being trapped in little energy packets.**

**Looking what’s happening in the rectangles more closely.**
(We’d suggest that you read through the book once and then come back to look at this page more closely.)

**Rectangle 1. Plants suck up water—H₂O—from the Earth.**
*The first rectangle shows water molecules moving into the roots of the plant. You can tell they’re water molecules because water is H₂O and Molly’s water molecules have a large white dot, the oxygen atom, and two small blue dots, the two hydrogen atoms. Is this what water molecules really look like? No.*

Ask students to make labels for the picture. They can label the water molecules, the dirt, the root, oxygen atoms, hydrogen atoms. For extra credit, they can find what’s “wrong” with Molly’s illustration. (In her illustration, it looks like there’s a vein inside the plant’s roots that’s full of water. Animals have veins like that. Plants don’t. Their vascular tissue—the xylem and the phloem—is packed with cells.)

**Rectangle 2. In daylight, green plans catch my energy with their chlorophyll.**
*The second rectangle—the one that looks like a vase—shows chlorophyll inside a leaf. The chlorophyll is catching the sunlight-energy and is glowing from the captured light-energy.*

Again, this is image of chlorophyll catching sunlight is more suggestive than accurate. For extra credit, ask students to find pictures that show the internal structure of a leaf and of chloroplasts.

**Rectangle 3. Plans use my energy to break apart the water—break the H₂O into H and O₂, hydrogen and oxygen.**
*The third rectangle shows the plant using the captured light-energy to split water molecules into oxygen and hydrogen. There are water molecules entering from the lower left. The double white balls heading up are the oxygen molecules (O₂) and the blue balls streaking down are hydrogen.*

Ask students to label the chloroplast, the water molecules, the oxygen molecules, and the hydrogen atoms. Ask students to write a sentence to describe what’s happening.
Rectangle 4. But as plants break apart the water, they trap my energy as little packets. 
*The fourth rectangle shows the plant trapping the captured light-energy in little “packets.”*

Ask students to write a sentence to describe what’s happening in this picture.

Summarize what happened to the sunlight energy: the sunlight energy was trapped by the chlorophyll in the leaves and now it’s in the little packets. What happens next?

Summarize what else happened as the plant used sunlight energy to make the energy packets: the plant pulled water up from the soil, split the water molecules, and released oxygen from the water into the air.

Sequences: There are four pictures in rectangles on pages 10-11 and four pictures with rectangles here on pages 14-15. Ask students to look at the two sets of four and to see if they can tell the difference between them. The pictures on pages 14-15 show a sequence of events in order. The pictures on pages 10-11 are in no particular order. Those pictures do not show a sequence.

pp 16-17 (leaves with one big square) 
What are the double white dots? Oxygen (O₂) molecules produced as a by-product of photosynthesis drifting out of the leaves into the air.

What are the things with two white dots and a black dot? Carbon dioxide (CO₂) molecules. The two white dots stand for oxygen and the black dot for carbon.

Ask students first to read the sentence that describes what’s happening in the illustration in the large rectangle. “*Now plants use the packets of my energy and the carbon dioxide from the air to build...”*

Next ask them to describe in more detail what’s happening in that illustration. The energy packets (the glowing orange blobs) fly in from the top and crash into the large, orange ball. The orange blobs are no longer glowing because they have passed their energy on to the strange clusters of black, white, and blue balls floating off the page to the right. Carbon dioxide molecules pulled out of the air enter the large, orange ball from the left and are incorporated into the strange glowing clusters floating off to the right.

Ask students what the colored balls stand for. White is oxygen, blue is hydrogen, and black is carbon. So the strange clusters are molecules made of carbon, hydrogen and
oxygen. (For reasons that only Molly knows, the oxygens here have gotten bigger than the carbons.)

The large orange ball represents an enzyme, rubisco, that makes the process possible. You can read more about rubisco in the notes at the end of the book.

Summarize: The energy has gone from the sun, to the chlorophyll, to the packets, and now to the strange molecule of carbon, hydrogen, and oxygen. We'll find out what that molecule is on the next page.)

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**pp 18-19 (green hills with sugar in the sky)**

What are the strange clusters of black and white and blue balls? **Sugar!**
Where are the dots of sunlight-energy in this picture? They're in the sugar and in all the plants!

What do plants build with the sunlight-energy? Yes—**sugar! Plants make sugar inside their leaves!** (It's not the same as the white sugar crystals we eat. Think of it as “plant sugar.”)

Can everybody say “photosynthesis”? What does photosynthesis mean? **It means making life with sunlight.**

Before you move on to the next page, ask students where the sunlight energy (the yellow glow) is now. It's in the sugar and it's in all of the plants, in their leaves and stems and fruit and flowers.

Summarize: Something very important has happened, something that Penny calls the conversion of gas into mass. Green plants have taken carbon dioxide from the air (a gas) and turned it into a substance (sugar). The carbon dioxide is useless to us as an energy source (food). Sugar—and remember, we're talking about glucose or plant sugar here, not sucrose, the stuff that's on the kitchen counter—is the basic energy source for all living things.

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**pp 20-21 (brown hills with only animals)**

Read the text on page 20. (Beginning, “But wait! You are not green!” and stopping at “...whole wide world.”)

As students to look at the picture and compare it to the picture on pages 18-19. What's the difference? **In the first picture there are no animals. In the second picture there are no plants.**

Where is the sunlight energy in the second picture? **It's in the sunlight (the little yellow dots), but it's not in the animals.** How can you tell? **The animals don't glow.**
Now read the text on page 21. Beginning, “So…”

pp 22-23 glowing, green hills with both plants and animals)
Read the text and then ask students, What’s happened to the animals in this picture? **They’re glowing because they have sunlight energy in them.** How did they get the sunlight energy? **By eating plants.**

Summarize: The sunlight energy has gone from the sun, to the chlorophyll, to the energy packets, to the sugar, to all the parts of the plants. Now the sunlight energy is in the animals that ate the plants.

pp 24-25 (big leaves and sky)
At this point, we’ve finished with the movement of the sun’s energy and photosynthesis and we’re moving on to a second, related process, respiration. As part of photosynthesis plants “breathe in” carbon dioxide and “breathe out” oxygen. As part of respiration, animals do the opposite: they breathe in oxygen and breathe out carbon dioxide. They breathe in the oxygen and use it to “burn” the food (sugar-energy) they got from plants. The result is a cycle, the carbon cycle, that is described on pages 24-29 and illustrated in Printable 5.

(Note: carbon cycles neatly back and forth from plants to animals, from carbon dioxide to sugar and back to carbon dioxide. Oxygen is more complicated. It goes from plants to animals and into the carbon dioxide that animals breathe out. But the oxygen that plants breathe out doesn’t come from the carbon dioxide that they breathe in. It comes, as you may remember, from water that plants suck up from their roots. So there’s a balance between plants that breathe in carbon dioxide and breathe out oxygen and animals that do the opposite, but the oxygen doesn’t cycle neatly the way the carbon does.)

What are those double white dots floating everywhere? **Oxygen molecules.** Where does the oxygen in the air come from? **When the plants put sunlight energy into the energy packets (way back on pages 14-15) they split water molecules and released oxygen molecules into the air.**

pp 26-27 (child breathing in)
What’s the child in the picture doing? **Breathing in, inhaling.** Breathe in. What’s in the air that you breathe in? **Oxygen—from plants!**

What are the white double-dots that the child is breathing in? **Oxygen (O_2).** Where did the oxygen come from? **From green plants.** What do you do with the oxygen inside your body? **We use it to slowly burn the food we’ve eaten to make the energy we need to move and grow and live.**
The four sentences on page 27 are the basic take-home message of the book. “Without plants you would have no oxygen. Without plants, you would have no food. Without plants, you could not live. Without plants, there would be no life on Earth.” So take a minute or two with that page. Even if students don’t understand the details of photosynthesis, they should get this point.

pp 28-29 (child and other animals breathing out)
What’s the child in the picture doing? **Breathing out, exhaling.**
Breathe out. What’s in the air that you breathe out? **Carbon dioxide.**
And what happens to the carbon dioxide? **The plants breathe it in and use it to make more sugar.**

Breathe in. What goes in? **Oxygen that comes from plants.**
Breathe out. What goes out? **Carbon dioxide that goes to plants.**
In and out. Inhale and exhale. Oxygen and carbon dioxide. Plants’ gift to us. Our gift to plants.
What are the triple black and white dots that the child is breathing out? **Carbon dioxide (CO₂).** What happens to that carbon dioxide after you breathe it out? **Plants use it to build more sugar.**

pp 30-31 (life circling around)
(Note: it’s not the sunlight energy that circles around. Energy moves one-way through the system, from the sun to green plants to animals, and then it is lost as heat. What circles around, uniting all living things, is the carbon.)

pp 32-33 (circles of animals and plants)
Where is the sunlight-energy? **In the plants and the animals.**
**From the plants to the animals.** There is sunlight-energy in all of us.
Extensions

Experiments
How does sunlight affect plants?
Put one houseplant in sunlight and one in a dark closet for several days (or cover one with a thick paper bag rather than putting it in a closet, if you don’t have one in your classroom). Then observe the differences between the two plants. This can be done in a casual or more formal manner, with or without daily recordings of observations.

Plant seedlings, either in paper cups with soil or on wet paper towels in plastic bags, and experiment by putting some in a sunny spot, and others in darkness.

During a sunny weather spell, stake off a square of grass in your schoolyard and cover it with a shoebox or other lightweight object. After several days, remove the box and see how lack of sunlight affected the grass.

Plant a bed of grass in your classroom in a large container. A long rectangular flowerbox for windowsills would be ideal. Divide it into sections and experiment by covering some sections with construction paper and exposing others to sunlight.

Tape small leaf-size pieces of black construction paper over several leaves on a plant. After several days take off the black paper and compare those leaves with the leaves that were untouched. What do you conclude?

Do green plants really give off oxygen?
Put a green leaf in a jar full of water and put it on a sunny windowsill. Later, use a magnifying glass to observe closely and you’ll see tiny bubbles on the leaf. Why are there bubbles on the leaf?

Do the same thing with another leaf but do not expose it to light. Do you see bubbles? What do you conclude from this?

Collect pond water and some pondweed, put in a large jar or recycled plastic bottle, and observe the pondweed with a magnifying glass to see if you can detect bubbles. Does this mean that all green plants breathe out oxygen? Even underwater ones?

If growing seedlings, place a clear jar over them and place on a windowsill. Leave overnight, then check in a.m. Condensation should collect on the inside, as evidence of transpiration—the plants were “breathing” out oxygen overnight.

How do plants breathe?
Conduct an experiment to see which side of a plant leaf “breathes” gases. Where does the carbon dioxide go in and the oxygen go out? Rub Vaseline on the top side of five leaves on a plant. Then rub Vaseline on the bottom side of five other leaves on a plant. Observe the leaves each day for a period of time and see what happens. What do you conclude?
Activities

Sunlight

• Make sun tea – Harness the power of the sun instead of using a kettle! Fill a glass jar with cold water and put in about one tea bag for every two cups of water (stronger if you like but most kids don’t like it too strong). Leave in the sun for one hour. Take out the tea bags and stir in some maple syrup to sweeten (or have an adult make a simple syrup by boiling two parts water to one part sugar). Add lemon if you like. Have a tea party to celebrate sunlight.

• Make solar leaf prints – Place leaves in patterns on construction paper. Leave in the sun for a certain period of time; when you take off the leaves you’ll see outlines of the leaf shapes and see the mark of the sun’s energy where the sun has bleached the paper.

Leaves

Go on a leaf hunt. Collect leaves of different shapes and sizes and bring them back to the classroom. There are several things you can do with them:

• categorize them according to shape, color, etc
• make leaf prints with paint – paint the leaves, then place them paint-side down on construction paper, put another piece of paper on top and press down like a printing press – examine the veins, stems, and other details in the leaf prints, then label them w/ arrows
• make leaf rubbings – choose a variety of different leaves - cover a leaf with thin recycled computer paper and rub it lightly with a green crayon or colored pencil – examine the different vein patterns and talk about what happens inside the leaf during photosynthesis

Plants—general

• Make a “Living Sunlight” mural for your classroom wall. Write the subtitle of the book at the top: “How Plants Bring the Earth to Life.”

• Learn about plant parts by having a Salad Party! Students volunteer to each bring in a different plant part for the salad – a vegetable that’s a flower (like broccoli), a stem (like celery), a root (like a carrot) or a fruit (like tomato or peppers, etc). Begin with categorizing by plant parts. Then have kids help wash and prepare the salad, and then eat it all together as a celebration of plants.

Food cycles / “air” cycles

• Make a terrarium and observe the mini ecosystem in your classroom. Add a couple creatures (like snails, salamanders) along with plants. Observe each day. Talk about how the air and water and sunlight energy and plants and animals are all connected in their little world.

• Make a collage using magazine clippings and pictures printed from the Internet of plant and animals that could live in one ecosystem. Paste the pictures on a poster and draw arrows to show the flow of energy.

• Make simple food chain mobiles with sun, plant, animal, etc.
Web Links

Online Activities for Kids
Parts of a Plant and the Plant Life Cycle
http://www.brainpopjr.com/science/plants/
The Great Plant Escape
http://urbanext.illinois.edu/gpe/case1/c1facts2c.html
Fun with Food Webs
http://www.harcourtschool.com/activity/food/food_menu.html
Chain Reaction: Build your own food chain
http://www.ecokids.ca/pub/eco_info/topics/frogs/chain_reaction/index.cfm
Web of Life: Blue Planet Challenge
http://www.bbc.co.uk/nature/blueplanet/webs/flash/main_game.shtml
Build-your-own Food Webs & Food Web Mysteries
The Carbon Cycle Game
http://www.windows.ucar.edu/earth/climate/carbon_cycle.html
Short video clips on photosynthesis for K—5
http://www.neok12.com/Photosynthesis.htm
NOVA Online: Illuminating Photosynthesis – flash animation and game
http://www.pbs.org/wgbh/nova/methuselah/photosynthesis.html
National Geographic for Kids: “Quick Flick” movie on photosynthesis
http://magma.nationalgeographic.com/ngexplorer/0204/quickflicks/

Teacher Resources
NOVA Online: Illuminating Photosynthesis
http://www.pbs.org/wgbh/nova/methuselah/photosynthesis.html
Photosynthesis guide from Newton’s Apple
http://www.newtonsapple.tv/TeacherGuide.php?id=915
Sugar and Carbon – How the Earth Works
http://science.howstuffworks.com/earth3.htm
Photosynthesis – How the Earth Works

Online videos:
Photosynthesis: The Process
Plants: Photosynthesis
Assignment Discovery: Photosynthesis (from the Discovery Channel)
Plants: Plants in the Tropical Rainforest
Exploring Time: The Carbon Cycle (from the Science Channel)