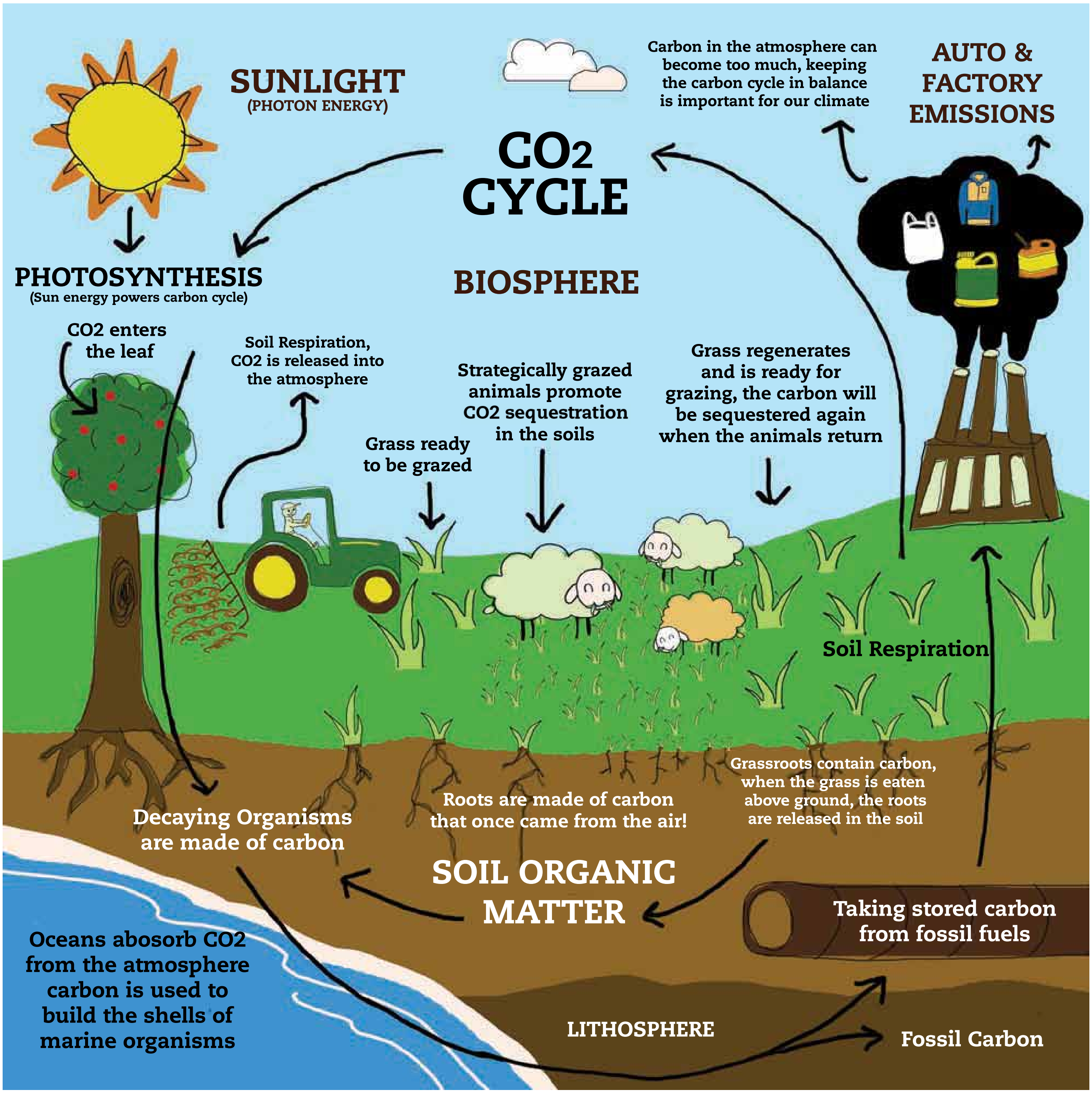
INTRO

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.

These lessons meet the following standards

Grade 1
Life Sciences 2.b, 2.e
Earth Sciences 3c

Grade 2
Earth Sciences 3.e

Grade 3
Physical Sciences
1.a, 1.b

Grade 4
Physical Sciences 1a, 2a
Life Sciences 2e

Using the EEI
Living Sunlight sets a foundation acknowledging core principles: EEI

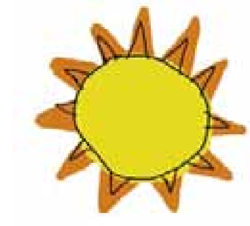
Principle I
The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

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

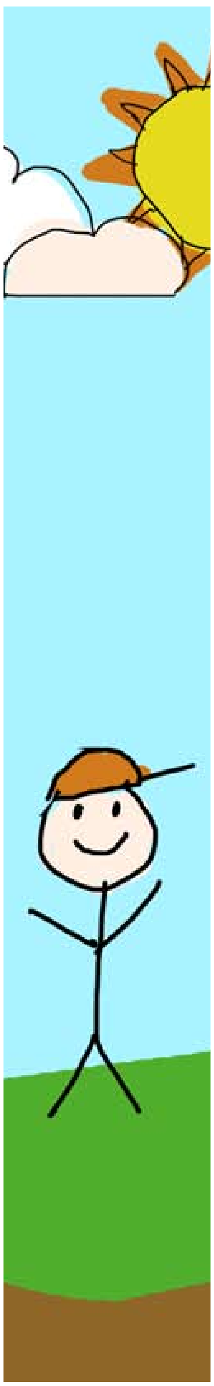
Visual & Performing Arts
1st Grade: 1.1
2nd Grade: 1.1
3rd Grade: 3.2
4th Grade: 2.4

From Student To Sun
Where Does My Energy Come From?



Lesson Time Frame: 40 minutes

Raw Materials:
Use of chalk, dry erase, or smart board
Paper, Colored pencils, crayons, or markers



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.

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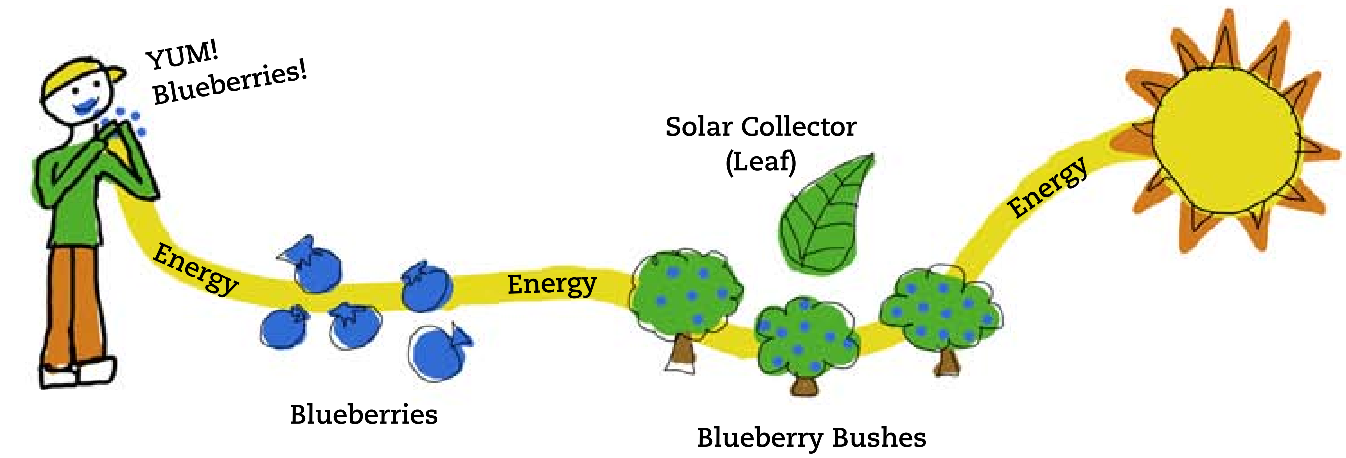
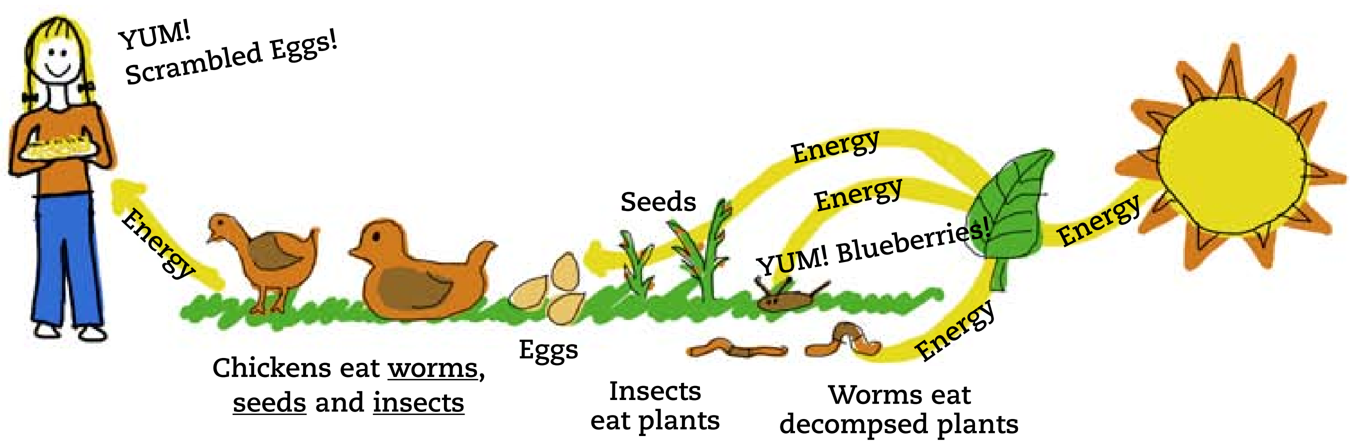
From Student To Sun
Where Does My Energy Come From?

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.

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From Student To Sun
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(For teacher reference, the plant's physical material structure is approximately 40% (by weight) made from carbon dioxide from the earth's atmosphere. The plant did not solely 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!)

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From Student To Sun
Where Does My Energy Come From?

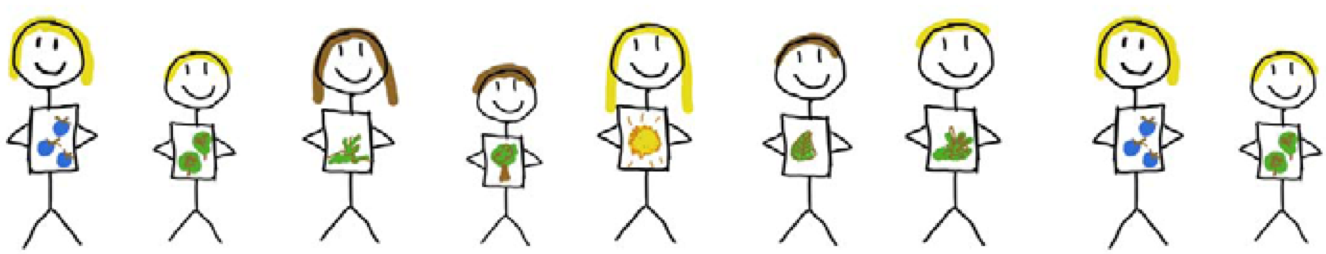
Art Activity: Indoor version

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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From Student To Sun
Where Does My Energy Come From?

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 publically 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.

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From Student To Sun
Where Does My Energy Come From?

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!)
http://inhabitat.com/13-year-old-makes-solar-power-breakthrough-by-harnessing-the-fibonacci-sequence/

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 hardier species—think of the difference between a Redwood tree and a Maple tree, or the difference between an evergreen shrub, and a tulip.

Out of Thin Air!

Lesson Time Frame: 40 minutes

Raw Materials:
Potted Plant, use of chalk, dry erase, or smart board
Paper, Colored pencils, crayons, or markers

Vocabulary:
Oxygen
Carbon Dioxide
Stomata (plural for Stoma)

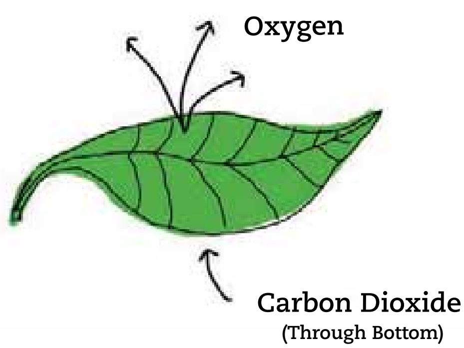
Once students have connected to the fact that their personal energy derives from the sun, and have tracked back to the 'solar collectors' known as leaves, the next step is to connect how plants take carbon dioxide from our air, and transform it into their very own physical structure—this lesson supports 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.



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?

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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.'

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Out of Thin Air!

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).

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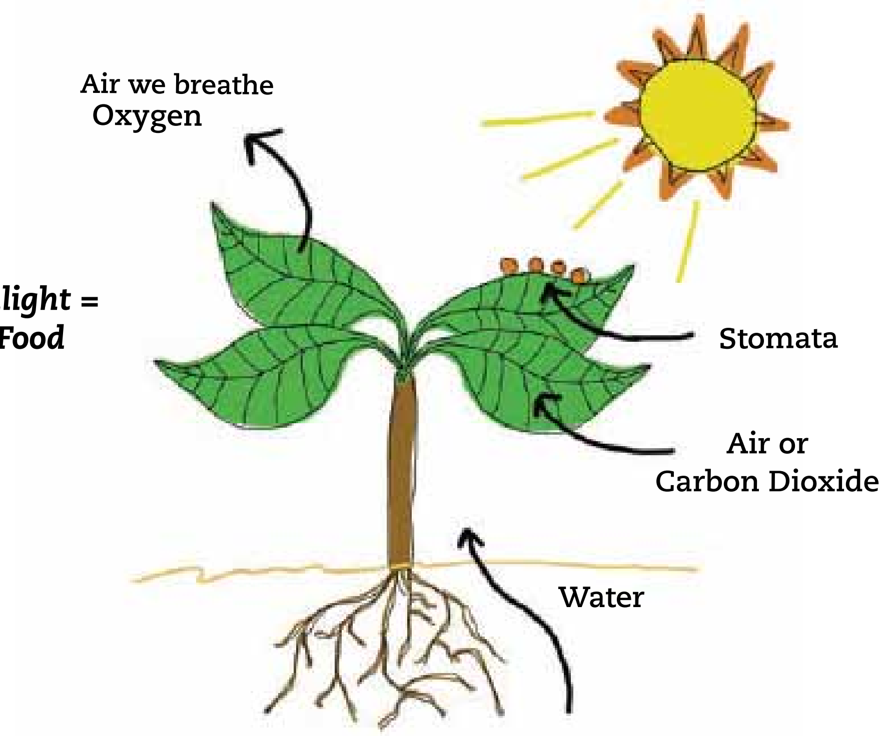
Out of Thin Air!

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:

Water + Air + Sunlight = Food Clothes & Food



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 CO_2 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.

What Carbon Pool is it From?
"How Fresh is Your Carbon?"

Lesson Time Frame: 40 minutes

Raw Materials:
Drawing Utensils, Paper

Vocabulary:
Carbohydrate
Biosphere
Fossil Carbon

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), than 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).

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How Fresh is Your Carbon?

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).

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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?*

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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?