



H I G H S C H O O L

S T E A M , E N V I R O N M E N T A L S Y S T E M S ,
G O V E R N M E N T



CHOOSING TO CONSUME

Driving Questions:

How does the level of atmospheric carbon affect global climates?

How do the crops we grow as food affect the amount of carbon in the environment?

How can changing what food crops we choose to grow affect carbon's effect on climate change?

Materials Needed:

Notebooks or computer to document data collection, test plants (store bought or grown), oxygen probes with data logging software, a controlled lab environment in which to grow plants

In this lesson, students will:

- explore how, over time, levels of atmospheric carbon correlate with global climate data. They will investigate how the plants we cultivate have an effect on carbon levels via photosynthesis and respiration, and use plant data to hypothesize how changes in agronomy could influence climate change.

National Learning Standards:

Science: LS2-7; ETS1-1; ETS1-3
Social Studies: VII,e; VIII,d
Art: Pr6.1.Ia; Re.7.1.Ia; Re8.1.Ia;
Cn10.1.Ia; Cr1.2.IIa; Cr1.1.IIIa; Cr3.1.IIIa



SPINNING THE COCOON

Prior to class or as a class, students should read NASA's data on climate change found on their [website](#). Define greenhouse gasses as any atmospheric gas that absorbs and re-emits radiant energy from the sun. Students will assist in compiling a list of known greenhouse gasses such as carbon and methane. As a class, discuss how an increase in these gasses would affect the level of radiant energy absorbed and emitted in the Earth's atmosphere. Analyze the charts and graphs depicting global climate and atmospheric carbon levels on the Exploring the Environment [website](#).

Draw or present an image of the carbon cycle and analyze areas where carbon is emitted such as via the burning of fossil fuels. Also point out carbon "sinks" such as peat bogs and carbon-sequestering plants. Ask students to hypothesize how current human activities may be influencing global climate change through increased carbon levels, and brainstorm ideas on ways to reduce this greenhouse gas. Use this to transition into a discussion on photosynthesis and the different rates at which it occurs.

Review students' prior knowledge on the basics of photosynthesis. Students should be able to recall, at minimum, that plants take in carbon dioxide and release oxygen in the presence of certain forms of light such as the sun or grow lamps. Write the basic formula for photosynthesis $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ on the board. As a class, discuss what occurs in plants in the absence of light. Students should be able to recall that, in the absence of light, plants consume oxygen and release carbon dioxide in the process of respiration.

Even though plants undergo respiration and are known to release carbon dioxide, they are still carbon sinks and reduce the amount of carbon in the atmosphere. Explain that plants perform photosynthesis and respiration at different rates. Use [this](#) resource to explore how differences between photosynthesis and respiration indicate the net carbon consumption of a plant. Discuss how changes to the size of leaves throughout a plant's life cycle can change its net carbon consumption.

As a class use elodea leaves, sodium bicarbonate, an oxygen sensor and data-logging software to track data on photosynthesis and respiration rates, then calculate the net carbon consumption of the elodea leaf.

KERNEL OF KNOWLEDGE

Theories suggest that increased carbon in our atmosphere has led to our food crops containing increased amounts of sugar, replacing other healthy nutrients.



METAMORPHOSIS

Students will research both typical and atypical food crops. As a group, they will choose three crops that would be considered a food-producing crop. The plants chosen must be plants that can be cultivated and experimented on by the students over an extended period of time (at minimum the vegetative and fruiting/harvesting stage of the plant), and that can be grown in a highly controlled lab environment with grow lights. The students can decide whether the plants will be grown from seed or if they will be purchased as seedlings.

Student groups will design an experiment that tests the following parameters pertaining to carbon regulation:

- What amount of carbon is sequestered by the plant via photosynthesis at various points in the plants growth cycle?
- What amount of carbon is emitted (or what amount of oxygen is consumed) by the plant during a simulated overnight respiration period during the same points in the growth cycle?
- Data should also be collected on the amount of resources such as water and fertilizer used to keep the plants alive.

The project design will be at the discretion of the students. Most will choose to clip leaves and use the harvested leaves and sodium bicarbonate solution in test tubes to measure the photosynthetic rate with an oxygen sensor over a period of time. They can then measure oxygen consumption of the same sample when deprived of light. Special care should be taken by students to ensure light intensity remains consistent during data collection throughout the entire project.

While this project should be student designed, you will facilitate by ensuring students are using data collection tools correctly, and collecting data at frequency intervals that allow them to determine rates of photosynthesis compared to rates of respiration at various points in the plant's life cycle. You may also assist students with calculating actual CO₂ consumption and release based on the data collected.

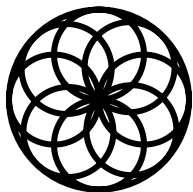
Students should use the data they collected to determine which food crops are better carbon sinks. They will summarize the results of their research, outlining which food crops they recommend planting to help reduce atmospheric carbon and to what extent the crops may have an effect based on net carbon consumption alone. Students should also use the additional data they collected on water use and crop yield to render a more detailed conclusion.



METAMORPHOSIS

UPCYCLE

When compost is properly worked, it emits small amounts of CO₂. If, however, waste is buried in a landfill, it produces methane. If the methane is not recaptured and used, it can be just as bad for the environment as carbon dioxide. Students should determine the amount of CO₂ released by composting materials and investigate if the crop yield is better than using chemical fertilizers. As an extension, students may also try growing hydroponic or aquaponic plants, or select another growth medium, to determine their crop yield and net carbon consumption.



KALEIDOSCOPE

This video project may be done in small groups or individually and can be offered as extra credit.

Have students create a short video that:

- explains NASA's purpose,
- identifies the branch of government to which the agency reports,
- provides an example of a technology NASA has released publicly that has improved consumer products,
- provides an explanation of research NASA has provided publicly relating to climate change,
- explains how society can reduce carbon emissions, and
- shares ways citizens can convince government officials to enact laws that reduce carbon emissions in the Earth's atmosphere.

Students may come up with varying responses in their video but should understand that NASA is an independent executive agency created by Congress that reports directly to the President. Its purpose is to conduct space exploration and develop aeronautics technologies for the benefit of mankind. NASA has released several important technologies such as memory foam and invisible braces, which have allowed consumers access to a variety of innovative products. The agency has also provided the public evidence that climate change is a real phenomenon.

For inspiration, students can watch the films *An Inconvenient Truth* and *An Inconvenient Sequel: Truth to Power*. When finished, have them upload their videos to Flipgrid.



eARTh

Activist art brings awareness to an issue that affects a large group of people. Often, it is driven by political or environmental issues. With your students watch some of the videos below that feature artists who use their work to advocate for causes about which they feel strongly.

[Aida Sulova](#): An artist who paints on public trash cans to bring awareness to the serious issue of waste plaguing Kyrgyzstan.

[Paulo Grangeon](#): This artist worked with the World Wildlife Fund to create an installation that brings awareness to the dwindling numbers of pandas in the world.

[Chris Jordan](#): This artist creates photographs that show the massive amounts of debris that humans generate.

As you view these examples with your students, ask them to point out whether the artists have been successful in conveying their message to the viewer. Though many of these images would traditionally not be considered “beautiful,” have the students discuss the ways in which the artist has used the elements of art and principles of design to create aesthetically pleasing works that carry a deeper message.

Now, either individually or in pairs/small groups, instruct the students to choose an environmental issue about which they feel strongly and create a piece of art based on that issue. The art should be large-scale and may take some time to fully execute. They need to produce multiple preliminary sketches and ideas before deciding upon their final design. When finished, the students should present their work to the class, discuss their creative process and explain why they chose their subject. They should be able to provide an in-depth knowledge on the issue and field questions from their peers.

Community Garden

- With your students, visit the [website](#) for the World Wildlife Fund (WWF). The WWF provides opportunities to “adopt” an endangered animal. As a class, choose an animal that you would like to adopt and create signs and posters with images of the animal on them to post around the school and community. Work to raise money to adopt your animal and advocate throughout your community for people to adopt additional animals available through the organization. The class may opt to create a video promo on behalf of the animal using stock footage and graphics to discuss the impact to the environment were the animal to go extinct.



CAREER CONNECTION

Applied Climatologist - Climatologists are scientists who study long-term trends in climate. Depending on the position, this career requires anywhere from a bachelor's to a doctoral degree.

Sustainability Consultant - Sustainability consultants help corporations plan and execute their sustainability and corporate social responsibility efforts - from energy efficiency to employee well-being and engagement. Education requirements for this job vary from on-the-job training and experience to a master's or doctorate degree.



CAREER HIGHLIGHT

Michael Pollan is a writer whose essays on food have inspired millions to rethink what they cook and consume. Several of his books relating to food science have been made into documentaries, including *Cooked*, a four-part Netflix documentary on different natural elements and their relationship to modern cooking methods.

