CO2 LEARNING CENTER

Video Two Lesson Plan

Gases Come Alive

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

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A note about our lesson plans:

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

This lesson plan was created by the CO_2 Coalition's Senior Education Advisor Sharon Camp, Ph.D. Analytical Chemistry; B.S., Geology, using Next Generation Science Standards (NGSS).

The NGSS are the standards on which most public-school systems have based their curriculum. We do not necessarily endorse the NGSS but have included the relevant standards for circumstances in which a teacher is required to use them. The lesson plans contain everything that a teacher might be required to submit in a formal lesson plan to a school administrator or science department head.

Understanding NGSS:

LS: Life Science

PS: Physical Science

ES: Earth Science

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

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

CO2 LEARNING CENTER

Lesson Plan: Video Two

Grades K-8

Next Generation Science Standards (NGSS) Learning Objectives:

5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun.

- **PS3.D: Energy in Chemical Processes and Everyday Life**.

  The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)

- **LS1.C: Organization for Matter and Energy Flow in Organisms**

  Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1)

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

- **LS1.C: Organization for Matter and Energy Flow in Organisms**

  Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth or to release energy.

- **PS3.D: Energy in Chemical Processes and Everyday Life**

  Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

- **LS1.C: Organization for Matter and Energy Flow in Organisms**

Plants, algae (including phytoplankton) and many microorganisms use energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

- **PS3.D: Energy in Chemical Processes and Everyday Life**

  The chemical reaction by which plants produce complex food molecules (sugars) uses sunlight as an energy input. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (secondary).

  Source: https://www.nextgenscience.org

Student Learning Goals

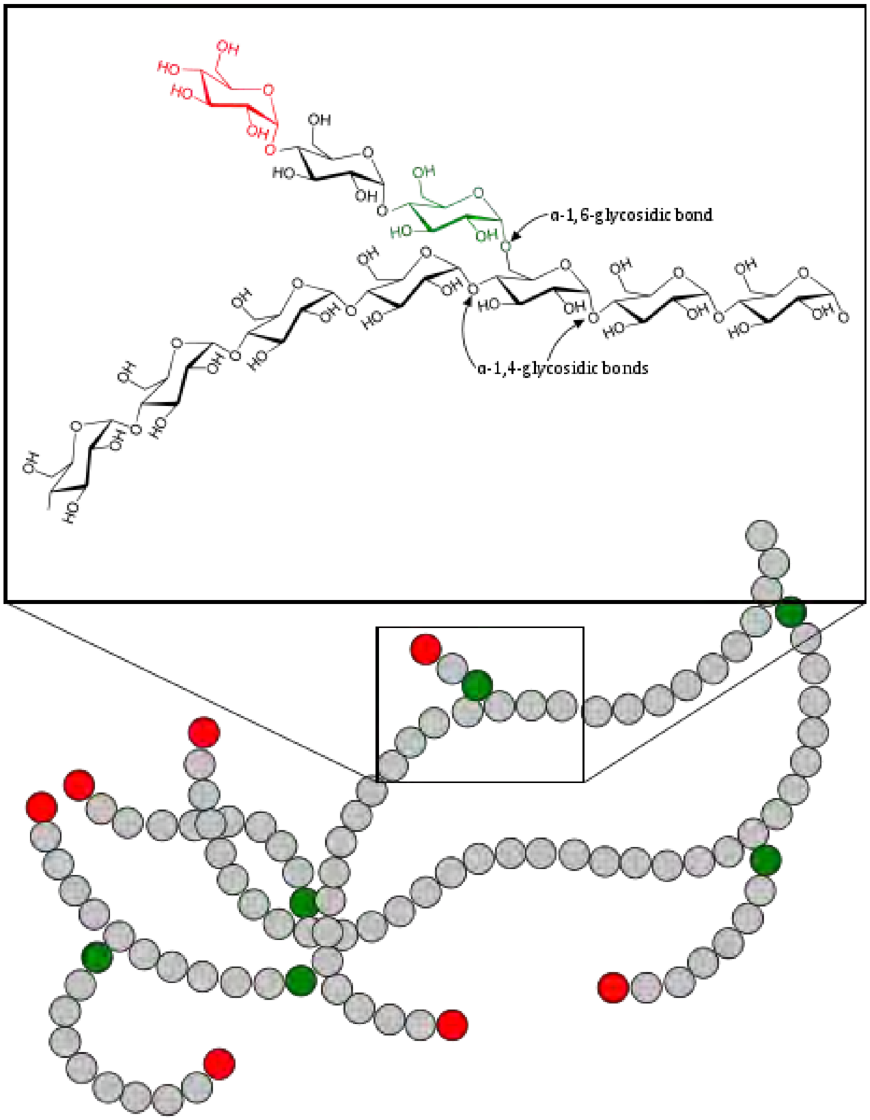
After watching the video, students will be able to:

- List three important gases for life.
- Explain how animals get the energy they need to live.
- Define carbohydrate.
- Define glucose.
- Describe where in the body food is broken down.
- Describe where in the body glucose is absorbed and where it goes.
- Explain how animals in the ocean and other water bodies get food.
- Explain why nitrogen is essential for plants.
- Explain how nitrogen is absorbed by plants.
- Explain how both terrestrial and aquatic plants make glucose.

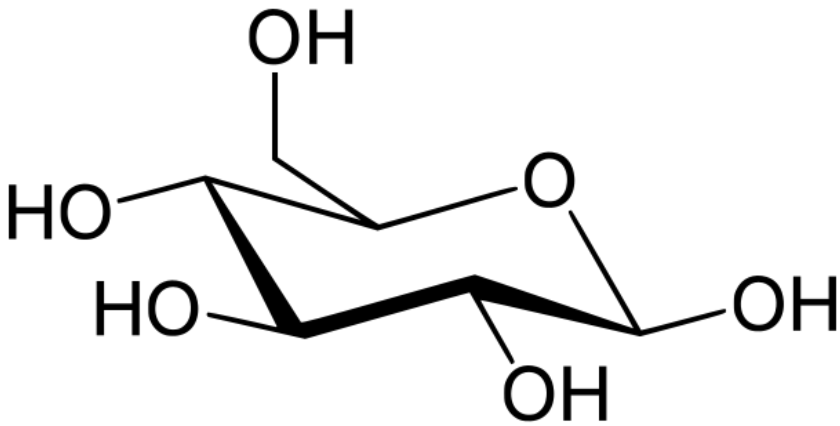
Background Information

Molecules in the body are divided into three main types: carbohydrates, proteins, and fats. Fats are also known as lipids. There is a lot more fat and protein in the human body than carbohydrate. Most of the carbohydrate is stored as glycogen, a multibranched polymer of glucose, but there is not more than about 1 kg of glycogen, while there can be many kg of fat or protein.

Fat, for animals, is the primary repository for long-term storage of chemical energy. The primary molecules used for energy are carbohydrates, and these large organic molecules are broken down in the digestive system to form glucose. Glucose, along with oxygen from the lungs, is sent through the bloodstream to cells where it is broken apart to release energy. This energy is used by both the cells to perform their functions and by the organism to maintain processes that allow the organism to survive and thrive. The term hydrate refers to water, which is made of hydrogen and oxygen. The addition of hydrogen and oxygen to a molecule (or other substance) is called hydration, and the removal of hydrogen and oxygen is called dehydration. Since the simple sugar glucose (and all carbohydrates) are composed of carbon, hydrogen, and oxygen, they are said to be hydrated carbon or carbohydrates.

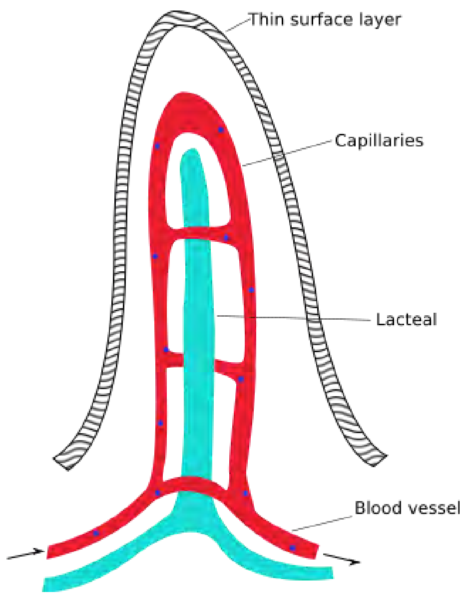


Source: Wikimedia Commons. Diagram of the structure of glycogen. Vectorized from File:Glycogen.png. Category:Glycogen Category:Nutrition Category:Branched polymers.
5 September 2017, GKFX talk



Source: Wikimedia Commons. Beta D Glucose. 5 October 2009, [Yikrazuul]

Glucose is the most important carbohydrate because it is used during cellular respiration to create energy for the organism.[2] The most important carbohydrate is starch, a polymer of glucose. But there are other carbohydrates like cane or beet sugar, which is sucrose. The most important carbohydrate in many vegetables is cellulose, which few animals can digest directly. Gut bacteria like those in the rumen of cattle are needed to get useful energy from cellulose. In people, carbohydrates start to be broken down by saliva in the mouth, then continue to be broken down in the small intestine (not the stomach).

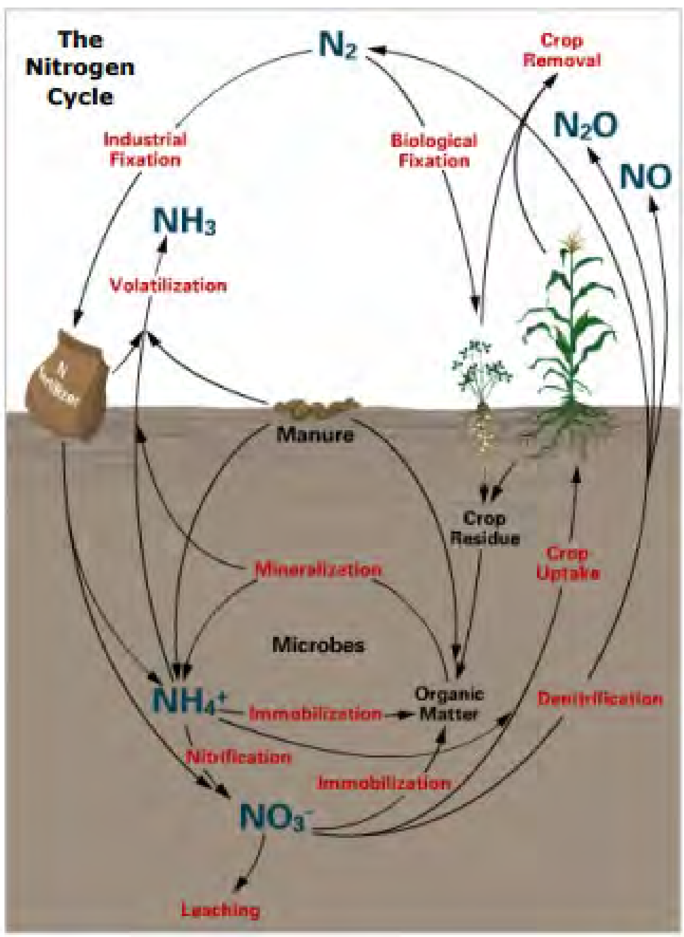


Source: Wikimedia Commons. A heavily simplified diagram of a single villus from a human intestine. 30 December 2008, Snow93

Small protrusions called villi, which line the intestinal wall, allow passage of glucose molecules into the blood stream. The capillaries in the circulatory system allow the distribution of blood to almost every cell in the body, where cellular respiration occurs in the mitochondria.

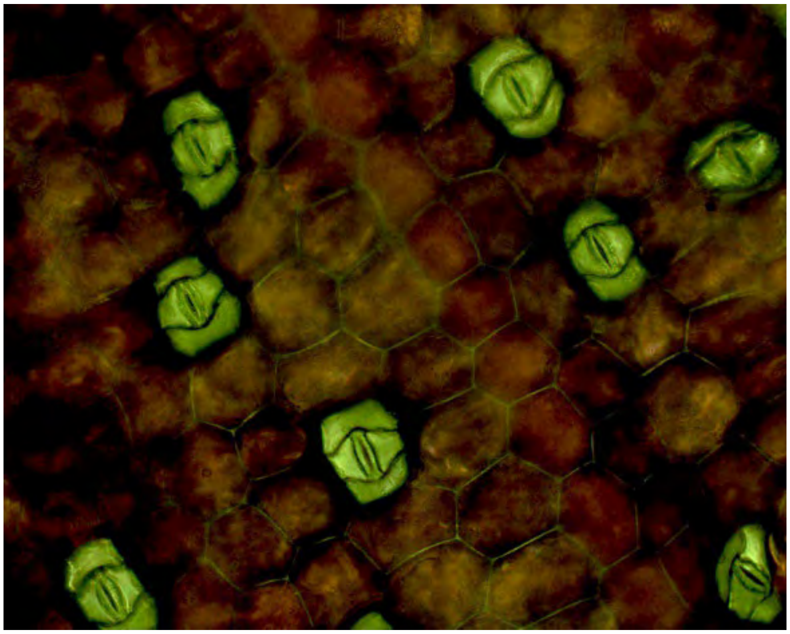
Just as there are herbivores on land, there are herbivores in water. These can either be fish or small organisms such as crabs or snails, which eat living or decomposing plant matter, These organisms are the primary consumers and are food for carnivores, or secondary consumers.

Animals, like plants, need nitrogen, but they get nitrogen from eating plants and other animals. Plants must get their nitrogen from the soil. The triple bond which connects the two nitrogen atoms together to form a nitrogen molecule is one of the strongest bonds in nature and is therefore very difficult to break. The only organisms that can break this bond are bacteria (microbes) in the soil (both underwater and on land). The diagram of the nitrogen cycle below shows most of the steps that are involved in changing a simple nitrogen molecule into other molecules that plants can absorb through their roots.[1] The nitrogen cycle involves many different bacteria. These organisms "eat" one specific molecule and release another one as a waste product. This waste product, in turn, provides food for another species of bacteria. Many steps occur because each step is performed by a different species of bacteria. The form of nitrogen that is most easily absorbed by plant roots is the ammonium ion, NH_4^+. The ammonium is converted to nitrate, NO_3^- in a separate step. For a more detailed explanation of the nitrogen cycle, see footnote 1 below.



Source: Nitrogen Basics – The Nitrogen Cycle,
http://nmsp.cals.cornell.edu/publications/factsheets/factsheet2.pdf

Glucose is vital for plants and animals since the energy they need is stored when this molecule is made and released when this molecule is broken down. The only organisms on Earth that can take the energy from the Sun and convert it into food energy are organisms that contain chlorophyll such as plants and algae. They take CO_2, which they absorb from the air through openings in their leaves called stomata, and use water they absorb from their roots and energy they absorb from the Sun to create glucose using a chemical process called photosynthesis. Photosynthesis occurs in the chloroplasts of the cell, which contain the pigment chlorophyll.



Source: Wikimedia Commons. Tradescantia zebrina leaf viewed under microscope, the red epidermis contrasts with the underlying green tissue and allows for easy location and identification of the stomata. 19 March 2014, AioftheStorm

Chlorophyll is essential in breaking down the CO_2 and H_2O molecules and recombining them to form glucose.[2] The process of photosynthesis is described in greater detail in Video Three.

1. *Nitrogen Basics – The Nitrogen Cycle,* http://nmsp.cals.cornell.edu/publications/factsheets/factsheet2.pdf
2. Ritchie, G.A. (2018). *Inside Plants: A Gardeners' Guide to Plant Anatomy and Physiology.*

Suggested Activities

1. Using Manipulatives as Models for Molecules: Using Manipulatives as Models for Molecules: It is often very useful to use models to represent molecules and how they can break apart and the elements be put back together to form different molecules. This can be easily accomplished by using beads, Legos or other items that connect interchangeably. For older students, using a separate color block for each element can work well, or a molecular modeling kit can be used. If you prefer, you can use Styrofoam balls to more accurately represent the shape of the molecule. Find or paint balls in different colors to represent the elements and fasten them together with toothpicks. Have the students form CO_2 and H_2O molecules, then break them apart and recombine the elements to form glucose, which shows how carbon dioxide and water is used by the plant to make food. Glucose is a complicated molecule whose atoms are connected to form a circle. There are many pictures of models online that you can use for reference. For younger students, you may want to build a molecule model that they can look at.

2. Demonstrating that Plants Need Sunlight: The easiest way to demonstrate the necessity of sunlight for plants is to grow seeds in a closed closet versus seeds grown in sunlight. Mung beans or lima beans sold in a garden store will germinate very quickly. The beans could be shallowly planted in a small pot or many seeds in a seed starting tray, or they could simply be put in a plastic bag with a damp paper towel. Each student can keep a daily log of observations to note differences in appearance and growth rate.

Materials: Seeds (mung bean or pole bean seeds germinate quickly and are large and easy to see; buy seed packets and not dried beans from the grocery store for best results), small pots or a seed starting tray, soilless seed starting medium or plastic bags with damp paper towels, popsicle sticks or other materials to label the plants with the student's name, a sunny window sill or grow light, a dark closet or cabinet, journals for the students.

Procedure: *Students should hypothesize first what they expect to happen, and then see if their observations support or disprove their hypothesis.* Plants need sunlight to produce chlorophyll, so the seeds in the closet should have no pigment while the seeds in the light should have green shoots and leaves. If you want to allow the plants to grow for a longer period, pots would be better to use than plastic bags.

For seed starting tray: Each student should plant at least nine seeds (three per cell using three cells. When they start growing, leave the strongest seedling and remove the other two). Explain the importance of repetition when performing a science experiment. If there is enough room, let each student have seeds in both the sun and the darkness. If not, split the class in half and let one half use sun and the other use darkness. The plants in the sun will act as the control group, and the seeds in darkness are the experimental group. First, make sure the seed starting mix is damp. If not, put the mix in a large bucket and add water until the soil is moist but not wet. This will ensure that the soil will absorb the water later when the seeds need water. Fill the cells three quarters of the way full, then have the students place their seeds carefully on the top and label the cells with their names using popsicle sticks or plant labels. Then go back and just barely put soil over the top of the seeds. (If they are planted too deeply, they will take longer to germinate or may not germinate at all.) Water carefully from the top with a spray bottle until the soil is moist but not soaking wet. Then put the seeds in either the sun or the closet. If a sunny window is not available, a grow light can be used. Grow lights have the specific wavelengths of light, primarily red, that are essential for photosynthesis, and should be used instead of another kind of light.

For plastic bags: Each student should have a plastic bag (or two, depending on whether they have seeds in both sun and darkness) with their name labeled on it. Each student also needs one paper towel per bag (use a high-quality absorbent paper towel). The towels should be completely wetted, squeezed dry (gently so that they don't break), folded, and placed inside the plastic bag. Take the seeds and place them carefully on top of the paper towel, seal the bag, and place it in either the sun or darkness. This method allows the students to see the development of the roots and shoots; however, the plant's development is not the focus of this activity necessarily. Have the students write in their journals what their procedure was (as is age appropriate), including a drawing of what they saw. Let the students observe their seeds and record their observations daily. This could continue for as long as 10 days, depending on germination rates (seeds will germinate more quickly in warmth, so a heating pad for seed starting could be used to speed up the process). After the data has been collected, let the students draw conclusions that directly respond to their hypothesis (whether or not sunlight is critical for the development of plants).
Sources: https://joegardener.com/podcast/037-starting-seeds-indoors-pt-1/
https://www.mombrite.com/growing-beans-in-a-bag/

3. Demonstrating how the shape of a leaf affects the amount of sunlight it can absorb. This activity demonstrates how the shape of leaves is an important adaptation to a plant's ability to absorb light. Plants live in both full sun and part sun conditions, in wet and dry climates, and in warm and cold climates. Each species of plant has specific adaptations to allow them to survive in these varied environments, and one of these adaptations is the shape of their leaves. The leaves of a plant collect energy from the Sun. Not all plants need the same amount of sunlight. Each leaf and its shape help the plant maximize its chances of survival in its habitat by getting the right amount of sunlight it needs to make food. Leaves of tropical rain forest plants have larger surface areas than those of plants that grow in the desert. Not much sunlight can reach plants that grow in a dense jungle rain forest, so a larger leaf surface helps the plant get enough sunlight. Desert plants are likely to have a smaller surface to minimize water loss. In these hot climates, plants like cacti have leaves that are reduced to spines. The spiny leaves regulate the amount of sun the plant takes in and work together with the succulent stem of the cactus to help conserve water. Other plants close their leaves and flowers at night.

Materials: pictures of leaves from different environments, real leaves, journaling materials.

Procedure: *First, have the students hypothesize how the shape of a leaf is related to the amount of sunshine it receives. Also, have the students hypothesize in which environment they would expect to have large leaves, and in which environment they would expect to* *have small or thin leaves.* (Pines and fir trees will be an exception to their expectations.) Give the students cards with different shaped leaves and have them guess how the shape of each leaf helps the plants get more light, and in which environment they could expect to find this plant (wet or dry, cold or warm, full sun or part sun). Then discuss their hypotheses and have the students refine their explanations to match their observations.

To further explore how leaf shapes help plants get the right amount of sunlight, students can perform a demonstration outdoors. Working in pairs on a bright sunny day, students can replicate how the shape of a leaf provides different amounts of surface area and sunlight to a plant. Have the students first compare pictures of different leaf types and talk about the type of habitat the plant might grow in. Then take the students outdoors and instruct them to use their hands to demonstrate different leaf shapes. By turning their hands from side to side, students can see which shapes create larger surface areas like rainforest plant leaves, or smaller surface areas like desert plants, by looking at the shadows their hands cast. This helps students visualize how surface area determines the amount of sunlight touching the leaf and being absorbed. If possible, different shapes of local leaves can be brought into the classroom for the students to look at closely. Use these leaves to connect the plants' environment with their leaf shape. Then let the students make connections between their hypotheses and their observations. Remember, the hypothesis should be changed to explain the observations. Observations that do not support the hypothesis should not be ignored; rather, the "wrong" observations should be used to disprove the hypothesis.
Source: https://aroundthekampfire.com/2020/03/leaves-help-plant-get-sunlight-plant-needs-science-activity.html

4. **Making paintings with chlorophyll:** This activity demonstrates that chlorophyll is a pigment. Students squeeze chlorophyll out of leaves onto a sheet of paper using a spoon. This activity also allows the incorporation of art into science.

   Materials: metal or wooden spoon, paper, crayons or colored markers, different kinds of leaves (either provided by the teacher, or the students can bring their own from home or they can collect leaves from outside at school, if possible). Spinach leaves work well; leaves with a waxy surface work poorly.

   Procedure: Because this is a modeling activity, there is no need to make a hypothesis. Fold a sheet of white paper in half. Place several leaves between the folded paper, then press firmly on the leaves between the pages and rub with a metal spoon. Avoid plastic spoons as they break when pressed as firmly as necessary. Let students discover that they can also "paint" their pictures by crushing and balling up the leaves to use as paintbrushes. This takes less time, releases more chlorophyll, and students are better able to control where the pigment goes on the page. As students work, encourage them to compare the different leaves they are using and discuss which release the most chlorophyll and which release very little. Ask students to talk about why they think the leaves of some plants work better while others do not. What qualities or attributes of the leaf make it better or worse for this project?

Source: https://aroundthekampfire.com/2019/02/chlorophyll-paintings-plant-science-leaf-rubbing-art-activities.html

5. **Digestive System Model:** The digestive process is difficult to model, but there is one creative, albeit messy, model that might work. Since digestion is the process by which large insoluble molecules of food are broken down into smaller soluble molecules, a model that demonstrates this process might be useful in illustrating how digestion works.

   Materials: Potato masher, bowl, funnel, a small piece of banana, plain biscuit, 30mL water, 30mL orange juice, medium-size Ziploc bag, scissors, one leg of pantyhose, tray or plate.

   Procedure: Because this is a modeling activity, there is no need to make a hypothesis. Place the biscuit and banana into a bowl and gently crush with a potato masher. This represents the food being chewed. Pour the crushed food into an empty Ziploc bag and add the water. The water represents saliva. Make sure there is no air in the bag and seal it. Squeeze the bag for about a minute to start the digestion process. Pour the orange juice into the bag (this represents stomach acid). Again, make sure there is no air in the bag and seal it. Squeeze the bag for another minute, crushing up the biscuits and banana further. This represents the food breaking down further inside the stomach. Once the stomach contents feel like a thick liquid, cut a small hole in one corner and carefully squeeze into the open leg of the pantyhose (small intestine). Hold the hose over the tray or a bowl and gently squeeze the liquid out. The liquid on the tray represents the nutrients the body absorbs and uses. Keep squeezing until no more liquid comes out. The food left behind in the hose represents waste products that cannot be absorbed. Cut a hole in the bottom of the hose and squeeze the contents into the jar. This is the poo.

   Source: https://www.science-sparks.com/digestive-system-model/

Formative and Summative Assessments

1) What are three important gases for life that are found in the atmosphere?
2) How do animals get the energy they need to live?
3) What is a carbohydrate?
4) What is glucose? Why is it important to the body?
5) Where in the body is food broken down?
6) Animals and people need glucose to live. Once glucose is in the body, in what organ is glucose absorbed?
7) Once glucose is absorbed by the body, where does it go? Why is oxygen needed?
8) How do animals in the ocean get their food?
9) Why is nitrogen needed for plant growth?
10) How do plants get the nitrogen that they need?
11) What chemical reaction do plants use to make food? What reactants are needed for this reaction, and what is given off?

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What is the CO_2 Coalition?

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

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

Learn more at CO2Coalition.org and CO2LearningCenter.com.