W 1227

LIGHT HARVESTERS

Explore the powerful pigments of plants

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Light Harvesters

Explore the powerful pigments of plants

Skill Level

Intermediate – Advanced

Learner Outcomes

The learner will be able to:

- Explain that plants synthesize their food through the process of photosynthesis
- Understand that pigments in plants help them capture sunlight for photosynthesis
- Analyze chromatographs for pigment separation
- Identify examples of pigments in daily life

Educational Standard(s) Supported

4-LS1-1; MS-LS1-6; HS-LS1-5

Success Indicator

Learners will be successful if they:

Can explain the inputs and outputs of photosynthesis and how a plant is able to gather the necessary inputs.

Time Needed

30 minutes active time; 1-2 hours total

Materials List

- Clear glass or plastic container (Mason jar, drinking glass, cleaned out peanut butter jar, etc.)
- Disposable paper coffee filter
- Rubbing alcohol (isopropyl alcohol)
- Wooden spoon or other blunt object for crushing
- Green leaves from 2 different plants (about 10 per plant)
- Scissors
- Tape or paperclip

Authors

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Introduction to Content

In this lesson, students will be introduced to the pigments that give plants their colors and the role they play in photosynthesis. They will discuss the process of photosynthesis: how plants obtain carbon dioxide, water, and sunlight and combine them to produce sugar and oxygen. They will learn that pigments in plant leaves are used to capture sunlight that drives photosynthesis and visualize different pigments using chromatography.

Introduction to Methodology

Students will use paper chromatography to separate and visualize the variety of color pigments found in different plant leaves. This activity can be done independently or as a class and is flexible in the materials needed. The experiment requires students to gather plant leaves from their backyard or fridge. Other needed materials are common household items, including rubbing alcohol, clear jars, and utensils. Students can compare results between other students and different plants and reflect on the biology of these pigments in nature.

Terms/Concepts

Photosynthesis: the process by which green plants and some microorganisms use sunlight to make food from carbon dioxide and water

Pigment: a substance that appears a certain color because it selectively absorbs wavelengths of light; a substance that gives objects their color

Chlorophyll: a green pigment responsible for the absorption of light to provide energy for photosynthesis

Chromatography: the separation of a mixture by passing it through a medium in which the different components of the mixture move at different rates

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Prepared using research-based practices in youth development and experiential learning.

Setting the Stage/Opening Questions

All living things need some sort of food to give them energy. What do we as humans do when we're hungry? We might go to the grocery store or a restaurant, grow things in a garden, or hunt for food. We, and other animals, can go get food when we want it. But how do plants get food when they can't move or hunt? Plants are primary producers, which means they can harness the sun's energy to make their own food! This process is known as photosynthesis, and plants need three main things to perform it: water, carbon dioxide, and sunlight. This activity will focus on molecules that allow plants to capture sunlight and turn it into energy.

Ask: *What do plants need to survive?*
Students will likely identify some components such as water, food, soil, shelter, and air. Encourage students to be specific about some of these things: What from the air do they need? Do they need sun? Where does their food come from? Explain that plants use carbon dioxide, water, and sunlight to create oxygen and sugar, which is what they use as food. While we humans have to hunt and grow our food (or make a trip to the store!), plants can synthesize food in their own cells. Lucky them!

Ask: *How do plants get carbon dioxide, water, and sunlight?*
Plants get their carbon dioxide similarly to how we get oxygen: they "breathe" it in through openings on their leaves called stomata. They can absorb water through their roots and transport it up their stems to their leaves. But light is trickier – plants need a way to capture energy from the sun. The light the sun gives off is white light, which means it contains all different wavelengths of light. When you see a rainbow, it is the result of this white light being diffracted so that you can see individual color spectra. Plants absorb these different light wavelengths using pigments. A **pigment** is a substance that selectively absorbs certain wavelengths of light and reflects others. The wavelengths it reflects are what give objects their color. **Chlorophyll** is a pigment found in green plants and algae that absorbs most wavelengths of light and converts it to energy but reflects green wavelengths. This is why leaves look green to our eyes.

Chlorophyll is just one of many types of pigments found in nature. While chlorophyll reflects green wavelengths and therefore gives a green color, other pigments make things

Strategies to Increase Student Engagement

Have students collect leaves from different plants to compare between species (just be sure to keep the samples separate!).

Students can watch this video on the leaf chromatography experiment to learn more and have a visual of the process: https://www.youtube.com/watch?v=qH-AJDqsSII

Bill Nye The Science Guy episode on light and color: https://www.youtube.com/watch?v=g5BHxozBPuA other colors. Encourage students to think of examples of plants that are different colors (leaves in the fall, flowers, vegetables like carrots and beets). Other pigment examples include carotenoids, which are responsible for yellow and orange colors (like carrots), and anthocyanins, which give red and purple colors (like red cabbage and blackberries).

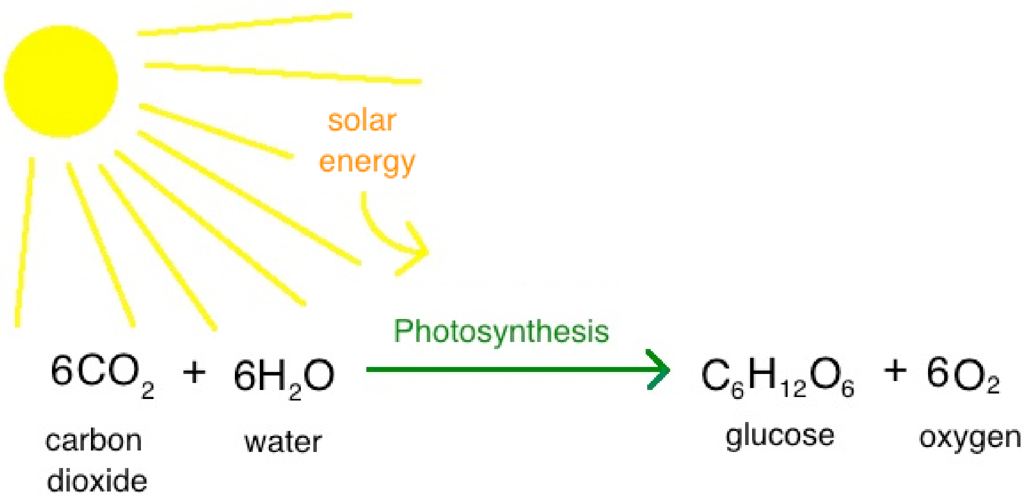


Figure 1. The chemical inputs and outputs of photosynthesis.

Ask: *Why do leaves change colors in the fall?*
During the spring and summer, when leaves are green, chlorophyll is the most abundant pigment. So what causes leaves to change colors in the fall? Deciduous trees lose their leaves in the fall and winter to conserve water and reduce the risk of damaging themselves from freezing. Instead of photosynthesizing through their leaves during this time, they store up sugars throughout the spring and summer that help sustain them during the colder months. Trees cut off circulation to their leaves to stop photosynthesis and water transport, and as the leaves start to die, the pigments in them break down. When the chlorophyll disappears, it allows the other pigments (e.g., carotenoids and anthocyanins) to show through, resulting in beautiful fall colors. Different types of trees have different ratios of pigments, which gives variety to the leaf colors.

Experience

Part I: Answer the questions on the student handout about how plants produce their own food. Have students complete the diagram to show the inputs and outputs of photosynthesis.

Part II: Leaf pigment chromatography activity

1. Gather about 5-10 green leaves from two different bushes or trees. Alternatively, students can use colorful fruits or vegetables (See "Extensions and Variations" section).
2. Make a prediction: What color pigments do you think are in your leaves/fruit? If you collected tree leaves, do you remember what color they turned last fall?
3. Rip or cut plant samples into small pieces and place in the bottom of a sturdy jar.
4. Pour a small amount of rubbing alcohol into the jar on top of the plant sample, just enough to cover the plant material (should be a few tablespoons, depending on the size of your jar).
5. Crush the sample in the alcohol using the blunt object, such as a wooden spoon or the blunt end of a kitchen utensil. Do this until the alcohol turns colors, usually 3-5 minutes.
   Alternative: rather than crushing, you can just leave the sample to soak in the alcohol overnight.
6. Cut a strip from the coffee filter that is 1-inch wide and as long as the height of your jar (e.g. if your jar is 4" high, cut a 4" x 1" strip). Lower one end of the strip into the alcohol in your jar.
7. Lay a pen or pencil across the top of your jar and attach the top of the filter paper to it with tape or a paper clip. Make sure the bottom edge of the paper is submerged in the alcohol.
8. Explain to students how chromatography works: Chromatography is a way to separate different components in a mixture (in this case, pigments). When dissolved in a liquid (alcohol), different pigments will move at different rates through the stationary phase (paper coffee filter). The different pigments show up as different colored bands on the paper. Have students hypothesize what pigment colors they will see based on what color their alcohol turned while crushing.
9. Let the filter absorb the mixture for 30-60 minutes, or until you can see different bands of colors in the middle of the strip. The longer you wait, the clearer the separation should become.
   Note: If you fail to observe band formation after this amount of time, try leaving it overnight.
10. Once finished, have students record their results and compare their observations to their hypothesis. Students can compare to others in the class or perform multiple experiments with leaves from different plants or various pigmented fruits and vegetables. Compare chromatographs and note where certain pigment bands show up.

Share

Were the colors on the chromatograph what you predicted? How do different plant samples compare to each other? Are there differences in which color bands show up? Do you see color bands in the same order between different plants? If so, why might this be?

Process

Why do some types of samples have colors that others don't? Discuss

Extensions and Variations

Leaves aren't the only plant parts with pigments: fruits, vegetables, and flowers are filled with them too! These pigments help keep how different plants contain different types of pigments.

Why do different pigments form different bands on your paper? Re-emphasize how chromatography works; i.e. that different components in the liquid phase (pigments in alcohol) move at different rates through the stationary phase (paper coffee filter).

Generalize

Imagine the beginning of fall, and some leaves on your favorite tree have just started to change colors to a bright orange. You gather both orange and green leaves from the same tree. You do two chromatographs in two different jars, one with the orange leaves and one with the green leaves. Can you hypothesize differences and similarities in the chromatographs between the two?

Apply

On a hot sunny day, it's often recommended you wear a white shirt instead of black to keep cool. Using what you know about pigments using wavelengths of light to create energy, can you hypothesize why this might be?

Albedo is a term used to describe the proportion of light that is reflected by a surface. Buildings and pavement often have lower albedo (meaning they reflect less) because they are darker colors and absorb more light. This is sometimes referred to as the "urban heat island effect." Have you ever noticed that walking down a city sidewalk can feel warmer than walking through an open field? Discuss how human development can alter the albedo of the landscape and how this can influence local temperature. What techniques could help increase albedo (increase reflected light) in developed areas? (Additional reading can be found here - https://climate.ncsu.edu/edu/Albedo).

Pictured above is an example of the experimental set-up. You can see the plant material covered by rubbing alcohol, with a pencil holding the end of a coffee filter in the alcohol.

References

Module adapted from: Scientific American
"Find the Hidden Colors of Autumn Leaves"
[*https://www.scientificamerican.com/article/bring-science-home-leaf-colors/*](https://www.scientificamerican.com/article/bring-science-home-leaf-colors/)

Supplemental Information
Educational Standards Met

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

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.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

TIPPS
Life Skills

6th Grade
Head – Thinking:
Learn to form ideas, make decisions, and think critically.

Use skill, effort, or ability to accomplish a goal.

Health - Living

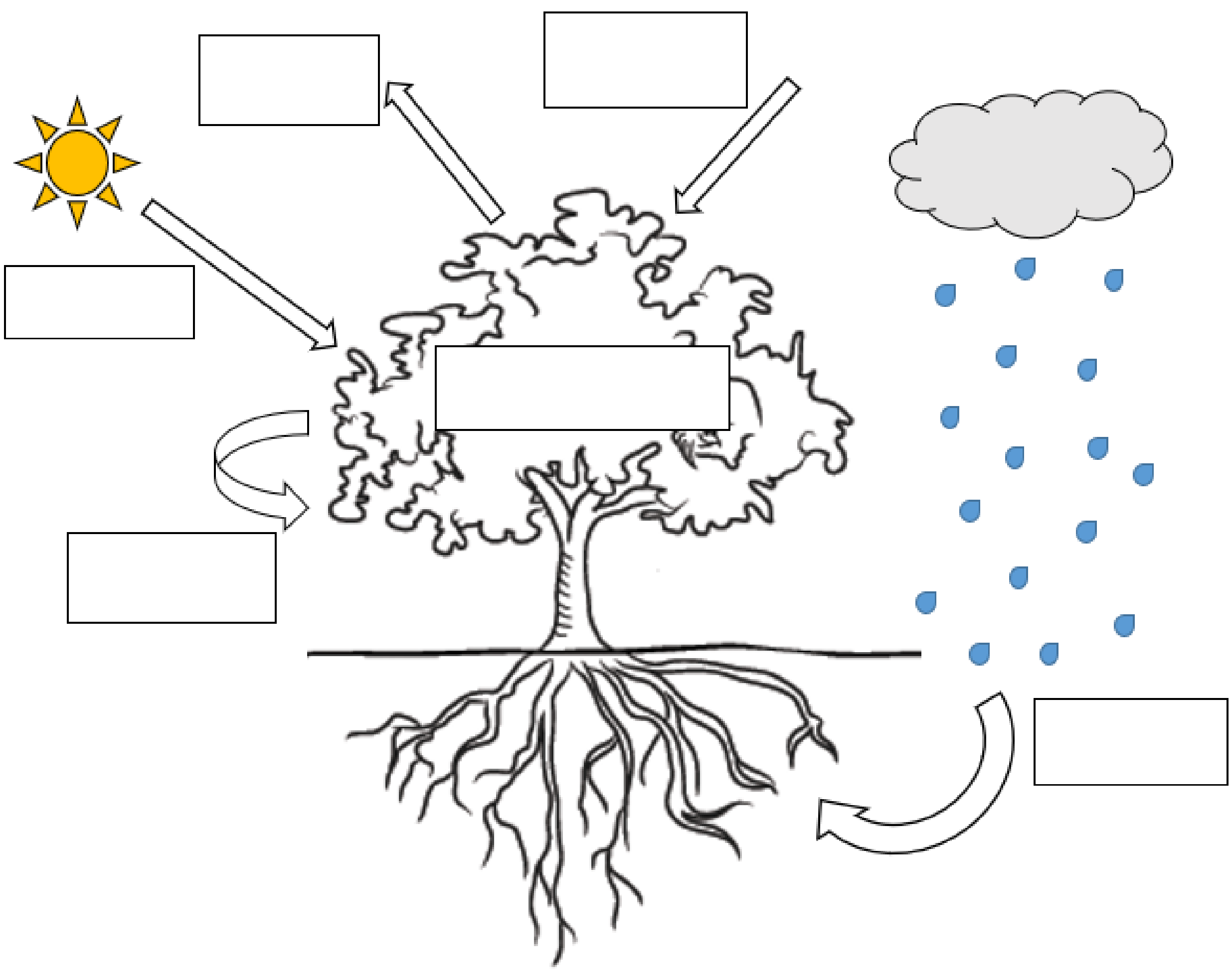
Student Handout

Part 1

Plants are primary producers, which means they make their own food. What is this process called?

What three things do plants need to make their own food? What are the two by-products of this process?

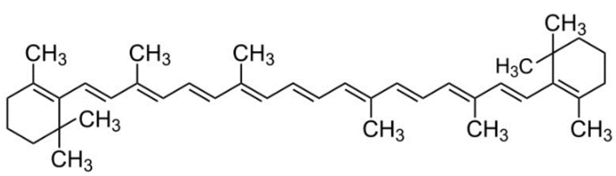
In the following diagram of a tree, draw the inputs and outputs of this plant process. Use the arrows as a guide; they show where these components enter and exit the plant. Be sure to label the plant substance that is responsible for capturing the energy for this process.



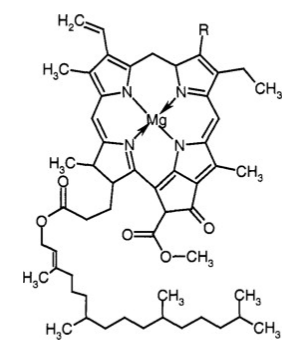
Part 2

Draw your resulting chromatograph below. Be sure to label each band with the color. What pigments might they be? Below are some examples.

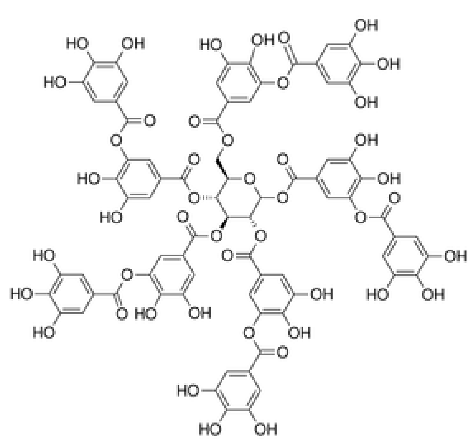
Carotenoid (yellow, orange)



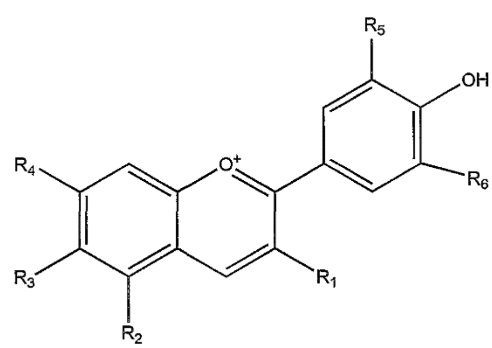
Chlorophyll (green, yellow)



Tannin (red, brown)



Anthocyanin (red, purple, blue)



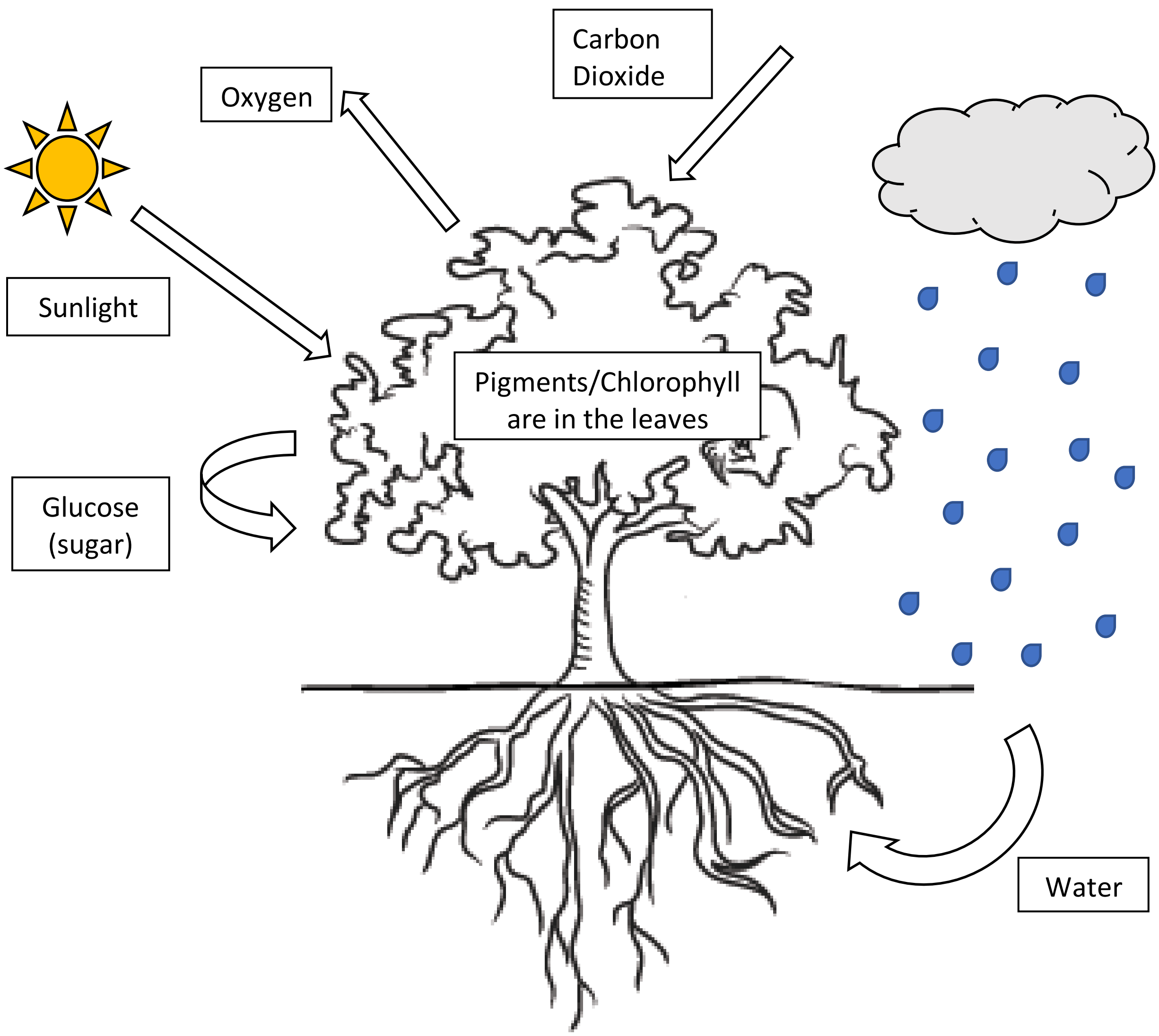
Student Handout Answer Key

Part 1

Plants are primary producers, which means they make their own food. What is this process called?
Plants make their own food through a process called photosynthesis.

What three things do plants need to make their own food? What are the two by-products of this process?
Plants need 1) water, 2) carbon dioxide, and 3) sunlight to perform photosynthesis. The outputs are 1) oxygen and 2) glucose (sugar).

In the following diagram of a tree, draw the inputs and outputs of this plant process. Use the arrows as a guide; they show where these components enter and exit the plant. Be sure to label the plant substance that is responsible for capturing the energy for this process.



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