



# un-be- LEAF-able

We know that autumn has arrived as temperatures turn cooler and colorful leaves start falling around us. **THIS STEM GEM TAKES ON TREE BIOLOGY AS WE EXPLORE AN AGE-OLD QUESTION OF WHY LEAVES CHANGE COLOR IN AUTUMN.** From green to yellow, orange, brown and red, what is the cause of this amazing explosion of color? In Un-be-leaf-able, young people will explore leaves, photosynthesis, and chlorophyll as they unlock the hidden surprise inside every broadleaf.

## WHY ARE LEAVES GREEN?

Leaves are green because they contain a green chemical known as chlorophyll. Chlorophyll is the chemical plants use to make a simple sugar for food through a process known as photosynthesis.

## WHAT IS PHOTOSYNTHESIS?

Plants cannot run around to find food. They have to make their own food. Photo means light and synthesis means to put together. Plants make food by using the energy of sunlight to fuse together water and carbon dioxide into sugar. Each leaf is a tiny chemical factory. Every leaf is covered in tiny pores, used for collecting carbon dioxide, and filled with chlorophyll, a chemical exceptionally good at absorbing sunlight. Using energy from the sun, the leaves breakdown water into oxygen and hydrogen atoms and carbon dioxide into carbon and oxygen atoms. The oxygen is released by the plant as a waste product that we find very useful. The hydrogen and carbon are joined together to make a simple sugar that provides food for the plant.

## WHY DO LEAVES CHANGE COLOR IN THE AUTUMN?

Temperatures can drop to freezing in winter. The leaves on evergreen trees are coated in a protective wax and their sap contains anti-freeze chemicals that protect them from freezing, so the tree keeps its leaves year-round. The leaves on a

## BIG IDEAS (continued...)

deciduous tree do not have this protection. Every autumn when the days start to get shorter, these trees prepare for the cold by dropping their leaves. The leaves on a deciduous tree are bright green because they are mainly filled with chlorophyll. However, leaves also contain smaller amounts of other chemicals that have different colors to help them catch the full spectrum of light from the sun. As the days get shorter and the trees stop making chlorophyll, the yellow, orange, and brown pigments that have been hidden by the green chlorophyll can now be seen. Some trees (only about 10%) produce a red-purple pigment as winter approaches, making the trees exceptionally vibrant. The red pigment is a chemical that helps the tree harvest the last remnants of the sugar from the leaves in order for it to sustain itself through winter. The hidden colors in a leaf can be separated and seen using a chemical technique known as chromatography.

### WHAT IS CHROMATOGRAPHY?

Chromatography is a technique used to separate liquid or gas mixtures. In chromatography, a mixture is dissolved then added to a porous or absorbent material, such as a coffee filter. The original ingredients of the mixture will move at different rates as they travel through the porous material, eventually separating and leaving behind a pattern. This pattern is called a chromatogram.



-  **What color are the leaves on a tree?** *Green*
-  **Do trees need food?** *Yes, all living things need food and water*
-  **How do trees make food?** *Young people's choice*
-  **What happens to some trees in autumn?** *The leaves change color and fall from the tree*
-  **What are some of the rules we should have when working with chemicals?** *Explain the following Chemistry Safety Rules and ask for additional ideas. Note: Contrary to youth development practices, two of these rules are stated in negative terms to communicate explicit safety expectations. (1) Do not eat or drink any chemicals at any time. (2) Do not touch or smell any chemicals at any time. (3) Listen carefully and follow all directions. (4) Use both hands for stirring and pouring and keep mixing containers flat on the table while mixing. (5) Ask to have things passed instead of reaching across others. (6) Wash hands before and after any experiment. (7) Keep paper towels nearby to clean up spills.*



**CHLOROPHYLL** A green pigment, present in all green plants, responsible for the absorption of light to provide energy for photosynthesis.

**CHROMATOGRAPHY** The separation of a liquid or a gas mixture by dissolving it and allowing the different components to spread out along an absorbent, or porous, material.

**DECIDUOUS** A broadleaved tree or shrub that sheds its leaves every year.

**EVERGREEN** A plant that retains its leaves throughout the year.

**MIXTURE** Two or more combined substances that do not react chemically and that can be separated back into their original ingredients. For example, sand combined with marbles is a mixture.

**PHOTOSYNTHESIS** A process used by plants to convert light energy into chemical energy.

## what YOU WILL NEED

- ! **A selection of green leaves from several different deciduous trees. Spinach leaves will also work if deciduous trees are not accessible onsite.**
- ! **Isopropyl (rubbing) alcohol, 70%**
- ! **Water glasses or mason jars**
- ! **Coffee filters**
- ! **Bowls**
- ! **Tape**
- ! **Warm water**
- ! **Pencils**
- ! **Mortar and pestle or a large spoon and bowl**
- ! **Scissors**
- ! **Hand lenses (if available)**

## & before YOU BEGIN

Plan and organize a nature walk for young people to collect deciduous leaves. Collect a selection of leaves prior to the activity if your location does not allow for an organized nature walk.

## warning

Warning isopropyl alcohol should not be ingested and only used under close adult supervision. Do this activity as a teacher-led group activity if working with young children. Always review chemical safety rules.

## EXPLORE & EXPERIMENT

- 1 Invite young people to an outside area with accessible deciduous trees.** Have them select a tree to examine. Encourage them to consider the following questions: What shape are the tree's leaves? What pattern do you notice within the bark? What smell do you notice from the bark? What are the different parts of the tree?
- 2 Next, have young people select a different tree to explore.** Invite them to describe the similarities and differences compared to the first tree.
- 3 Divide young people into small groups and have each group collect two or three leaves from a chosen tree.** Encourage young people to select leaves from trees that display a dramatic color change in autumn, like maples, as they will show the best colors. Have them exercise caution while collecting leaves and refrain from climbing any trees.
- 4 Have each small group return indoors and invite them to examine and share descriptions of their leaves.** If available, distribute hand lenses so young people can closely view the leaves.
- 5 Ask young people to share their ideas why they think the leaves are green.** Explain that leaves contain a green chemical called chlorophyll. Chlorophyll is very important to plants. It absorbs sunlight, which plants use as energy to make food.
- 6 Ask young people what happens to leaves of deciduous trees in autumn.** Explain that in autumn, deciduous trees stop making chlorophyll and hibernate for winter. When the chlorophyll breaks down, the colors from the other chemicals in the leaves show through. This is why the leaves seem to change color in autumn. The colors have always been in the leaves, but they have been blocked by the intense green of the chlorophyll.

## EXPLORE & EXPERIMENT (continued...)



- 7** Explain that each small group is going to make their own autumn by using chromatography to separate the different chemicals and their colors in each leaf.
- 8** Have each group use scissors to cut the leaves into enough pieces to equal about one-quarter cup.
- 9** Have young people take turns using a mortar and pestle or bowl and spoon to grind the leaves into a fine pulp. Encourage them to scrape the pulp into glasses or jars.
- 10** Go around to each group and pour enough isopropyl alcohol over the leaves to just cover them.
- 11** Ask young people to observe any changes in the color of the alcohol and discuss.
- 12** Provide each group with a bowl and have them fill it with warm water. Ask them to place their glasses or jars into the bowls of warm water for about 30 minutes to accelerate the dissolving rate of the chemicals in the leaves.
- 13** Pass out a coffee filter and pencil to each group and have young people cut the filter paper into a strip about 6-inches long and 1-inch wide.
- 14** Have the groups attach the filter paper strips to the pencils with a piece of tape, making sure the bottom of the strips hang straight.
- 15** Instruct the groups to balance their pencils on the top of the glasses or jars and adjust the length of the filter paper strips so that the bottom just touches the green liquid.
- 16** Have each group check their papers every five to 10 minutes.
- 17** Explain that the warm alcohol dissolves the chemicals that are in the leaves. These chemicals are absorbed by the filter paper and travel up it. The chemicals that are the most soluble will travel the furthest. After 15 to 30 minutes, different colored bands should start to appear at different heights on the strip.
- 18** Encourage young people to study their strips and identify the different colors they see. The results will vary depending on the types of leaves that were used. An orange-colored band is likely to be near the top. Below that should be a yellowish band, a blue-green band, and a greenish-yellowish band, respectively.
- 19** Explain that the different colors are from different chemicals that help the leaves absorb as much energy from the sun as possible.
- 20** If doing this activity in autumn, have young people collect some leaves that have already changed color. Have the groups repeat the experiment with these leaves to explore how the colors on the filter paper differ from a green leaf. Invite young people to predict what they will see.

# make THE CONNECTION

1. Provide young people with coffee filters, pencils, washable markers, scissors and cups of water.
2. Instruct young people to cut their coffee filters into a leaf shape. Have them use a pencil to write their initials on the edge of their leaves.
3. Invite young people to use washable markers to draw a ring on the center of their leaves. Have them make sure the inside of the ring is not colored and there is space around the ring for the pigment from the marker to travel.
4. Encourage them to fold their filter leaves into a triangle with the center of the marker ring as one of the points.
5. Have young people dip their leaves into a cup of water so only the white tip is immersed. The water will travel up the filter paper and dissolve the pigments in the ink, separating them just like with the tree leaves.
6. Invite young people to leave their filters soaking for a few minutes before taking them out and placing them in a safe location to dry.
7. Encourage young people to hang or display their leaves to make an autumn forest.



## EXTEND & EVALUATE

Have each young person look closely at a leaf and carefully draw a diagram of it. Invite each youth to color his or her leaf drawing and label each different part.

**Discuss the parts of a leaf with young people after they have completed their diagrams.**

- The blade is the main flat area.
- The petiole is the stalk where the leaf attaches to the tree.
- The veins of a leaf provide structure and carry water and food throughout the leaf.
- The midrib is the main vein that runs the length of the middle of the leaf.

