Capillary Carnations

Section THE CHEMISTRY OF LIFE & EARTH SCIENCES

Estimated Time Setup: 5-10 minutes; Procedure: 24 hours

OVERVIEW

Place white flowers in colored water and watch as the flower petals transform!

In this activity, students learn how plants move water and nutrients from the external environment into their roots, stems, leaves, and flowers. Students place white flowers in water dyed with food coloring, and over the course of a day the flower petals turn the same color as the dyed water!

INQUIRY QUESTIONS

Getting Started:

- What does a plant need to survive, and where does a plant find these things?

Learning More:

- What are the structures in a plant that enable it to get water and nutrients?

Diving Deeper:

- How does capillary action allow water to move from the soil up to the leaves of a plant?

CONTENT TOPICS

This activity covers the following content topics: properties of matter, properties of water, surface tension, adhesion, cohesion, plant structure and function, transpiration, capillary action

This activity can be extended to discuss: pressure, agriculture, irrigation, plant lifecycle, photosynthesis

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- 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-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.

MATERIALS

For one setup:

- White flower (see "Elaborate" section for other materials you can substitute)
- Clear cups
- Water
- Food coloring
- Scissor or knife

Optional materials:

- Bounty® paper towels

ACTIVITY NOTES

This activity is good for:

- Demonstrations
- Large groups

Safety Tips and Reminders:

- Food coloring can stain clothes and skin. Students should wear gloves and smocks, or an adult can help with coloring the water.
- Review the Safety First section in the Resource Guide for additional information

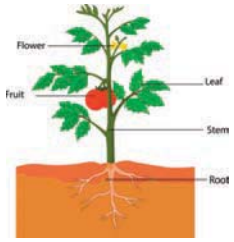
Fun Fact #1

The oldest known flowering plant is Monteschia vidalii, which was found fossilized in Spain and is estimated to have lived 130-124 million years ago!

ENGAGE

Use the following ideas to engage your students in learning about the chemistry of life & Earth science:

- This activity fits well after or alongside a study of the parts of a plant!



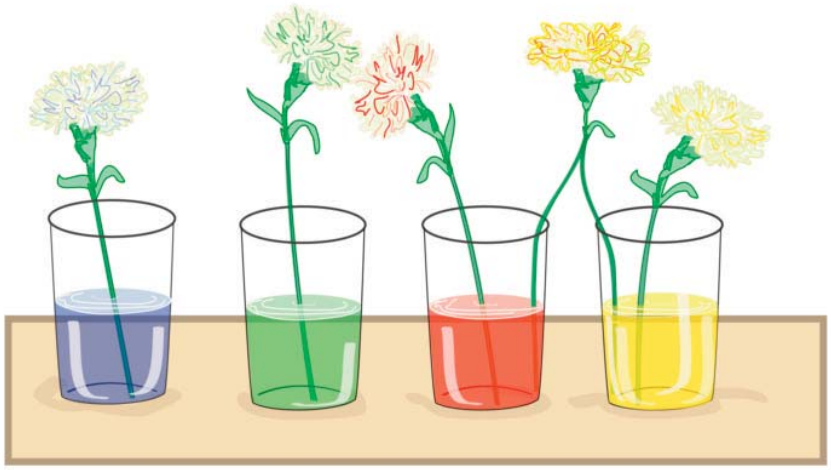
- Start with a discussion about what plants need to survive and grow. What do they need from their environment? How do these things get from the external environment into the plant itself? Where have students seen these processes?
- Take students outside and ask them to examine a plant of their choosing. What structures do they see? What might these structures do for the plant? They can draw a picture and write their ideas. Once inside the classroom, provide an example of a flower with intact roots so they can see the entire plant structure. This can lead into a discussion about the function of each plant part and how it relates to the ability of a plant to grow, survive, and reproduce.
- Show students examples of dyed flowers from a local shop. How do they think those colors and patterns were made?
- Before the experiment, take a Bounty® paper towel and hold the bottom of it in a cup of water. Have the students watch as water rises up the paper towel. Ask your students if they know how this is possible. Discuss how water can rise up against the force of gravity. Most will know that the water is being absorbed by the paper towel, but they may not know that it is because of capillary action. The water adheres to the fibers in the paper towel and climbs up the paper towel, pulling other water molecules upward as well because of cohesion.

See the Elaborate section of this activity for more ideas to engage your students.

EXPLORE

Procedure:

1. Fill a cup hallway with water
2. Add 20-30 drops food coloring
3. Cut two inches from the bottom of the flower's stem
4. Place the flowers in the colored water
5. Wait several hours, or until the next day, then observe the results



DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Examine the flower structures closely. What do you notice about the stem? The petals? The leaves? Write your observations.
- Draw a picture of the flower at the start of the experiment and make a prediction as to what you think will happen!
- Draw a picture or take photos at the middle and end of the experiment. What changes do you notice?
- At the end of the experiment, closely examine the bottom of the stem again. Use a hand lens to look closer. What do you see? Does this help to explain what happened to the flower?

EXPLAIN

What's happening in this Activity?

First review the Chemistry of Life & Earth Sciences Background section to gain a deeper understanding of the scientific principles behind this activity.

Both plants and animals have specific needs that must be met for them to survive. For animals like humans, we need food, water, air, and more. Similarly, plants need food and water to survive. But without being able to move to get the nourishment they need, how can a plant survive? And where do their water and nutrients come from?

One of the most important things plants need to survive is water. Plants can absorb some water through their leaves, but most of the water a plant gets is through the soil using its roots. The soil also contains nutrients the plant needs, which are often dissolved in this water. But how does a plant bring water from the soil all the way up to the branches, leaves, and flowers?

The secret lies within the properties of water and the microscopic structures inside the plant. As we know from the Surface Tension Activity Guides, water has properties similar to other liquids, but also some properties that are unique. Like other liquids, water particles exhibit cohesion. **Cohesion** is the attractive force between two like particles in a liquid. In a sample of water, each H_2O molecule is attracted to the other H_2O molecules nearby, making them tend to stick together. **Surface tension** is a property of liquids that describes the attraction of liquid molecules at the surface. Molecules at the surface of the liquid are more strongly attracted to one another than molecules in the liquid. This brings the surface molecules closer together and creates a surface "film." As a result, moving an object through the surface of a liquid is more difficult than moving the object when it is completely submerged in the liquid.

Another property of liquids is **adhesion**, which is the attractive force between two unlike particles. For example, a water molecule (H_2O) is attracted to the tissue of a plant, which is made of different molecules. Water molecules not only stick together – especially at the water's surface – but they also stick to other surrounding molecules, even if they are different.

A final property of liquids that explains how water moves through a plant is capillarity, or **capillary action**. Capillary action is the movement of liquid upwards through a narrow tube and against the downward force of gravity. Capillary action is possible due to adhesion and cohesion. Plant tissues attract water molecules through adhesion. When one molecule moves, the water molecules around it follow because they stick together due to cohesion. Adhesion between water and the plant tissue and cohesion between water molecules pull the water molecules up from the roots all the way through the furthest leaves and flowers on the plant.

The structure inside a plant that carries water and dissolved nutrients up from the soil is called the **xylem**. The xylem runs vertically like a long tube from the bottom to the top of a plant, and also provides structural support to keep the plant upright. You can think of it like a hose: when water is running through it the hose is stiff and can maintain its shape, but when the water is off the hose is deflated. Similarly, a plant that does not have enough water in the xylem will appear wilted, and when it has enough water the plant will stand upright again .

In this activity, we can watch water moving through a plant by first dyeing the water. The petals change color because water moves from the space surrounding the plant and into the roots or stem, and then all the way up to the petals through the processes of adhesion, cohesion, and capillary action.

Notes

EXPLAIN continued

But how does water get all the way to the top of the plant – especially in trees hundreds of feet tall? The process that pulls the water to the top of the plant is called **transpiration**. This is when water evaporates from the plant leaves, and as it evaporates it creates suction pressure in its place. It is almost like sucking water through a straw: as the sun heats the earth, its energy warms plant leaves. Liquid water in the leaves evaporates into a gas, exits the plant, and goes into the air. The loss of water from the leaves creates a kind of vacuum, pulling up more water to replace what was lost. This water is pulled up through the xylem, from the roots, and originally from the soil itself!

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED

For younger students, emphasize the following concepts:

- Plants need water to survive.
- Plants get water from the soil using their roots and stems.
- Plants have internal structures to transport water and nutrients.

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Plants have internal structures called xylems, which are tubes that transport water throughout the system.
- Capillary action helps water move through a plant using the forces of adhesion and cohesion (surface tension).

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Try an array of colors by setting up multiple carnations in water dyed different colors.
- Don't have carnations? This experiment can be done with many plants, such as other flowers, cabbage leaves, stalks of celery, or lettuce. Try different examples and see what works best!
- Does the concentration of food coloring or the color of the dye matter? Try the experiment with different amounts of food coloring, or with different colors, to see which works the best. Be sure to only test one variable at a time!
- To dye one carnation's petals two different colors, use a knife or scissor to split the stem lengthwise into two halves until it is around 2-3 inches from the top of the stem. Place each half of the stem in a separate colored water solution (you might have to tape the stems to the cups to keep them in place). Or, after you cut the stem in half, put one half in plain water and the other in colored water.
- Ask students how they would add a control to the experiment. What part of the procedure would they change? Would it still be placed in water? Should they still add food coloring?
- How quickly does water move through a plant? If you are able to do frequent checks, set up a timer and note when you first see color in the petals. Or, set up a camera and record a video or take pictures throughout the next few days. Are there other factors that affect how quickly water moves through a plant? See if it varies based on stem length, thickness, the type of flower or plant, and more!
- After the experiment, cut the stems and see if students can find the xylems (hint: they should be colored!). A hand lens might help, and if you take a thin enough cross-section you can examine it under a microscope.
- Will other colored liquids work for this experiment? Try juices or different types of dyes and see what works the best!
- Watch the CEF staff demonstrate this experiment here (and be sure to watch until the end!).

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

Capillary action explains why we often water the roots of a plant, not the leaves. The leaves can take in some water, but the roots and stems are the best vehicles to get water into a plant.

Some plants that might appear to have plain, simple designs to the human eye actually have elaborate markings that can only been seen on the ultraviolet light spectrum. Many insects that act as pollinators can see ultraviolet light, and plants use these designs to attract pollinators to their flowers!

Careers in Chemistry

- Over certain holidays flowers are dyed unusual, bright colors. Florists have a number of techniques and dyes to help them safely color flowers in exciting new ways.
- Irrigation systems need to efficiently deliver just enough water to plants so they can grow, but not drown. It is also important to not waste any water and use only what is needed. There are hundreds of ways to build and design irrigation systems, many of which funnel water right to the base of a plant so it can be taken up by the roots, instead of losing it to the air through evaporation.

Notes

EVALUATE

- Ask students to draw a picture of a flower and indicate using arrows how water moves through the plant. Can they label each place the water goes? For more advanced learners: can they label the parts?
- Have students conduct a writing exercise about what they learned in this experiment. They could create a poem, comic, series of social media posts, or write a story about what processes are occurring within the plant.
- Is there anything similar about the ways that plants get water and the way that humans get water? Have students do some research on their own to learn about the system humans use to transport nutrients.

Fun Fact #2

The largest single flower in the world is Rafflesia arnoldii, which is a rare flower found in Indonesia. The flower bloom can be up to three feet across and weigh 15 pounds! This plant is also a parasite, so instead of getting its own water and nutrients, it grows attached to other plants and steals what it needs from its host. This flower also emits a foul odor that people claim smells like rotting meat, which attracts pollinators like flies .