Brown Bananas

Section CHEMICAL REACTIONS *Topic* BASICS OF CHEMICAL REACTIONS

Estimated Time Setup: 10 minutes; Procedure: 4-5 days

OVERVIEW

Students will observe how fruit ripens, and how this process can be affected by a variety of packaging.

In this activity, students place bananas in three different packaging materials: a paper bag, plastic bag, and plastic wrap. Control bananas receive no packaging. Over the course of a week, students observe how the ripening process is affected by the fruits' surroundings. Students learn that ripening is a chemical process that requires oxygen flow to produce ethylene – a plant hormone that causes the fruit to change color and grow softer and sweeter.

MATERIALS

For one setup:

- 4 green, unripe bananas
- Brown paper bag
- Sealable gallon plastic bag
- Plastic wrap

INQUIRY QUESTIONS

Getting Started:

- What physical changes can we observe with our senses as fruit ripens?

Learning More:

- What chemical changes occur when fruit ripens?

Diving Deeper:

- What is the chemistry of ripening and how do environmental factors affect these processes?

CONTENT TOPICS

This activity covers the following content topics: physical changes, chemical changes and reactions, diffusion, chemistry of fruit ripening, enzymes, catalysts

This activity can be extended to discuss: agricultural processes, food production and storage, glucose production, diabetes, hormones, environmental science

NGSS CONNECTIONS

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

- MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

ACTIVITY NOTES

This activity is good for:

- Pairs
- Small groups
- Large groups
- Project or take-home assignment

Safety Tips and Reminders:

- There is no eating or drinking in the laboratory—even when we are working with normally edible materials.
- Ensure that this experiment is set up in a place where it will not attract unwanted animal visitors!
- Review the Safety First section in the Resource Guide for additional information

Fun Fact #1

The average American eats 27 pounds of bananas each year!

ENGAGE

Use the following ideas to engage your students in learning about the basics of chemical reactions:

- Start with a discussion about how food is harvested, packaged, and transported to grocery stores, and then to students and their families. How long do students think this process takes? Why is fruit still fresh when it arrives in their local grocery stores, and how can they keep fruit fresh longer once they get home?
- Start with a dilemma: you want to make banana bread and need ripe bananas, but these are still green! Is there a good way to speed up the ripening of a banana if you don't have time to wait?
- Do some group brainstorming: what do students think happens when fruit ripens? What changes do they notice? What chemical changes might be happening? If needed, prompt them to think about changing appearances and smells. What do they think causes this?
- If possible, go to a few local grocery stores and take photos of how the bananas are packaged. Some might be left out, others might be wrapped up or in some sort of packaging. Show the photos to the students and ask why they think they are packaged or displayed in these ways. How might this affect the rate at which it ripens?
- Do a blind taste test! (Even though eating is not usually allowed in the laboratory, you can make exceptions as needed.) Provide unlabeled samples of ripe and unripe fruit. Do students see, feel, or taste any difference? Ask them to describe each sample. Can they tell which sample was ripe and which was unripe? How? What changes occur during ripening?

See more ideas for engagement in the Basics of Chemical Reactions Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

EXPLORE

Procedure:

1. Place one banana in a paper bag and fold the top down several times so it is closed.
2. Place a second banana in a plastic bag and seal, leaving some air in the bag.
3. Wrap a third banana tightly in a few layers of plastic wrap, ensuring the ends are sealed.
4. Leave the fourth banana out in the open as a control.
5. Wait 4-5 days without tampering with the wrappings, then open to observe the results.




Notes

DATA COLLECTION & ANALYSIS

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

- Describe the physical properties of the unripe bananas. What do they look, feel, or smell like?
- Draw and label your experimental setup on the first day.
- Write observations each day for the bananas you can see.
- On the last day draw and label your results. Describe any changes to each banana and differences between the bananas. Why do you think they ripened at different rates?
- Describe the physical properties of the ripe bananas. What do they look, feel, or smell like? Do you think ripening is a physical or chemical change? Provide evidence for your answer.

Fun Fact #2

Humans also have catalysts called enzymes in our bodies to help reactions like digestion occur. Without an enzyme catalyst, the slowest known biological reaction would like 1 trillion years. With an enzyme catalyst, this reaction, which is essential to creating our DNA, happens in just 10 milliseconds.

EXPLAIN

What's happening in this Activity?

First review the Basics of Chemical Reactions Background section to gain a deeper understanding of the scientific principles behind this activity.

When a fruit ripens, it changes in a variety of ways. The fruit generally becomes sweeter, it softens, and its color changes—often it becomes less green. This is all because of chemical reactions happening in the fruit. The tissue of the fruit softens because of molecules that break down the walls of cells in the fruit. The color changes because a compound called chlorophyll, which is responsible for the green color of plants, is being degraded. The taste becomes sweeter because sharp-tasting acids are broken down, and starches are converted into sugars like glucose. These are all chemical changes. Bananas are usually picked before they are ripe, so they can be transported long distances without being damaged.

In this activity, there are three liquid samples: water, light corn syrup, and vegetable oil. When they are put together they make distinct layers based on differences in density. The density of each substance differs because each has a different chemical makeup—each is made up of different molecules with varying sizes, atomic weights, and molecular arrangements. If you calculate or research the density of each liquid sample, you will find that the light corn syrup has the greatest density, followed by water, then vegetable oil. This aligns with what you saw: the light corn syrup forms the bottom layer, with water in the middle, and vegetable oil on top.

Unripe Bananas

Ripe Bananas

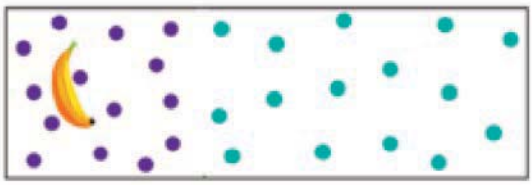
One of the things that triggers the ripening process is a plant hormone called ethylene. Hormones are substances produced by living things, like plants and animals, that regulate the biological processes we rely on to survive. Ethylene is an odorless gas with the formula C_2H_4: each molecule contains two carbon atoms and four hydrogen atoms.

Fruits ripen when exposed to ethylene, and also produce ethylene themselves as they ripen. Plants also produce ethylene when heated or bruised. To produce ethylene, plants need oxygen from the air around them.

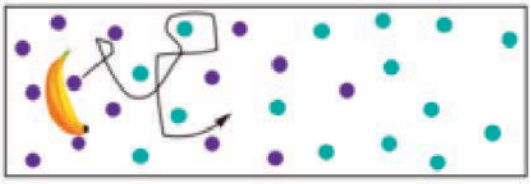
When more ethylene is present, the chemical reactions associated with ripening occur faster. Ethylene helps the starch in the fruit breaks down more quickly into sugars like glucose. The cell walls are broken down more quickly, and the green compound chlorophyll degrades faster. Because of its effects on the ripening process, ethylene is said to be a **catalyst**. A **catalyst** is a substance that changes the rate of a reaction but is not used up by the reaction.

When a fruit produces ethylene gas, that gas travels through the air because of a process called diffusion. **Diffusion** is the movement of fluid (liquid or gas) particles from an area of high concentration to an area of low concentration. This means that the ethylene gas emitted by a plant spreads out after being released. If there are other fruits nearby, they are affected by that additional ethylene in the air.

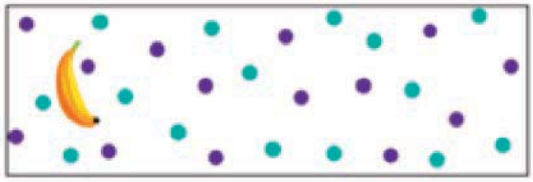
EXPLAIN continued



When the banana produces ethylene, there is a high concentration of ethylene (represented by the purple dots) right around the banana, and none in the surrounding air (blue).



The ethylene particles spread out away from the banana, from the area with a high ethylene concentration to an area with a low ethylene concentration.



The ethylene spreads out until it reaches equilibrium. *Equilibrium* is when all the gases are spread evenly throughout the area. Because the banana keeps producing ethylene, in real life the ethylene gas may never fully reach equilibrium.

The conditions also must be right for the reactions behind ripening to occur. Environmental conditions, like temperature and pressure, affect whether or not a reaction occurs and how fast it proceeds. The enzymes in plants do not function if the environment is too cold. Therefore, storing fruits in cold places can stop them from ripening and make them ripen slower.

In this experiment, the banana sealed tightly in plastic wrap should ripen the slowest, if at all. Because it is wrapped tightly, it is not exposed to any oxygen in the air and cannot produce any ethylene. The banana wrapped in a plastic bag with air inside will ripen faster because it has access to oxygen. The ethylene produced by that banana is contained, and the high concentration of ethylene in the bag makes the banana ripen quickly as well. The banana in the paper bag should ripen fastest. Like the plastic bag, the paper bag keeps the ethylene produced by the banana contained. But the paper bag also allows additional oxygen to pass through because it is **porous** (has very small holes). The banana in the paper bag is kept in close contact with its own ethylene, and also has an unlimited supply of oxygen.

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	DIVING DEEPER
For younger students, emphasize the following concepts: • Basics of chemical reactions • Basics of diffusion	**For more advanced students, emphasize the following concepts:** • Catalysts and their effect on the rate of reactions • Factors that affect chemical reactions

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.

- Fruits produce more ethylene in response to bruising. Try the experiment again, but this time use bruised bananas. Use bananas from the same bunch, and bruise some while leaving others as they are. Do the bruised bananas ripen faster or slower than the unbruised bananas?
- More fruit, more ethylene! Do the results change if there are more bananas in each setup (i.e. a bag with 2-3 bananas instead of one)? Test it out!
- Many people put fruits and vegetables in the refrigerator. Is this an effective way to slow ripening and keep fruit fresh? Try placing bananas in a variety of temperatures. How does this affect ripening? Does light exposure have any effect?
- Other fruits produce ethylene gas while ripening, too. Try placing bananas alongside different fruits (i.e. apple, pear, lemon) in clear plastic bags so you can observe the ripening process. Which fruit exhibits the fastest ripening?
- Take time lapse photos of your experiment. Photograph each banana each day to create a slideshow to better visualize how the ripening happened. You can even extend the experiment to one or two weeks to see the full progression.
- Integrate conservation of matter into this activity. Have students record the mass of each banana at the start of the experiment. Do they think the mass will stay the same or change by the end of the experiment? Why? Measure the mass at the end of the experiment. What did they find?
- Which fruits ripen by producing ethylene gas? Do some research, then try the experiment again, but use a different fruit in each bag along with a control outside of the bag.

CHEMISTRY IN ACTION

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

Real-World Applications

Results from experiments like these are used every day as people store their produce. Want to make guacamole but only have unripe avocados? Put a bunch of them together in a bag with an ethylene-producing fruit, like an apple or banana, and they will ripen in a snap!

Ethylene absorbing pads, beads, or bags can often be found in fruit packaging. These products quickly absorb ethylene while fruit is stored so it doesn't overripen in transit.

Careers in Chemistry

- There are many people and scientists involved in fruit production and distribution processes, including those who grow, harvest, transport, store, advertise, check for quality, and more. You can find videos online to learn how bananas are harvested, packaged, and distributed, and learn fascinating facts about the science of how quality is measured and the ways in which produce is stored to ensure you get the freshest product!
- The US Department of Agriculture provides guidance for food production, storage, nutrition and more. The scientists and policy makers work to ensure Americans are eating food that is good for them and that we are educated about where our food comes from and its nutritional benefits. They even have a YouTube channel where you can check out some produce storage hacks!

EVALUATE

- Present students with a new experimental setup with slightly different packaging for each banana. Examples could be a shoebox, mesh bag, paper towel, or plastic container. What do they predict will happen and why? What evidence do they have from the first experiment to back up their ideas?
- Provide a variety of scenarios for students to solve based on their results from this experiment. For example, if you want to quickly ripen a bunch of bananas, what setup would you try? If you want to keep them unripe as long as possible, what would you do? Thinking beyond the constraints of the experimental setup: can they design a more effective mechanism or packaging to control the ripening of a banana?
- Add a research component to this experiment: ask students to investigate how bananas are harvested, packaged, and transported to local grocery stores. How might these processes help bananas stay fresh and not ripen too quickly? Students can collect data from labels to see where bananas they eat are coming from in the world and plot out the travel route and the steps taken before the bananas arrive at their home.
- Ask students to write a proposal to a local grocery store recommending a better way to store their produce. Students should draw diagrams of their proposal and include the associated costs. Their proposal should indicate the problem they are aiming to solve, their solution, the science behind the effects it would have, and the benefits for the store and its customers.