NOVA

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PBS

Forgotten Genius

PROGRAM OVERVIEW

NOVA draws on family archives and interviews with colleagues and relatives to tell the compelling story of 20th-century chemist Percy Lavon Julian, a world-class scientist and civil rights pioneer who helped break new ground in the chemistry of plants.

The program:

- reviews Julian's early education—which occurred at a time when black children in Alabama were not allowed to study past the eighth grade—and recalls how Julian found a way to earn a 10th-grade education and enter DePauw University in Indiana in 1916.
- recounts the challenges Julian faced to earn his undergraduate degree and graduate first in his class and later earn his master's degree from Harvard University in 1923.
- follows Julian's bid for a Ph.D. at the University of Vienna in Austria, where he sought to isolate the active ingredient in *Corydalis cava* and identify its chemical structure.
- reports on the young scientist's move back to Howard University in 1931, where university politics and scandal led to his resignation and his return to DePauw to work as a research fellow.
- documents Julian's efforts to revive his career by taking on one of the world's leading organic chemists in a race to synthesize the alkaloid physostigmine.
- identifies the continuing racial obstacles the brilliant chemist faced in his pursuit for employment before being hired by the Glidden Company, where he began researching the soybean.
- profiles Julian's work to synthesize the steroid progesterone from plants after his accidental discovery of a method to isolate steroids from soybean oil.
- details the path Julian took to try to synthesize Compound S, a steroid that would become a key factor in making cortisone available to millions of sufferers of rheumatoid arthritis.
- follows Julian as he leaves Glidden to form his own company, Julian Laboratories, which would produce steroid intermediates—compounds just one step short of a finished product.
- presents the obstacles Julian had to overcome to make his business succeed.
- reports on the role Julian played in the fight for racial equality.

BEFORE WATCHING

1 Review with students a time line of Julian's life as well as the Jim Crow laws—state and local laws enforcing racial segregation—in force during much of his life. Discuss with students ways these laws may have impacted Julian's efforts to become a scientist. Find a time line and overview of Julian's life at www.pbs.org/nova/julian/lrk-whowasjulian.html

2 Have students write down three character traits they think would be necessary to succeed in science. Write these traits on the board during a class discussion. Which three appear most often? Which do students think would be the most important ones to succeed? Why?

3 Organize the class into five groups, and as students watch the program, have them take notes on the following topics: Julian's scientific achievements, his business achievements, the challenges and discrimination he faced in America while pursuing his education and career, the mentoring he received, and the actions he took to further civil rights.

AFTER WATCHING

1 Have students who took notes on the same topic meet, discuss their notes, and then prepare a short presentation for the class. What did Julian accomplish scientifically? What were his greatest challenges? Who helped him the most? How did he help others?

2 Have students compare the traits they brainstormed earlier to those that Julian needed to succeed. Which of the traits did Julian have? Which traits did Julian have that students had not thought of? Would scientists of color today need those traits? Why or why not?

CLASSROOM ACTIVITY

Activity Summary

Students visit stations in the classroom to investigate physical and chemical changes and then apply what they have learned to a story about physical and chemical changes that occur in everyday life.

Materials for Teacher Demonstration

- whole peppercorns
- mortar and pestle
- glass of room-temperature water
- ice cubes
- paper
- matches

Materials for Each Team

- copy of "What It Takes to Change" student handout
- copy of "Station Instructions" student handout
- copy of "Data Chart" student handout

Materials for Each Student

- copy of "Changes in Everyday Life" student handout
- goggles
- 1 red pen
- 1 blue pen

Station Materials

STATION 1

For each team
- 1 dirty penny
- 1 clean steel screw
- 60 mL white vinegar
- 8 oz clear plastic cup

For station
- 100 g salt
- plastic teaspoon
- magnifying glass

STATION 2

For each team
- 1 g baking soda
- 1 film canister with lid

For station
- 10 mL vinegar
- 5 mL graduated cylinder

STATION 3

For each team
- 1 g sodium polyacrylate
- 8 oz plastic cup

For station
- 500 mL water
- 50 mL graduated cylinder
- garbage bag

STATION 4

For each team
- 1 antacid tablet (should contain citric acid and sodium bicarbonate)
- 1 sealable sandwich bag

For station
- 500 mL water
- 50 mL graduated cylinder
- garbage bag

STATION 5

For each team
- 2 sealable sandwich bags

For station
- 300 mL purple cabbage juice
- 100 mL vinegar
- 100 g baking soda
- 20 mL graduated cylinder
- garbage bag

STATION 6

For each team
- 55 g cornstarch
- paper bowl

For station
- 500 mL water
- 20 mL graduated cylinder

LEARNING OBJECTIVES

Students will be able to:

- differentiate between physical and chemical change.
- identify physical and chemical changes that occur in everyday life.

CLASSROOM ACTIVITY (CONT.)

Background

When Percy Julian entered DePauw University he barely had a 10th-grade education because public schools for black children stopped at eighth grade across most of the South. (Julian completed an additional two years at a local teacher training school for Negroes.) In addition to his university coursework, Julian took remedial classes at a local high school for two years to catch up with his white classmates. With the help and encouragement of his chemistry professor, Julian succeeded in not only catching up, but in surpassing his peers. He would go on to graduate from DePauw first in his class. In this activity, students do their own investigations into some basic principles of chemistry—they explore physical and chemical change and learn to differentiate between the two.

Procedure

1. **Review safety protocols.** Have students wear goggles for all stations. All powders should be handled with care and neither smelled nor tasted. Students should wash their hands after they have finished with the stations. Discard dry and gelled polymers in the trash, not in the sink.
2. Set up the stations in advance of the activity. The amounts listed for the materials needed for each station are enough for 10 teams. Place station labels, paper towels, and trash bags (for disposal) at each location.
   Station 1 (chemical): Place 60 milliliters of white vinegar in each cup. Supply pennies, steel screws, salt, plastic teaspoon, and magnifying glass.
   Station 2 (chemical): Put 1 gram of baking soda in each film canister. Place vinegar, graduated cylinder, and film canister lids nearby.
   Station 3 (physical): Place 1 gram of sodium polyacrylate in each cup. Place the water and graduated cylinder nearby. (Because the polyacrylate is highly sensitive to moisture, it is best to prepare the cups just prior to the activity.)
   Station 4 (chemical): Place the antacid tablets, sealable bags, water, and graduated cylinder at the station.
   Station 5 (chemical): To make the cabbage juice, cut up a purple cabbage into small chunks, add enough water to cover, and boil until the liquid turns purple. Supply the cabbage juice, vinegar, baking soda, graduated cylinder, and sealable bags.
   Station 6 (physical): Place 55 grams of cornstarch in each bowl. Place the water and graduated cylinder nearby.
3. Organize students into teams and distribute the "What It Takes to Change," "Station Instructions," and "Data Chart" student handouts.
4. Tell students that substances can change in two ways: physically or chemically. Inform students that you are going to demonstrate three changes and have students make observations about how each substance changed following each demonstration.

EXPLORE MORE ONLINE

Learn More About Julian
Visit WGBH's multimedia digital library, Teachers' Domain, to find classroom resources and lesson plans about Percy Julian, his life, and his work.
www.teachersdomain.org/exhibits/pj07-ex/index.html

CLASSROOM ACTIVITY (CONT.)

5 First put ice in a glass of room-temperature water and set it down. Have students describe the glass of ice water. Next, show students the whole peppercorns and ask them to describe their physical properties. Then crush the peppercorns and have students describe the new form of the pepper. Ask students to describe how the peppercorns changed. Go through the same steps with a piece of paper and then burn it. After all the demonstrations are done, have students look at the ice water again and record their observations. Discuss with students how the changes were similar and different among the three demonstrations. Explain to students that two demonstrations showed physical change (peppercorns crushed and ice melting in water) while the other showed a chemical change (paper burned). In the cases of the ice melting in water and the paper burning, energy changes also occurred (the ice absorbed heat in order to melt and the burning paper radiated heat). Energy changes can accompany both chemical and physical changes.

6 Have students brainstorm a list of observations they could make that would indicate a physical or chemical change. *(In physical changes, changes may occur in the material's properties but the chemical composition of the material is the same before and after the change. In a chemical change, one or more new substances are formed.)* Stress to students that in a physical change, properties may change but molecular identities do not. Therefore, in a physical change, students should look for changes in properties, but not a change in the chemical nature of the original material. To identify a chemical change, students should look for signs like color change, production of gases or solids, and/or production of an odor.

7 Have student teams rotate through all the stations. After completing all the stations, have students work in teams to decide whether each station showed physical or chemical changes. Point out to students that more than one change may have occurred at each station.

8 Once all teams are done, as a class discuss what kind of changes each station represented and what evidence supported each type of change. (See Activity Answer on page 5 for more information.) Reconcile any differences in student answers.

9 When students have completed the first part of the activity, distribute the "Changes in Everyday Life" handout to each student to help assess student understanding. Have students read the story and identify the physical and chemical changes within it. You may want to tell them that there are at least 12 changes listed. When everyone is done, review the passage as a class and discuss the changes that are listed and why they are physical or chemical.

10 As an extension, have students write their own stories that incorporate physical and chemical changes. Each story should include at least three examples of each type of change. Have classmates swap stories to try to find the changes in each other's work.

STANDARDS CONNECTION

The "What It Takes to Change" activity aligns with the following National Science Education Standards (see books.nap.edu/html/nses).

GRADES 5–8

Physical Science

- Properties and changes of properties in matter

Video is not required for this activity.

Classroom Activity Author

Developed by WGBH Outreach staff.

ACTIVITY ANSWER

The following is a description of what is occurring at each station.

Station 1 (chemical): The mixing of the vinegar (acetic acid) and salt (sodium chloride) is a physical change. The cleaning of the penny is a chemical change. (When the pennies are put into the vinegar-salt mixture, the substance that makes the pennies appear dirty—copper oxide that formed when the copper atoms in the penny combined with the oxygen in the air—is dissolved by the weak acid.) The reactions that occur when the screw is dropped in the solution represent a chemical change (the surface of the steel screw dissolves). Evidence for change: the salt mixed into the vinegar, the penny changed color, gas bubbles formed on the screw.

Station 2 (chemical): When mixed, baking soda and vinegar form carbon dioxide gas inside the film canister. Production of this gas creates the pressure that causes the lid to pop off. Evidence for change: gas bubbles are released.

Station 3 (physical): The sodium polyacrylate absorbs the water. (Sodium polyacrylate, which can usually be found in disposable diapers, can absorb about 800 times its weight in distilled water.) Evidence for change: gel forms.

Station 4 (chemical): As the antacid tablet—which typically includes sodium bicarbonate (baking soda) and citric acid—dissolves in water it produces a carbon dioxide gas that forms when the sodium bicarbonate encounters the acid in an aqueous solution. Evidence for change: bubbles form and bag inflates.

Station 5 (chemical): Purple cabbage juice changes color in response to changes in the overall hydrogen ion concentration (pH) of the solution. Acids such as acetic acid (vinegar) donate hydrogen ions to the purple solution, which turns the purple cabbage pigment red or pink. Bases such as sodium bicarbonate (baking soda) accept hydrogen ions when added to purple cabbage juice, causing the pigment to become blue or blue-green. Evidence for change: the purple cabbage juice changes color.

Station 6 (physical): The cornstarch mixes with water and becomes more solid. The mixture is a colloidal suspension—the cornstarch is not dissolved but mixed into a suspension that doesn't settle out. Evidence for change: when mixed with water, cornstarch has properties not present when it is in powder form.

ACTIVITY ANSWER (CONT.)

Just One of Those Days

Students may note additional changes that are not mentioned here, such as the biting of the apple, the cracking of the eggs, or the jelly and butter mixing as being physical changes. Accept all reasonable answers.

sour milk: *chemical*
rusty tack: *chemical*
decaying plants: *chemical*
saltwater evaporation: *physical*
ice melting: *physical*
glass breaking: *physical*
apple browning: *chemical*
whipping eggs: *physical*
cooking eggs: *chemical*
browning bread: *chemical*
melting butter: *physical*
dyeing hair: *chemical*

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LINKS AND BOOKS

Links

NOVA—Forgotten Genius
www.pbs.org/nova/julian
Offers features about Julian's role as a civil rights trailblazer, a speech Julian made, a time line of his chemical achievements, stories from those who knew him, information about plants that have been synthesized into chemicals, a way to make steroids online, and more.

General Chemistry Online!
antoine.frostburg.edu/chem/senese/101/index.shtml
Provides an overview of chemistry basics.

Science Alive! The Life and Science of Percy Julian
www.chemheritage.org/scialive/julian
Provides information about Julian's life and career, with material on his childhood, college years, scientific discoveries, and civil rights work.

Books

A to Z of Chemists
by Elizabeth H. Oakes.
Facts on File, 2002.
Tells the stories of 150 historical and contemporary chemists.

Chemical Achievers: The Human Face of the Chemical Sciences
by Mary Ellen Bowden.
Chemical Heritage Foundation, 1997.
Provides teachers with photos and biographies of 80 chemists, many of whom are people of color.

The Joy of Chemistry: The Amazing Science of Familiar Things
by Cathy Cobb.
Prometheus Books, 2005.
Includes science and history, and connects chemistry to the real world.

What It Takes to Change

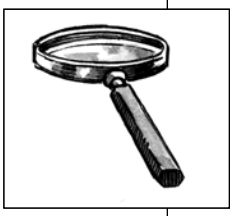
Changes in matter are happening all around you. But not everything changes in the same way. Some changes in matter are physical; others are chemical. Find out more about these types of changes in this activity.

Procedure

1. In this activity, you will move around the room in teams to different stations, where you will observe the properties of several substances before and after a change. You will then use these observations to help you identify each change as physical or chemical. You will support your claim with evidence from your observations.
2. Choose one team member to record your team's observations on your "Data Chart" student handout.
3. Start at the station designated by your teacher and follow the directions on your "Station Instructions" handouts for each station.
4. When you have completed all the stations, discuss your observations as a team. Come to an agreement about whether each change was physical or chemical and discuss what observational evidence supports your claim. Finish filling in the chart with your answers.
5. After the chart has been completed, your team will participate in a class discussion about the types of changes that occurred at each station.
6. After you have completed the stations part of the activity, you will complete the "Changes in Everyday Life" student handout individually.

Station Instructions

Station 1

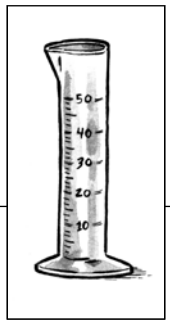


Stir a teaspoon of salt into the vinegar until it has dissolved. Choose a penny. Draw both sides of the penny, noting the location of any discoloration. Drop a penny into the liquid mixture. Watch it for 2 minutes. Use the spoon to take it out. Note any changes in appearance on your original drawing. Drop the screw into the liquid and let sit for 1 minute. Observe the screw in the liquid with the magnifying glass. Record your observations. Put your paper cup and penny at the back of the station.

Station 2

Put a paper towel under your canister. Add 1 milliliter of vinegar to the film canister that contains baking soda, and quickly put the lid on. Record your observations. Place the lid and canister at the back of the station.

Station 3



Slowly add 50 milliliters of water to the granules in your cup. Record your observations. Dispose of the cup in the garbage bag at the station.

Station 4

Pour 50 milliliters of water in the bag. Flatten the bag to remove the air. Seal the bag most of the way. Put a tablet in the bag and hold it at the top of the bag while you finish sealing it. Drop the tablet into the liquid. Observe and record the results. Dispose of the sealable bag in the station's garbage bag.

Station 5

Place 15 milliliters of cabbage juice in a bag. Add 1 teaspoon of vinegar. Seal the bag and shake. Record what you see. Place 15 milliliters of cabbage juice in a second bag. Add 1 teaspoon of baking soda. Seal the bag and shake. Record your observations. Dispose of the sealed bags in the garbage bag at the station.

Station 6

Add about 20 milliliters of water to the cornstarch in the bowl and stir. Gradually add more water and use your hands to mix the substance until all of the cornstarch is wet (your mixture should not be runny or powdery). Squeeze the mixture in your hand. What happens? Now just hold it in your hand. What happens? Record your observations. Put the mixture in the bowl when you are done and place the bowl at the back of the station.

Data Chart

Station	Observations (Properties of Substances Before and After Change)	Type of Change (Chemical or Physical)	Evidence for Change
1			
2			
3			
4			
5			
6			

Changes in Everyday Life

Physical and chemical changes occur all around you every day. Read the story below and circle the physical and chemical changes you see within it. Use your blue pen to circle physical changes and your red pen to circle chemical changes.

Just One of Those Days

Aaahhh. A brand new day. You go into the kitchen and open the fridge and pour a glass of milk. Before you even drink it you can tell from the smell that the milk has soured. You make a glass of ice water instead. Suddenly, you hear your cat screech. You run to help her and see she has stepped on a rusty tack (you know from science class that it rusted due to oxidation). You run to call the emergency traveling vet to come to your house. As you are walking back to the kitchen, you notice that some of your plants are dying and beginning to decay and that some saltwater has evaporated out of your fish tank. You make a mental note to take care of both after school.

You go back to get your ice water but find that the ice has melted. You are so thirsty you don't care and drink it anyway. You suddenly realize how hungry you are and take an apple from the counter and bite into it. Yum. Then you hear glass breaking. (What kind of crazy day is this?!) You run to see what has happened and find that the traveling vet accidentally broke a window. But he promises to pay for the damage before he takes your cat away to attend to her injury.

What a day, and it's only just begun. You go back to the apple, but it has turned brown. You decide to make some eggs and toast instead. You first whip the eggs with a fork and then cook them. You pop a piece a bread in the toaster, which a few minutes later turns nice and brown. You melt some butter on the toast and add some grape jelly.

You think about dyeing your hair purple but then remember how your parents reacted when your sister did that. So instead you just decide to finish breakfast and catch the bus, hoping the crazy part of your day has ended.