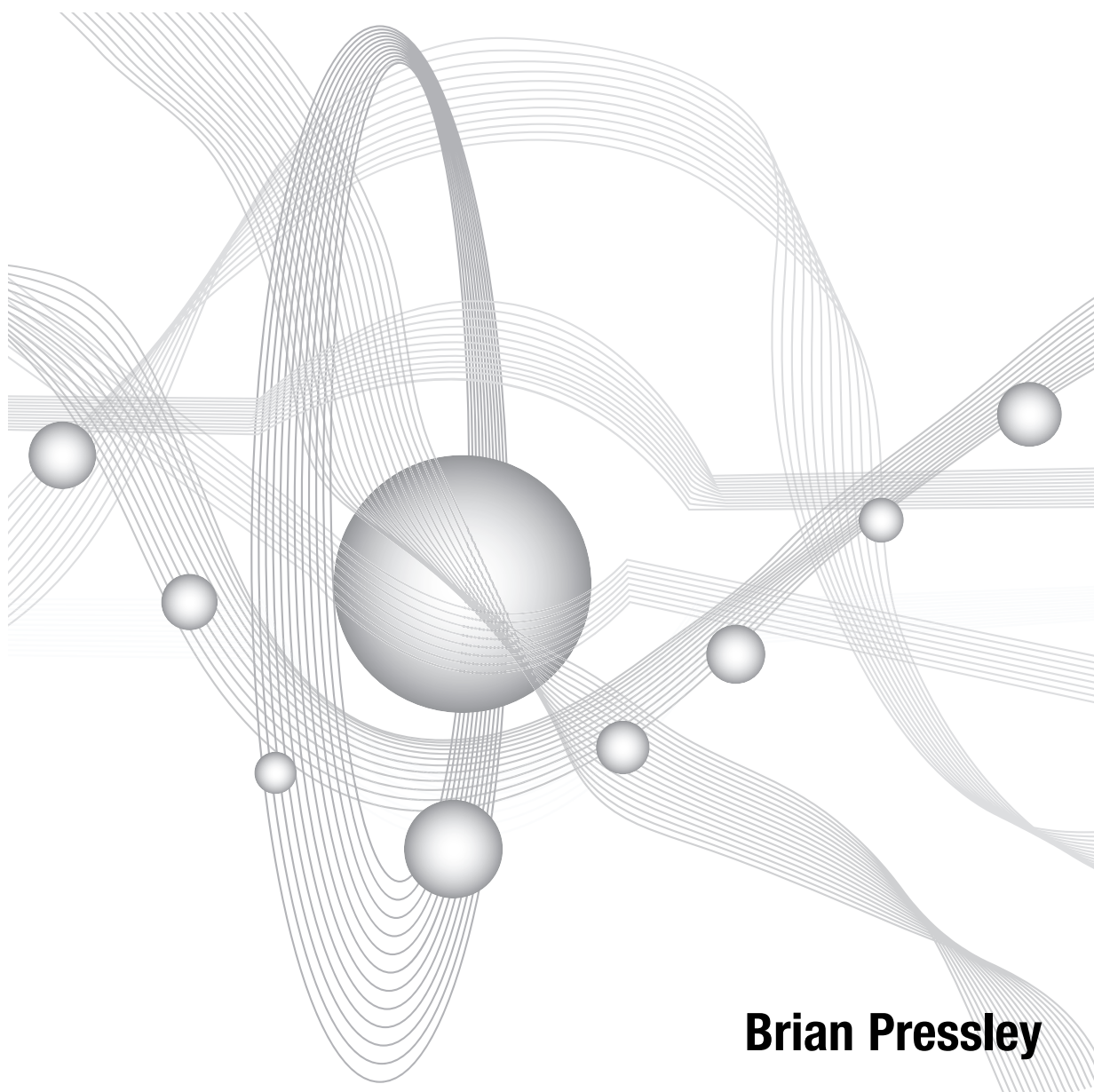


Real-Life Science

CHEMISTRY



Brian Pressley

WALCH  PUBLISHING

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Introduction

The *Real-Life Science* series is designed to engage students with topics of high interest that involve places, phenomena, technology, and concepts that they may encounter in their everyday lives. The topics were chosen by professionals in science education, and the National Science Education Standards were used to develop lessons that addressed a number of content standards. Each book in the series has a correlations chart that shows core standards that are addressed by each lesson, as well as other standards that are addressed, but are not the main focus of the lesson.

Using “real-life” examples is a technique that is well supported by the National Science Teaching Standards as well. The list below includes some of the standards that suggest that quality instruction can and should include material that does more than just require students to memorize and repeat basic facts.

Teaching Standard A

Teachers of science plan an inquiry-based science program for their students.

- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

Teaching Standard B

Teachers of science guide and facilitate learning.

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.

Teaching Standard E

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

- Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
- Model and emphasize the skills, attitudes, and values of scientific inquiry.

Each book in the *Real-Life Science* series features lessons you can use in your classroom today. Use these engaging lessons to help your students explore the intriguing ways that science is at work all around them.

National Science Education Standards Correlations

C = Core standard X = Other or optional skill

Title	Physical Science Content Standard B Grades 9–12: Structure of atoms	Physical Science Content Standard B Grades 9–12: Structure and properties of matter	Physical Science Content Standard B Grades 9–12: Chemical reactions	Physical Science Content Standard B Grades 9–12: Motions and forces	Physical Science Content Standard B Grades 9–12: Conservation of energy and increase in disorder	Physical Science Content Standard B Grades 9–12: Interactions of energy and matter	Science and Technology Content Standard E Grades 9–12: Abilities of technological design	Science in Personal and Social Perspectives Content Standard F Grades 9–12: Personal and community health	Science in Personal and Social Perspectives Content Standard F Grades 9–12: Natural and human-induced hazards	History and Nature of Science Content Standard G Grades 9–12: Historical perspectives
1. What Is Fire Made Of?		C	C			X				
2. What Is Smoke Made Of?		C	C			X			X	
3. What Substances Burn Under Water?		C	C			X				
4. How Do Fire Extinguishers Stop Fires?		C	C			X	X	X	X	
5. Why Does Dynamite Explode?		C	C	X	X					
6. Why Does Hydrogen Peroxide Fizz on a Cut?			C			C		X		
7. How Do Soap and Shampoo Make Me Clean?		C		C				X	X	
8. What Does Hand Sanitizer Do That Soap Doesn't?		C						X		
9. How Does Antiperspirant Stop Me from Sweating?		C	C				X	X		
10. What Does Moisturizer Do to My Skin?		C	C				X	X		
11. How Does Sunless Tanning Work?		C	C				X	X	X	
12. How Do Teeth Whiteners Whiten Teeth?		C	C				X	X	X	
13. Where Do Artificial Flavors Come From?		C					X	X	X	

(continued)

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14. Why Do Pop Rocks® Pop?		C	C				X			
15. What Is MSG?		C						X	X	X
16. Why Doesn't Chewing Gum Dissolve When I Chew It?		C								X
17. How Do Drain Cleaners Remove Clogs?		C	C			X			X	
18. Why Is There an Expiration Date on Bottled Water?		C				C	X	X		
19. Why Do Some Plastics Glow in the Dark?	C	X				C				
20. How Does Glue Hold Things Together?		C					X			
21. How Does All That Air Get into a Can of Keyboard Duster?		C			C		X	X		
22. How Do Scratch-and-Sniff Stickers Have Smells?		C					X			
23. Why Are There Packets of Silica Gel in the Electronics I Buy?		C	C				X	X		
24. Why Is the Statue of Liberty Green If It's Made from Copper?		C	C							
25. How Is Something Decaffeinated?		C	C							

National Research Council. *National Science Education Standards*. Washington, DC: National Academy Press, 1996.

National Research Council. "National Science Education Standards."
<http://books.nap.edu/readingroom/books/nses/6e.html#csa912>.

1. What Is Fire Made Of?

Topics

states of matter, fire triangle, ignition temperature

Goal

To explain the components that make up fire and to differentiate between the nature of the reaction and the physical materials that are present during the reaction

Context

When students are learning to separate materials into groups such as solids, liquids, gases, and plasmas, but before they learn about groups such as mixtures, colloids, suspensions, and so forth, they are curious about materials that seem to fit into more than one group, such as fire or gelatin.

Teaching Notes

- Ask students to guess all of the things that are present in a fire. Try to get them to think about the process of burning and the physical appearance of the fire.
- Have students compare the various types of fires they have seen. Ask them how a propane fire, such as in a gas grill or stove, is different from or similar to a candle flame or a forest fire.

- Ask students to explain what they think makes up the parts of a fire. In a campfire, for instance, would they include the light, the heat, the smoke, the wood at the bottom, and the orange and yellow flames?

Extension Activity

Show students a burning match and a burning candle. Let a small piece of paper burn in a beaker if you have proper ventilation to evacuate the smoke. Ask students to name all of the things they see as different parts of the fires that they observed.

Answer Key



1. What Is Fire Made Of?

Explanation

In every science class, the question is asked sooner or later—is fire solid, liquid, gas, or plasma? There are a couple ways to answer this question. The first is that fire is a chemical reaction and isn't made of anything. This answer, however, avoids the spirit of the question, which is more about the materials we see in and around a fire. The majority of the common fires that we see, such as from wood or paper burning, are made up of hot gases and tiny solid particles that are so hot they glow. The kind of materials found in a flame can be solid, gas, and plasma. Some research suggests that some flames, such as candle flames, contain microscopic drops of liquid that are moved about by currents in the fire.

The fire triangle is made up of three components: fuel, oxygen, and heat. Fuel can be any material that will burn in the presence of oxygen, such as wood, gasoline, or dry grass. Oxygen makes up about 20% of Earth's atmosphere and is necessary for a material to burn. Cutting off the supply of oxygen is one of the main ways of extinguishing a fire. The third component, heat, is often supplied by a source that is already quite hot, such as an open flame, or from a source that can produce heat from friction, such as a lighter or a match.

Generally, a heat source comes in contact with the fuel in the presence of oxygen, and a self-sustaining chemical reaction occurs. As long as fuel and oxygen are present, the fire continues. Fires are exothermic, which means they give off heat. As fires give off heat, it is possible for enough heat to escape to allow the materials involved to go below the ignition temperature, which is the temperature the fuel needs to reach before it will ignite. If the temperature of the materials in the fire drops below this point, the fire will go out.

assessment page

1. What Is Fire Made Of?

Circle the letter of the best answer.

1. Fire _____.
 - a. is a chemical reaction
 - b. requires only fuel
 - c. does not need oxygen
 - d. occurs in the absence of heat

2. Fires may be made out of _____.
 - a. solids
 - b. gases
 - c. plasmas
 - d. all of the above

3. The fire triangle _____.
 - a. consists of fuel, oxygen, and light
 - b. consists of fuel, oxygen, and heat
 - c. consists of plasma, gases, and solids
 - d. consists of fire, air, and wood

4. Fuel _____.
 - a. is not part of the fire triangle
 - b. can be in the form of heat
 - c. is any substance that will burn in the presence of oxygen
 - d. is any substance that will not burn in the presence of oxygen

5. Oxygen _____.
 - a. makes up about 25% of Earth's atmosphere
 - b. makes up about 20% of Earth's atmosphere
 - c. can support a fire without the presence of heat
 - d. is not part of the fire triangle

(continued)

assessment page

1. What Is Fire Made Of?

6. Heat _____.
- is part of the fire triangle
 - is not part of the fire triangle
 - is never found in a fire
 - is a chemical found in all fires
7. Exothermic reactions _____.
- absorb heat from their surroundings
 - do not involve heat
 - cause fires to go out
 - give off heat as a product
8. Ignition temperature _____.
- is the highest temperature a fire can reach
 - is the temperature at which oxygen is created in a fire
 - is the temperature below which a fire will go out
 - is the temperature at which a fire turns from orange to blue
9. Fire often has _____.
- a large amount of liquid in it
 - tiny solid particles that are so hot they glow
 - very low-temperature solids
 - ice crystals that form and melt
10. A fire can be extinguished by _____.
- adding more heat
 - adding more fuel
 - cutting off the supply of nitrogen
 - cutting off the supply of oxygen

8. What Does Hand Sanitizer Do That Soap Doesn't?

Topics

chemical reactions, biochemistry, safety

Goal

To describe the mechanism that hand sanitizer uses to clean hands and to clarify how that method is different from using soap and water

Context

Students see hand sanitizer and do not completely understand when it is appropriate to use it. They also are being told more often by people on television and teachers in their health classes to use it to protect themselves from catching colds. Understanding how it works and what it is designed to do can make them safer.

Teaching Notes

- Ask students to name any hand sanitizer brands they can think of and ask if they know what the difference is between the various brands.
- Ask students to describe how hand sanitizers “clean” your hands. They may know there is some alcohol in the sanitizers, but will probably not know how it does its job.

- Invite students to share some of the situations in which they have used hand sanitizers. After the lesson, be sure to call attention to the situations in which the hand sanitizers were effective as well as those in which the use of hand sanitizers was not effective.

Extension Activity

Find out the ingredients from a few of the leading brands of hand sanitizer and share them with students. Have students research the nature of the chemicals used and what properties they have.

Answer Key

- | | |
|--------------|-----------------------|
| 1. Alcohol | 6. Soap |
| 2. Glycerin | 7. Lotion |
| 3. Perfume | 8. Skin irritants |
| 4. Cellulose | 9. Oil |
| 5. Water | 10. Proprietary blend |

8. What Does Hand Sanitizer Do That Soap Doesn't?

Explanation

In general, soap is able to speed the dissolving process for dirt. It also has the ability to chemically remove oils from surfaces and then carry those oils away with rinse water. Hand sanitizers, also called *alcohol gels*, are designed to allow people to clean their hands of germs when they don't have access to soap and water. The alcohol in hand sanitizer breaks down the cell walls of germs, which causes the germs to die. The germs are then shed from hands along with dead skin cells or are washed off when the hands are washed with soap and water. Standard hand sanitizers usually contain 60% alcohol or higher to be effective. When the amount is too high (between 90% and 100%), the lack of water can actually impair the effectiveness and prevent the sanitizer from doing its job.

The alcohols in hand sanitizers are there to kill bacteria and viruses. However, not all of the bacteria and viruses are killed by the standard alcohols that are used. Most hand sanitizers use ethanol (C_2H_5OH) or isopropanol (C_3H_7OH). These are effective at killing a wide variety of, but not all, germs and viruses. In addition, hand sanitizers generally do not dissolve dirt. They are not recommended for use when there is visible dirt on the surface of the hands. (However, the hand sanitizer may still give some protection against germs in such a situation.) Hand sanitizers are also made less effective by the presence of certain kinds of oils, fats, and proteins. One common combination of fats and proteins that resists the sterilizing power of alcohol gels is raw meat. Raw hamburger, chicken, pork, turkey, steak, and a number of other meats all limit the effectiveness of the alcohols in hand sanitizers. Therefore, hand sanitizers are unable to kill a significant amount of the germs. This means that using hand sanitizers to clean one's hands while preparing food is neither safe nor effective.

assessment page

8. What Does Hand Sanitizer Do That Soap Doesn't?

Complete each sentence by writing the missing word or words on the line.

1. In general, soap is able to speed the _____ process for dirt.
2. Soap has the ability to remove oils from _____.
3. Hand sanitizers allow people to clean _____ from their hands when they don't have access to soap and water.
4. Hand sanitizers break down the _____ of germs.
5. Hand sanitizers generally need to have an alcohol content of at least _____.
6. Alcohol contents higher than _____ can limit the effectiveness of hand sanitizers.
7. Hand sanitizers generally contain either isopropanol or _____.
8. Oils and _____ may reduce the effectiveness of hand sanitizers.
9. In general, hand sanitizers don't dissolve _____.
10. Cleaning your hands with hand sanitizer isn't safe or effective when _____.

20. How Does Glue Hold Things Together?

Topics

adhesion, cohesion, van der Waals forces

Goal

To clarify the behavior of glues at the molecular level

Context

Students have access to a wide variety of adhesives and glues, as well as to materials such as tape and epoxy. Each of these uses a combination of properties to hold materials together, and those chemical and physical properties are found throughout chemistry.

Teaching Notes

- Discuss with students the concepts of cohesion and adhesion and how they are different.
- Ask students to list as many things as they can think of that are used to stick things together, such as glue, tape, and so forth.
- Clarify what van der Waals forces are, and how they cause attraction between molecules. Explain how these polar molecules behave.

Extension Activity

Supply students with a wide variety of glues to glue together some simple objects such as pennies or pieces of wood. Test the objects to see how hard they are to get apart or if it is even possible without damaging the objects.

Answer Key

1. Adhesion
2. Cohesion
3. Van der Waals forces
4. Hydrogen bonding
5. Dipole-dipole interactions
6. London dispersion forces
7. Ionic bonding
8. Covalent bonding
9. Metallic bonding
10. Hydrophobic interactions

20. How Does Glue Hold Things Together?

Explanation

There are a number of factors that allow glue to do its job. However, scientists are still discovering new factors that determine how well a glue holds two surfaces together. Glues are more generally known as adhesives because they experience adhesion. Adhesion is the property of a material that allows its molecules to be attracted to the molecules of a different material. It is similar to cohesion, which is the property of a material that allows the molecules of the material to be attracted to themselves. For example, grease has lots of adhesion, which means it sticks to everything. But grease also has poor cohesion, meaning that it does not stick to itself in a manner that holds it together very strongly.

Good glue will have both high adhesion and high cohesion. Many types of glue have good adhesion and cohesion because of van der Waals forces. Van der Waals forces are the attraction experienced between two polar molecules. A polar molecule is one that has a positively charged end and a negatively charged end. The opposite charges attract, so the positive end of one molecule is attracted to the negative end of another molecule. For adhesion to work, the surfaces must be in extremely close contact with each other. This is why most glues are wet. The moisture in the glue allows it to spread thinly so that it contacts as much of the surface as possible. This also reduces the need for cohesion in the glue itself.

The second major factor in the way that glue sticks surfaces together is the physical interlocking of the surfaces involved. Almost any surface you see, no matter how smooth, is full of bumps, holes, and jagged edges at the microscopic level. This is another reason why many types of glue are liquids. Glue works itself into these irregular surfaces and then dries. This allows the nooks and crannies to be filled with solid glue, which holds the surfaces together.

20. How Does Glue Hold Things Together?

Complete each sentence by writing the missing word or words on the line.

1. Glues are more generally know as _____.
2. Adhesion is the property of a material that allows its _____ to be attracted to the molecules of a different material.
3. Cohesion is the property of a material that allows the molecules of the material to be attracted to _____.
4. Grease makes a bad glue because it sticks to _____ better than it sticks to itself.
5. Glues have high adhesion and high _____.
6. Van der Waals forces are the attraction experienced between two _____ molecules.
7. _____ in a glue allows the glue to spread thinly so that it contacts as much of a surface as possible.
8. One major factor in the way that glue sticks surfaces together is the physical _____ of the surfaces involved.
9. A polar molecule is one that has a negatively charged end and a _____ charged end.
10. Most surfaces are full of bumps, holes, and jagged edges at the _____ level.

25. How Is Something Decaffeinated?

Topics

chemical reactions, pressure, temperature

Goal

To describe the processes used to remove caffeine from beverages that traditionally contain caffeine

Context

Students have a wide variety of drinks to choose from that contain caffeine. Coffee, soda, lattes, iced-coffee drinks, and so forth all contain caffeine, and there's certainly a lot of debate over the long-term effects of consuming too much caffeine. The alternatives may have less caffeine, but what other chemicals might they pick up from the decaffeination process?

Teaching Notes

- Ask students for the names of beverages that have reduced caffeine or are caffeine-free versions of drinks that traditionally contain caffeine. Ask them why they think these drinks are offered with less or no caffeine.
- Discuss with students the use of caffeine and when and why a person would want a drink that did not contain caffeine.

- Explain the idea that a supercritical fluid can be used to spread like a gas throughout a group of coffee beans that are being decaffeinated while still dissolving caffeine like a liquid.

Extension Activity

Have students research advances in genetic engineering that are leading to the production of coffee beans and tea leaves that do not contain caffeine.

Answer Key



25. How Is Something Decaffeinated?

Explanation

Caffeine ($C_8H_{10}N_4O_2$) is a chemical that acts as a mild stimulant in the human body. Caffeine is naturally occurring and can be found in a wide variety of plants, such as coffee beans and leaves, tea leaves, cocoa beans, kola nuts, and guarana berries. In many of the plants caffeine is present, it is used as a natural pesticide. Products made from these plants have different amounts of caffeine in them, depending on the nature of the plant. For example, some kinds of coffee beans, such as those used to make espresso, have very high levels of caffeine. Cocoa beans, on the other hand, have a smaller amount of caffeine.

There are a number of processes for removing caffeine. One of the first methods was invented by a German coffee merchant named Ludwig Roselius. His process involved soaking coffee beans in salt water, steaming them with another saltwater solution, and then washing them with benzene. This process removed about 97% of the caffeine and was used for many years. Unfortunately, research eventually revealed that benzene is a strong carcinogen, and the process was abandoned.

There are many common methods of decaffeination that are used today. Water extraction and carbon dioxide (CO_2) extraction are two basic techniques. In water extraction, beans are soaked to remove both flavor and caffeine. The caffeine is removed by a carbon filter. Then a second batch of beans is soaked in the same water (now flavored with natural coffee-flavor chemicals). Caffeine, but not flavor, comes out of the second batch. The beans are then 99.9% caffeine-free.

In the second method, CO_2 extraction, coffee beans are soaked and then exposed to CO_2 at very high pressures. At these high pressures, the CO_2 spreads across the beans like a gas, but dissolves caffeine like a liquid. The CO_2 is removed, and the beans are 97% caffeine-free or better.

Many other products that are caffeine-free have simply never had caffeine added to them artificially. Scientists are also using genetic engineering to try and create plants such as coffee beans and tea leaves that don't have caffeine in them to start with, but still have the same flavors that people enjoy.

assessment page

25. How Is Something Decaffeinated?

Circle the letter of the best choice to complete each sentence.

- Caffeine has a chemical formula of _____.
 - $C_7H_{10}N_4O_2$
 - $C_8H_{10}N_4O_2$
 - $C_9H_{10}N_4O_2$
 - $C_8H_{11}N_4O_3$
- In plants, caffeine is used as a natural _____.
 - pesticide
 - herbicide
 - fertilizer
 - perfume
- The Roselius method of decaffeination involved soaking coffee beans in _____.
 - sulfuric acid
 - hydrochloric acid
 - soap
 - salt water
- The Roselius method of decaffeination removed about _____ of the caffeine from coffee beans.
 - 25%
 - 7%
 - 97%
 - 89%
- _____, used in the Roselius method of decaffeination, was found to be a strong carcinogen.
 - Salt water
 - Steam
 - Benzene
 - Aluminum chlorohydrate

assessment page**25. How Is Something Decaffeinated?**

6. In the water extraction method, caffeine is removed by a _____ filter.
- carbon
 - zinc
 - phosphorus
 - sodium
7. Using water extraction, coffee beans can be made _____ caffeine-free.
- 49.9%
 - 69.9%
 - 89.9%
 - 99.9%
8. Using the CO₂ extraction method, coffee beans can be made 97% caffeine-free using _____ CO₂.
- low-pressure
 - high-pressure
 - liquid
 - solid
9. The food that does not contain caffeine is _____.
- coffee
 - tea
 - cocoa
 - apples
10. Scientists are beginning to research how to make caffeine-free plants through _____.
- applying fertilizers
 - genetic engineering
 - applying pesticides
 - mechanical engineering