



**December 2018/January 2019**

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**Teacher’s Guide**



**Teacher's Guide for**

# “What’s Artificial Snow, and How is it Made?”

**December 2018/January 2019**

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### Tools and Resources

### Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Phase changes/Freezing** | The article focuses on the phase change of freezing liquid water into solid snow, and how it occurs both naturally in the environment and artificially through the use of snow guns and nucleators. |
| **Nucleation sites** | The formation of raindrops and snowflakes in clouds is enhanced when nucleation sites are present, and the article discusses this concept while providing examples of nucleation materials. |
| **Surface tension** | Reducing the surface tension in water droplets allows artificial snow to be produced more effectively as explained in the article, and the mechanism of surfactants in removing greasy stains is described. Also, the beading of water as included in the article is a function of surface tension. |
| **Surfactant** | The use of surfactants to reduce the high surface tension of water and produce smaller (atomized) droplets is an important point in this article. |
| **Polar molecules** | The polar nature of water molecules and the essentially nonpolar nature of greasy molecules causes consumers to need surfactants in the form of soaps and detergents, as explained with diagrams in this article. |

### Standards and Vocabulary

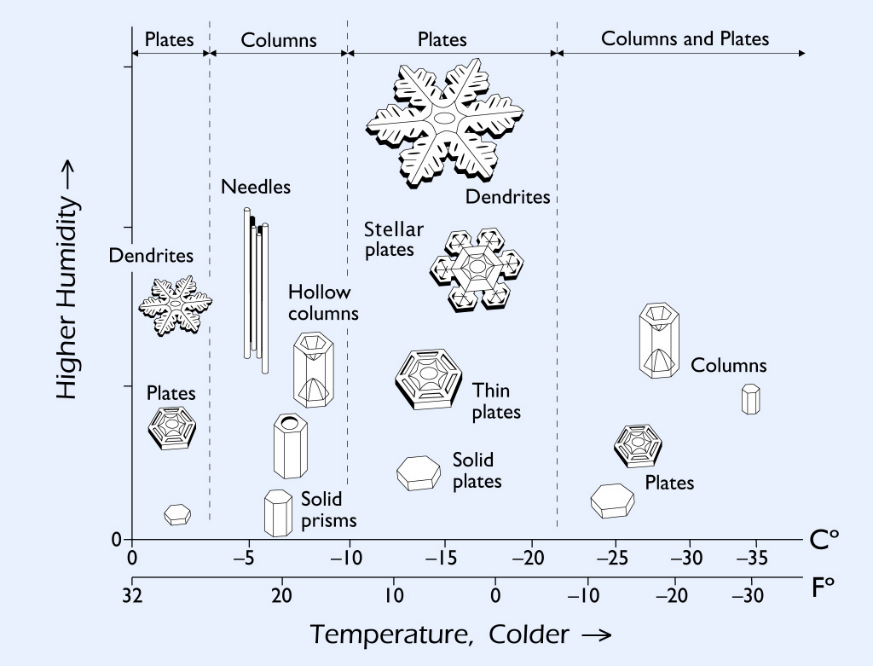
#### Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F:** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E:** Provide a concluding statement or section that follows from or supports the argument presented.

#### Vocabulary

* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Structural formulas
  + Crystalline structure
  + Environmental impacts of personal and societal decisions
  + Electromagnetic radiation
  + Colligative properties
  + Gas laws
* Consider asking students to read “Open for Discussion: A Slippery Slope” on page 4 to learn about concerns regarding using artificial snow prior to reading the article “What’s Artificial Snow, and How Is It Made?”
* Students from warmer climates may be unaware of the use of salt to melt ice on roadways. Ask them if they have ever traveled to cold climates and if they had trouble walking on icy sidewalks, or if they have seen this problem in movies or television. Show students the ACS Reactions video referenced on page 14 AFTER they have read the article to help them understand why salt is used to deice roads and how it works.
* Two of the articles relate to personal health (UV eye protection and cupping). Ask students how the articles might impact their decisions regarding their health and why.
* Two of the articles relate to environmental impacts of our decisions (artificial snow and salting roads). Ask students how the information from the articles might help them make decisions in the future, and factors they might consider as citizens asked to provide input on related projects.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles, and what they would like to explore further.
* Ask students if they have questions about some of the issues discussed in the articles.

### Possible Student Misconceptions

1. **“Artificial snow is the same as natural snow because they are both frozen water.”** While they are similar, artificial and natural snow have some minor differences. Natural snow typically forms larger, lighter flakes, while artificial snow is usually smaller, heavier crystals. Because artificial snow is denser, it tends to compact less than natural (powdery) snow. And, even though artificial snow can last longer than natural snow, skiing and snowboarding equipment may tend to “catch” more on the artificial snow, causing more falls.
2. **“All snowflakes have six points.”** While all snowflakes have six sides, they do not all have six points. Six-pointed snowflakes are common; however, there are many different types of snowflakes. The six-pointed snowflakes are called stellar dendrites, but there are also columnar, needle, graupel (soft hail), and other types, all containing six sides. While the basic ice crystal or snowflake shape is hexagonal, there are many variations on the hexagonal shape based on weather conditions.

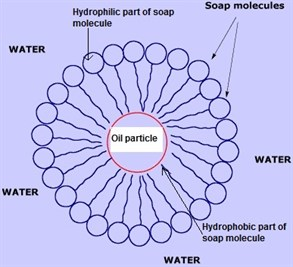
([*http://web.ipac.caltech.edu/staff/bts/PH\_10\_2007/libbrecht/rpp5\_4\_R03-1.pdf*](http://web.ipac.caltech.edu/staff/bts/PH_10_2007/libbrecht/rpp5_4_R03-1.pdf))

1. **“Cloud seeding reduces natural precipitation downwind of the seeded area.”** Clouds do not have a finite quantity of water vapor in them. If they did, this statement would be true. However, clouds continually absorb water vapor from the air, which allows them to produce precipitation downwind of the cloud-seeded area. Sometimes, the seeding produces additional precipitation downwind.

### Anticipating Student Questions

1. **“Why do snowflakes need a nucleator to form?”** The science of snowflake formation is not entirely understood. In warmer clouds, it appears that an ice nucleus formed around a nucleator must be present for the water vapor to freeze and allow the snowflake to successfully grow. Some experiments indicate that in order for water vapor to freeze (without a nucleator), the cloud temperatures must be below –35 °C (–31 °F). So, the nucleation site seems to facilitate snowflake formation at relatively higher temperatures. A related example might be making rock candy (crystalized sugar). When a stick or string with a textured surface is placed in a supersaturated solution of sugar, the sugar crystals form more readily on the textured surface than if no nucleation sites were present. Scientists often use a “seed crystal” or a technique like scratching the walls of a glass container to help initiate crystallization in a solution.
2. **“How do surfactants work?”** Surfactants, or surface-active agents, are compounds having both a hydrophilic (polar) end and a hydrophobic (nonpolar) end, making them amphiphilic (having both polar and nonpolar groups within the molecule). Common surfactants include detergents, emulsifiers, wetting agents, and foaming agents. Because water is a polar molecule, the hydrophilic end of the surfactant can interact with it, while the hydrophobic end of the surfactant can interact with the oily, greasy, or nonpolar substance. The interaction of the water, grease, and the surfactant forms structures called micelles (see diagram at right), where the nonpolar tails of the surfactant molecules embed into the grease and the polar heads form a hydrophilic layer around the grease. The micelle structures can then be carried away by the water.

*(*[*http://www.planet-science.com/categories/under-11s/chemistry-chaos/2011/06/soap---how-does-it-get-things-clean.aspx*](http://www.planet-science.com/categories/under-11s/chemistry-chaos/2011/06/soap---how-does-it-get-things-clean.aspx)*)*



In the case of artificial snow, the surfactants act to reduce the surface tension of water, allowing the water to break into much smaller droplets that can freeze more easily and produce a finer-textured snow.

1. **“Is it true that no two snowflakes are alike?”** In short, this statement is true. Snowflakes are hexagonally shaped, but their individual shapes are quite complex and contain an average of 1018 water molecules. If you could look at every snowflake, you would probably not find any duplicates. However, nano-snowflakes that are extremely small-—only 10 water molecules or so—are likely to have similar shapes. But since we cannot see these nano-snowflakes with the naked eye, and you are unlikely to encounter one, the statement is essentially true.
2. **“How does cloud seeding work?”** Even in regions where there is low humidity, there are usually clouds or some atmospheric moisture. Cloud seeding attempts to facilitate the collection of that water vapor around a particle or nucleation point. The seeding material can be various salts—including sodium chloride (table salt) and calcium chloride (road salt). However, the most common salt used is silver iodide (AgI), because its structure is similar to natural ice crystals. There are three types of cloud-seeding methods: static, where the nucleation material provides a place for condensation to occur; dynamic, where scientists try to increase vertical air currents and improve the quantity of moisture in the clouds; and hygroscopic, where moisture-attracting salts are shot into lower parts of clouds and collect water as they fall back down.
3. **“What is a hygroscopic material?”** A hygroscopic material is one that absorbs or adsorbs moisture from its surroundings. This process generally occurs at or near room temperature.

Examples of hygroscopic materials are some salts, including silver iodide and sodium chloride, as well as honey, silica gel (those moisture-absorbent packets often found in packages), ethanol, sulfuric acid, and sodium hydroxide (lye). Both sulfuric acid and sodium hydroxide are used industrially as drying agents to remove moisture, due to their high hygroscopicity. When water vapor is collected by a hygroscopic material, the water causes physical changes to that material, including an increase in volume, color, boiling point, and viscosity. The hygroscopic nature of ethanol that is added to many gasolines can cause moisture to collect in the fuel, causing problems with small engines and some machines (corroding parts, clogging filters, etc.).

1. **“What is the history of making artificial snow?”** While people have probably skied for a few thousand years, the desire for reliable snow—and a way to make it—didn’t take hold until the early 1900s, when skiing became more popular as a sport. The earliest snow machines were noisy, unreliable, and produced poor-quality snow. In many cases, the artificial snow was nothing more than essentially chipped blocks of ice spread or sprayed over the slopes or ski jumps. Improvements in equipment design in the 1940s and 1950s included the use of compressed air to force small water droplets through a nozzle and produce better-quality artificial snow. This improvement was effective enough that many resorts started using machines to augment natural snow. By the 1970s, as skiing continued to attract more enthusiasts, the demand for a longer season increased, and skiers expected better quality and quantity of snow, all snow machines used compressed air to atomize the water into fine droplets, added a fan to disperse the artificial snow, improved nozzle designs, and were engineered to operate more economically. In 1975, a protein nucleator was discovered that then became the trademarked artificial snow Snomax. As the popularity of skiing increased, and the need for large quantities of reliable snow for resorts grew, the snow-making machinery was improved. Computer controls, sensors, more powerful fans, better atomization of the water droplets, and other changes were made to allow resorts to lengthen their winter sports season and improve snow conditions.
2. **“How is snow created on movie sets and for other special effects?”**The Hiolski article mentions that faux snow is often a paper-based material. The cellulose paper snow can be produced in many different textures, sizes, and solubilities. The paper snow is usually sprayed on surfaces and may be dampened to make it stick to surfaces better. Snow can also be produced from foams, similar to some types of soap bubbles. The quickly dissipating foam snow is preferred for uses when the snow effect is needed in the air more than on the ground or when the faux snow might present a safety problem, such as for dancers on a stage. Other faux snow can be produced from polymer substances similar to the sodium polyacrylate used as moisture absorbers in baby diapers. Still more special effects types of snow used by professionals includes those made of rice starch, potato flakes, Epsom salts, cotton, and a variety of plastics and foams.

### Activities

**Labs and demos**

**“Solubility and Compound Type” lab:** This high school lab activity uses unknown substances to determine whether they are polar, nonpolar, or ionic by testing solubility and explaining the results based upon intermolecular and intramolecular forces. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/solubility-and-compound-type>)

**“Hands-on Activity: Soap vs. Shampoo Surfactant Lab”:** This high school lab activity requires 90 minutes over at least two days to make soap (unless purchased commercially), which students then compare to shampoo as they study surface tension, viscosity, ion interactions, and pH. Complete student and teacher support materials are included. (<https://www.teachengineering.org/activities/view/usm_surfactant_activity1>)

**Simulations**

“**Surface Tension: Capillary Rise Method”:** Students can manipulate this simulated lab to measure and then calculate the surface tension of seven liquids. The simulation provides operation guidelines and comprehensive, mathematical background information on surface tension. (<http://web.mst.edu/~gbert/SurfaceTension/cap.html>)

**“Molecular Polarity” (PhET):** This simulation allows students to explore the chemistry (including polarity, electronegativity, bonding, and diploes) behind the surfactants sidebar in the Hiolski article. (<https://phet.colorado.edu/en/simulation/legacy/molecule-polarity>)

**Media**

**“How Is Artificial Snow Made?”, video (2:20):** This video from ACS Reactions explains how artificial snow was made for the 2014 Winter Olympics at Sochi and provides a quick explanation of producing artificial snow. (<https://www.youtube.com/watch?v=ftMFMlk6FlA>)

**“The Science of Snowflakes”, video (5:59):** This PBS video starts with Wilson Bentley taking snowflake photographs starting in 1885, documenting the variety of flakes, and continues with the laws of chemistry and physics controlling the shapes of snowflakes. (<https://www.youtube.com/watch?v=fUot7XSX8uA>)

**Lessons and lesson plans**

**“Modeling the Melting of Ice” lesson:** This lesson plan (with complete teacher and student materials) requires 120–180 minutes to complete, depending on teacher choices, and it uses modeling techniques for students to create particulate-level diagrams of ice melting and explains the kinetic and potential energy changes in this phase change. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/modeling-the-melting-of-ice>)

**“Snowflake Webquest” lesson:** This lesson uses the Internet and the SnowCrystals.com Web site to pretest and then directs students to research and complete the worksheet to learn about types of snowflakes, their formation, their structures, and more. (<https://sciencespot.net/Media/SnowflakeWebquest.pdf>)

**Projects and extension activities**

**Use Clues to Solve an Ice Mystery” activity:** While targeted at grades 6–8, this activity analyzing the characteristics of different types of ice and their locations could be interesting to some students. The site also provides audio, video, and additional resources to related concepts in the activity. (<https://www.sciencefriday.com/educational-resources/use-clues-to-solve-an-ice-mystery/>)

**“Preserving Snow Crystals” lab project:** For students in snowy locations, this Web site provides information on three processes for capturing and preserving snowflakes; one process uses superglue, another uses Formvar (polyvinyl acetal resin), and the last uses acrylic spray paint. [(https://www.its.caltech.edu/~atomic/snowcrystals/preserve/preserve.htm](file:///C:\Users\Steve\Downloads\(https:\www.its.caltech.edu\~atomic\snowcrystals\preserve\preserve.htm))

### References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles published from the magazine’s inception in October 1983 through April 2013; all**

**available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [***http://www.acs.org/chemmatters***](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get 30 Years of *ChemMatters* Magazine!” (the icon on the right of the screen).**

**Selected articles and the complete set of Teacher’s Guides for all issues from the past three years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



“Artificial Snow: Powder for the Slopes” explains the science, manufacture, characteristics, and uses of artificial snow, making this article an excellent companion to the Hiolski article. (Rohrig, B. Artificial Snow: Powder for the Slopes. *ChemMatters*. 2000, *18* (4), pp 10–11)

“Clouds” provides information about types, formation, and properties of clouds, including formation of snow and cloud seeding. (Rosenthal, A. Clouds. *ChemMatters*. 2003, *21* (3), pp 12–15)

The Science of Snowflakes: Crystals from the Clouds” contains relevant material to the Hiolski article because it discusses snowflake formation, types, and chemistry. (Hazard, A. The Science of Snowflakes: Crystals from the Clouds. *ChemMatters*. 2009, *27* (4), pp 9–10)

“Battling Wildfires: When Water Won’t Cut It” contains an explanation of surface tension and surfactants, plus an illustration about how surfactants lower surface tension. (Karabin, S. Battling Wildfires: When Water Won’t Cut It. *ChemMatters*. 2010, *28* (1), pp 10–12)

The Teacher’s Guide for Karabin’s article above includes more information on surface tension, as well as activities involving surface tension, including floating a needle on water, black pepper on water with detergent added, and playing with magic sand.

### Web Resources for More Information

**Artificial snow**

The 2018 Winter Olympics events in PyeongChang used 90–98% artificial snow.

(<https://www.npr.org/sections/thetorch/2018/02/23/588308424/despite-frigid-weather-the-snow-in-pyeongchang-is-fake>)

This article contains information on the science of artificial snow, including machine-made snow, additives, sustainability, and additional references.

(<https://www.chemistryviews.org/details/ezine/8935791/Faking_It_The_Science_of_Artificial_Snow.html>)

**History of Artificial snowmaking**

This is a chronology of events involving artificial snow in Canada and the U.S.

(<http://newenglandskimuseum.org/wp-content/uploads/2012/06/snowmaking_timeline.pdf>)

**Snowflakes**

This website has information about snowflakes and an infographic about snowflake shapes.

(<https://www.compoundchem.com/2014/12/10/snowflakes/>)

This website is a rich resource with information (and additional links) on: Natural Snowflakes, Designer Snowflakes, Growing Snowflakes, Snowflake Science, and Snow and Ice Activities.

(<http://snowcrystals.com/>)

**Artificial vs natural snow**

This article looks at the differences between artificial and natural snow with respect to skiing and snowboarding.

(<https://charlikerns.wordpress.com/2012/02/04/is-natural-snow-better-than-man-made-for-skiing-and-snowboarding/>)

**2022 Beijing Winter Olympics**

With Beijing’s minimal annual snowfall, this article explains why the Winter Olympics held there, and likely future sites, will feature artificial snow.

(<https://qz.com/1213121/beijing-2022-winter-olympics-will-rely-entirely-on-artificial-snow/>)

**Special effects artificial snow**

This article details the use of artificial snow in seven movies by title and year beginning with *The Gold Rush* in 1925 through *The Day After Tomorrow* in 2004.

(<https://www.popularmechanics.com/culture/movies/g1092/snow-job-how-hollywood-fakes-winter-on-film/>)

This video, “How It’s Made – 1193 Special Effects Snow” (4:53), explains how artificial snow is made on a film set using special soap bubbles.

(<https://www.youtube.com/watch?v=ZzjvLyBU_B4>)

**Nucleation**

Read about how common bacteria serve as nucleation sites in forming snow in this article.

(<http://berkeleysciencereview.com/bacteria-frosted-snow-flakes/>)

Both homogeneous and heterogeneous nucleation are briefly addressed in this in-depth article, “Formation and Growth of Ice Crystals”.

(<http://www.atmo.arizona.edu/students/courselinks/fall11/atmo551a/ATMO_451a_551a_files/ColdClouds.pdf>)

**Surface tension**

This site provides explanations, pictures, and examples of the surface tension of water.

(<http://hyperphysics.phy-astr.gsu.edu/hbase/surten.html>)

**Surfactants**

Great detail regarding surfactants including illustrations, manufacture, types (anionic and cationic), chemical structures, and uses are found in this article.

(<http://www.essentialchemicalindustry.org/materials-and-applications/surfactants.html>)

**Hygroscopy**

This article explains a hygroscopic material, differentiates it from the similar-sounding term hydroscopic, and provides additional information on hygroscopy.

(<https://www.thoughtco.com/definition-of-hygroscopic-605230>)

**Cloud seeding**

This article discusses the lure of cloud seeding and the challenges for western U.S. states.

(<https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2018/02/20/why-cloud-seeding-is-increasingly-attractive-to-the-thirsty-west>)

This article looks at cloud-seeding methods in China and other parts of the world along with its critics and supporters.

(<https://science.howstuffworks.com/nature/climate-weather/meteorologists/cloud-seeding.htm>)

### Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article, and then locate and analyze information from the article.

* **Anticipation Guide (p 16):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**What’s Artificial Snow, and How Is It Made?**

* Before reading, ask students where artificial snow might be needed. Also, ask students how they think real snow forms, and how that might be different from artificial snow.
* As they read the article, students should compare their original ideas to the information in the article.
* **Graphic Organizer (p 17):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (pp 18–19):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Anticipation Guide

**Directions: *Before reading***, in the first column, write “A” or “D” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Originally, large blocks of ice were pulverized to create fake snow. |
|  |  | 1. Snow guns used at ski resorts use water and pressurized air to make artificial snow. |
|  |  | 1. No Olympic Winter Games have ever used artificial snow. |
|  |  | 1. Snow guns at ski resorts can produce as much artificial snow as needed if the temperature is 0 °C or lower. |
|  |  | 1. Artificial snow and natural snow crystals look the same under a microscope. |
|  |  | 1. Nucleation sites are needed for natural snow to form. |
|  |  | 1. Ice crystals have a hexagonal structure. |
|  |  | 1. If a surfactant is added to reduce the surface tension of water, the water droplets freeze more slowly. |
|  |  | 1. Most snow made for movie and television sets is made from cornflakes painted white. |
|  |  | 1. Cloud seeding projects to make rain were introduced in the 1990s. |

### Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to compare the requirements and materials used for making artificial snow and natural snow.

|  |  |  |
| --- | --- | --- |
|  | **Artificial Snow** | **Natural Snow** |
| Materials needed |  |  |
| Air temperature required |  |  |
| Structure (drawings OK) |  |  |
| Nucleators |  |  |
| Surfactants |  | N/A |
| Cloud seeding |  |  |
| Artificial snow in films and TV |  | N/A |

**Summary:** On the back of this paper, write a short explanation (2–3 sentences) of how artificial snow might impact the environment, providing reasons supported by information in the article.

### Student Reading Comprehension Questions

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

* 1. List two reasons why ski resorts may use machines to make snow.
  2. Why is it predicted that the 2022 Winter Olympics in Beijing will need to rely almost entirely on artificial snowmaking?
  3. Under what temperature conditions can snow guns usually produce as much snow as is needed?
  4. (a) What is a nucleator and, (b) what are three materials that can serve as nucleation sites?
  5. What material is used in Snomax as a nucleating agent?
  6. How does the use of a surfactant in the Drift snowmaking additive help in making artificial snow?

**Student Reading Comprehension Questions, cont.**

* 1. What causes water to bead up on the surface of a greasy material?
  2. Explain how a surfactant works to allow water molecules to remove greasy stains.
  3. List seven materials that have been used, or are still used, as faux snow in movies or on television.
  4. (a) Define hygroscopic, and (b) give an example of a hygroscopic substance.

**Critical-Thinking Questions**

***Write your answers on another piece of paper if needed.***

* 1. While the article doesn’t explicitly state them, what problems with cloud seeding might be inferred?
  2. Research and evaluate the benefits and environmental impacts of ski resorts producing artificial snow.

### Answers to Reading Comprehension Questions

1. **List two reasons why ski resorts may use machines to make snow.**

Two reasons why ski resorts may use machine s to make snow are

1. to extend the ski season, and
2. to enhance existing natural snow.
3. **Why is it predicted that the 2022 Winter Olympics in Beijing will need to rely almost entirely on artificial snowmaking?**

The 2022 Winter Olympics in Beijing will need to rely almost entirely on artificial snowmaking because of that region’s minimal precipitation.

1. **Under what condition can snow guns usually produce as much snow as is needed?**

As long as the temperature remains below about –8 °C (18 °F) snow guns can generally produce as much snow as is needed.

1. **What is a nucleator, and (b) what are three materials that can serve as nucleation sites?**
2. A nucleator is a particle that serves as a scaffold to begin ice-crystal formation in snow.
3. Three materials that can serve as nucleation sites are
4. mineral dust,
5. clay particles, and
6. bacteria.
7. **What material is used in Snomax as a nucleating agent?**

Snomax uses *Pseudomonas syringae* bacteria as a nucleating agent.

1. **How does the use of a surfactant in the Drift snowmaking additive help in making artificial snow?**

The surfactant in Drift reduces the surface tension of the water sprayed out of the snow guns and helps the water droplets freeze more rapidly into artificial snow rather than clumping together.

1. **What causes water to bead up on the surface of a greasy material?**

Water beads up on the surface of a greasy material because the attractive forces inside water are greater than its attraction to the greasy surface.

1. **Explain how a surfactant allows water molecules to remove a greasy stain.**

Surfactants contain both polar and nonpolar components that interrupt the attraction among the polar water molecules. This allows the nonpolar grease molecules to integrate with the water and permits attractions between the polar water and the nonpolar grease. The nonpolar portions of the surfactant molecules surround the grease stain and the polar portion of the surfactant molecules attract to the polar water molecules, allowing the stain to rinse away.

1. **List seven materials that have been used, or are still used, as faux snow in movies or on television.**

Seven materials that have been used, or are still used, as faux snow in movies or on television are

1. cornflakes painted white,
2. firefighting foam,
3. instant potato flakes,
4. flour,
5. marble dust,
6. gypsum, and
7. paper.
8. **Define hygroscopic, and (b) give an example of a hygroscopic substance.**
9. A hygroscopic material is one that attracts and holds water vapor molecules.
10. An example of a hygroscopic substance is table salt, NaCl.

**Critical-Thinking Questions**

1. **While the article doesn’t explicitly state them, what problems with cloud seeding might be inferred?**

Problems with cloud seeding that might be inferred from the article could involve costs, including the seed material (AgI), equipment (aircraft), and labor; inconsistent and unpredictable results; possible pollution from using seeding materials; difficulty in measuring any positive results; complex atmospheric conditions; the effects of transferring potential rainfall from one region to a different one; and moral issues, such as whether people should manipulate the weather.

1. **Research and evaluate the benefits and possible negative environmental impacts of ski resorts producing artificial snow.**

The benefits could include

1. the extended skiing season for customers,
2. the more reliable skiing conditions for customers,
3. the safer skiing conditions for customers,
4. the control of the type of snow produced,
5. that artificial snow can last longer than natural snow,
6. that artificial snow may be preferred for some winter sports like snowboarding,
7. the job security for ski resort employees, and
8. the protection of businesses and investments in ski resorts and the associated hospitality industry around ski resorts.

The negative environmental impacts of artificial snow could include

1. the vast amounts of surface or ground water used to produce the snow (estimated to be about 75,000 gallons for six inches of snow over a 200 foot by 200 foot area),
2. the delayed melting in the spring affects plants and animals in the area,
3. the delayed snow melt flowing into lower elevations later in the season,
4. the noise from compressed air used in the snow guns,
5. the large amounts of energy required to produce the snow,
6. the introduction of minerals such as zinc, copper, and lead from water sources (including treated sewage water) onto the landscape,
7. the carbon dioxide emissions from the electric energy or the diesel fuel powering the machines, and
8. the cost, which ESPN reports that ski areas spend between $500,000 to over $3.5 million per season.

(<http://www.espn.com/action/freeskiing/story/_/id/8809682/cost-snowmaking>)



**Teacher's Guide for**

### “Rocking Shades in the Winter”

**December 2018/January 2019**

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## Tools and Resources

### Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Electromagnetic spectrum** | This article provides images and explanations of the electromagnetic spectrum, along with information on the wavelengths, frequencies, and energies of visible light and ultraviolet light. |
| **Ultraviolet radiation** | The primary focus of the article is explaining the deleterious effect of ultraviolet radiation on human eyes and how to effectively prevent that damage. |
| **Wavelength and frequency** | The article discusses the relationships among the wavelength, frequency, and energy of ultraviolet light and other electromagnetic radiations. |
| **Polarization** | The author explains, and provides an analogy of, polarization of light and discusses how preventing glare due to polarization is different from UV shielding. |
| **Polymers** | This article describes the polymer chemical commonly used in sunglasses to block UV rays and provides the chemical structure for polycarbonate. |
| **Reversible reactions** | The photochromic reaction of glasses that transition from clear to dark is a reversible chemical reaction that is explained (with chemical structures for naphthopyran) in a sidebar. |

### Standards and Vocabulary

#### Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F:** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E:** Provide a concluding statement or section that follows from or supports the argument presented.

#### Vocabulary

* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Structural formulas
  + Crystalline structure
  + Environmental impacts of personal and societal decisions
  + Electromagnetic radiation
  + Colligative properties
  + Gas laws
* Consider asking students to read “Open for Discussion: A Slippery Slope” on page 4 to learn about concerns regarding using artificial snow prior to reading the article “What’s Artificial Snow, and How Is It Made?”
* Students from warmer climates may be unaware of the use of salt to melt ice on roadways. Ask them if they have ever traveled to cold climates and if they had trouble walking on icy sidewalks, or if they have seen this problem in movies or television. Show students the ACS Reactions video referenced on page 14 AFTER they have read the article to help them understand why salt is used to deice roads and how it works.
* Two of the articles relate to personal health (UV eye protection and cupping). Ask students how the articles might impact their decisions regarding their health and why.
* Two of the articles relate to environmental impacts of our decisions (artificial snow and salting roads). Ask students how the information from the articles might help them make decisions in the future, and factors they might consider as citizens asked to provide input on related projects.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles, and what they would like to explore further.
* Ask students if they have questions about some of the issues discussed in the articles.

### Possible Student Misconceptions

1. **“Expensive sunglasses provide better protection than cheap ones.”** Price is not a good predictor of sunglass quality or effectiveness. Even inexpensive sunglasses can offer good eye protection. The most important criteria include both checking the label to assure that the glasses block 100% of ultraviolet radiation—both UVA and UVB—and assuring the glasses fit well and completely shield your eyes.
2. **“Sunglasses that eliminate glare also stop UV rays.”** Not true! Polarized glasses block glare (as explained in the article). Glare improves your vision by reducing the amount of light reaching the eye and improving contrast. However, unless the polarized glasses are also designed to block UV rays, the light that reaches your eyes can still cause eye damage. Good sunglasses have both UV protection and polarization.
3. **“Sunglasses are only needed in the hot summer.”** As the article explains, exposing your eyes to UV rays can cause serious injury—regardless of the time of year or location. The UV rays bouncing off snow, water, or other reflective surfaces can all cause the same damage to the eyes. In addition, at higher altitudes the thinner atmosphere is less effective at blocking UV rays. So, cold winter snow sports in the mountains may expose your eyes to more UV rays than other activities in the hot summer.
4. **“Children don’t need sunglasses.”** Typically, children and teens spend more time (perhaps up to three times as much) outdoors in the sun than many adults. Research indicates that significant eye damage can occur before the age of 18. Also, children’s eyes don’t filter UV rays as well as adults’ eyes. So, everyone—children, teens, and adults—should wear sunglasses every time they are outside.
5. **“Sunglasses are not normally needed on cloudy or rainy days.”** Even on cloudy or rainy days, UV rays are still present and can injure your eyes. Many teens have suffered a sunburn on a cloudy day because they mistakenly thought that the clouds blocked the UV rays that cause sunburns. So, if there are sufficient UV rays to cause a sunburn on cloudy or rainy days, there are enough UV rays to injure your eyes.

### Anticipating Student Questions

1. **“Do darker sunglasses provide more UV protection that lighter ones?”** While it might seem reasonable that darker sunglasses would be better than lighter-colored sunglasses, this is not true. The level of UV protection is dependent upon the lens coatings or the type of polymer lens material. The lens color (gray, brown, blue, etc.) or shade of darkness of the sunglasses is not an indication of the level of UV protection. Read the labels to determine how effectively the sunglasses block UVA and UVB rays.
2. **“Does the size or the style of the sunglasses make a difference?”** Yes! Small lenses provide less protection than larger lenses because they shield less of the eye and don’t block as many UV rays from the eye. Also, sunglass styles that wrap around the sides of the eyes are more effective at blocking light from the eyes. Studies show that sunglasses that fit closer to the eyes provide better UV protection. Style is important in looking good, but be sure that style does not outweigh protection and function.
3. **“Does wearing a hat or cap protect my eyes from UV damage”** A hat may shade some sunlight (including some UV rays) from reaching your eyes, but it does not block all the UV rays that cause eye damage. Light reflected off surfaces like water, pavement, snow, etc. allow UV rays to reach your eyes underneath you hat. The best protection comes from wearing good sunglasses.
4. **“My eye doctor says that too much UV light can cause cataracts. What are cataracts?”**Cataracts are the leading cause of blindness in the world. A cataract occurs when the eye’s lens becomes cloudy. Most cataracts are related to aging, and they may be caused by proteins clumping in the lens, which clouds the eye. As the cataract grows, the lens becomes cloudier, making it harder to see. In addition to aging, cataracts may be related to smoking and diabetes, and it is known that to exposure to UV radiation increases the risk of cataracts. Research shows that the UV rays entering the eyes may damage proteins in the lens that leads to the clumping and poor vision.
5. **“Why is it hard to see my cell phone screen, some TVs, or LCD screens when wearing polarized sunglasses?”**When looking from certain angles, LCD displays may be difficult to see or may disappear when wearing polarized sunglasses. The LCDs (liquid crystal displays) used on ATMs, TVs, cell phone screens, etc. have a polarizer in the screen to produce the images and print that you typically see. So, if the polarizer in the display and the polarizer in your sunglasses are aligned roughly perpendicular to each other, the display will be difficult to see or may appear as a dark screen.
6. **“Why can boaters see underwater better when they are wearing polarized glasses?** Much of the light reflected off the surface of water is horizontally polarized. If the boaters’ glasses are polarized vertically, the glare is reduced allowing better vision into the water. Fishermen can spot fish and underwater objects more clearly if they are wearing polarized glasses. Of course, wearing polarized sunglasses allows boaters to both reduce the glare off the water and protect their eyes from damaging UV rays (a “win-win” situation).

### Activities

**Labs and demos**

**“Everyday Engineering: UV or Not UV? That Is a Question for Your Sunglasses”:** While this lab from the National Science Teachers Association (NSTA) is written for grades   
5–8, it may be appropriate for higher grades; it uses egg carton cubicles, UV sensitive beads, and sunglass lenses to test the ability of the lenses to filter UV light. (<https://learningcenter.nsta.org/resource/default.aspx/?id=10.2505/4/ss14_037_07_12&a=reviews>. Note that this link takes you to a brief abstract only; the full article is available to purchase or is free to NSTA members.)

**“Thionin—The Two-Faced Solution” demonstration:** This demonstration shows how light energy is used to induce a reversible chemical reaction with a color change, a process similar to the change in photochromic sunglasses—but in reverse, with the chemical going from colored to colorless. (<https://www.flinnsci.com/api/library/Download/1e347e52d1fa4253b324d388aea826d1>)

**Simulations**

**“Wave Interference” (PhET):** This simple student simulation includes an option **for** investigating light traveling through one or two barrier slits producing constructive and destructive interference to better understand the behavior of waves. (<https://phet.colorado.edu/en/simulation/legacy/wave-interference>)

**“Polarization of Light” (oPhysics: Interactive Physics Simulations):** Students can manipulate light waves traveling through filters with one or more slits and adjust the angle of one slit to study the polarization of light. (<https://ophysics.com/l3.html>)

**Media**

**“Electromagnetic Waves and the Electromagnetic Spectrum”, video (11:01):** This Khan Academy lesson defines and explains electromagnetic (EM) waves, portions of the EM spectrum, and energies of visible light. (<https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/v/electromagnetic-waves-and-the-electromagnetic-spectrum>)

**“How Do Polarized Sunglasses Work?” video (6:21):** The Science Asylum provides an upbeat look at how light is polarized and how polarization is used in producing effective sunglasses. (<https://www.youtube.com/watch?v=c9ew1J0PY-M>)

**Lessons and lesson plans**

**“Electromagnetic Waves: How Do Sunglasses Work?”:** This one-hour high-school lesson ties engineering to the activity, which compares polarized and non-polarized lenses, and supports teachers by supplying NGSS standards, a lesson plan, content, links to teacher and student materials, and assessment strategies, and extension activities. (<https://www.teachengineering.org/lessons/view/mis-2231-light-properties-sunglasses-electromagnetic-waves-polarization>)

**“Polarization”:** This lesson (part of the “Light Waves and Color” tutorial) supplies content, videos, illustrations, and a basic check for student understanding for polarizing light by reflection, refraction, or scattering, as well as providing a link to the related lesson “The Electromagnetic and Visible Spectra”. (<https://www.physicsclassroom.com/class/light/Lesson-1/Polarization>)

**Projects and extension activities**

**“Experiments with Polarized Light”:** This activity can be conducted at home using polarized sunglass lenses, an LCD computer screen, and common household objects; the article provides explanations with diagrams for how polarization works. (<http://www.physics.iitm.ac.in/~ph5060/manuals/polarization.pdf>)

**“Electromagnetic Spectrum Book” activity/project:** Students research and “create a book that describes all of the individual parts that make up the electromagnetic spectrum.” The activity provides student and teacher materials and a rubric; it suggests that the project takes from 2 days to a week to complete. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/electromagnetic-spectrum-book>.)

### References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles published from the magazine’s inception in October 1983 through April 2013; all**

**available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [***http://www.acs.org/chemmatters***](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get 30 Years of *ChemMatters* Magazine!” (the icon on the right of the screen).**

**Selected articles and the complete set of Teacher’s Guides for all issues from the past three years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



“A Light of a Different Color” describes ultraviolet light, its uses, and interesting characteristics including fluorescence. (Rohrig, B. A Light of a Different Color. *ChemMatters*. 1999, *17* (2), pp 4–6)

“Spectroscopy: Sensing the Unseen” provides readers with information on the electromagnetic spectrum, diffraction, and ultraviolet light, along with illustrations to enhance understanding. (Miller, S. Spectroscopy: Sensing the Unseen. *ChemMatters*. 2001, *19* (Special Issue 1), pp 4–6)

Ozone’s beneficial and detrimental roles in the atmosphere, including shielding the Earth from UV rays, are germane to the current article about sunglasses. (Kimbrough, D. Ozone: Molecule with a Split Personality. *ChemMatters*. 2001, *19* (Special Issue 1), pp 7–9)

“Studying the Energy of the Universe” provides an activity to make Schönbein paper used to test ozone levels. (Siegel, P. Studying the Energy of the Universe. *ChemMatters*. 2002, *20* (Special Issue 1), pp 6–9)

In “A Super Vision for Airport Security”, the electromagnetic spectrum is explained and Figures 1 and 2 nicely illustrate the electromagnetic spectrum, wavelength, and frequency. (Tinnesand, M. A Super Vision for Airport Security. *ChemMatters*. 2012, *30* (1), pp 14–16)

“Polymers: The Lucky Polymer” in the “Did You Know?” department briefly describes polycarbonate, the plastic in many sunglasses, especially as it is used in making CDs and DVDs. (Blaszcyk, R. Polymers: The Lucky Polymer. *ChemMatters*. 2013, *31* (1), p 4)

This article contains more information regarding ozone’s role as sunscreen for the Earth. (Carlowicz, M. The Ozone Layer: Our Global Sunscreen. *ChemMatters*. 2013, *31* (2), pp 12–14)

### Web Resources for More Information

**Sunglasses**

HowStuffWorks explains in detail the science of sunglasses including photochromic lenses, tints, various coatings, polarization, safety, and fashion.

(<https://science.howstuffworks.com/innovation/everyday-innovations/sunglass.htm>)

This is an infographic about the chemistry of sunglasses including lens material, UV protection, and photochromic chemistry.

(<https://www.compoundchem.com/2016/05/09/sunglasses/>)

**Photochromic eyeglasses**

This site gives additional information on how photochromic glasses work.

(<https://www.scienceabc.com/innovation/how-do-photochromic-photochromatic-glasses-work.html>)

ACS provides information on self-darkening lenses, the dyes used, and the chemical reaction.

(<https://pubs.acs.org/cen/science/87/8715sci5.html>)

**Polycarbonate**

This article describes the uses, manufacture, and possible future developments of polycarbonate plastic; it also includes numerous chemical structures.

(<http://www.essentialchemicalindustry.org/polymers/polycarbonates.html>)

Read this article to learn more about polycarbonate lenses used in glasses.

(<https://www.allaboutvision.com/parents/polycarb.htm>)

**Cataracts**

This article explains facts about cataracts including causes, effects on vision, and treatment.

(<https://nei.nih.gov/health/cataract/cataract_facts>)

An update in this article explains how UV rays may cause or contribute to cataract formation.

(<https://nei.nih.gov/news/briefs/uv_cataract>)

**Nonsurgical cataract treatment**

New research indicates that a nonsurgical treatment for cataracts may be possible, using special eye drops, to dissolve the clumped proteins which cause most cataracts.

(<https://www.sciencedaily.com/releases/2015/11/151105143817.htm>)

**Ultraviolet (UV) radiation**

Detailed Information about UV radiation can be found in this article.

(<https://www.fda.gov/radiation-emittingproducts/radiationemittingproductsandprocedures/tanning/ucm116425.htm>)

Learn about the health effects of UV on the eyes, including photoconjunctivitis, photokeratosis, pterygium, cancer, and cataracts.

(<http://www.who.int/uv/faq/uvhealtfac/en/index3.html>)

**Electromagnetic spectrum and energy**

Readers can review the electromagnetic spectrum using text and illustrations.

(<https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>)

The mathematical equation for calculating the energy of a photon and a brief explanation of the relationship between wavelength and energy are provides at this site.

(<https://www.e-education.psu.edu/meteo300/node/682>)

**Polarized light**

For more information on the polarized light, visit this link.

(<https://www.microscopyu.com/techniques/polarized-light/introduction-to-polarized-light>)

**Ozone**

This site provides review of the science of stratospheric ozone and how it shields UV radiation.

(<https://www.ozonelayer.noaa.gov/science/basics.htm>)

**Visible light and color**

This site provides classroom-ready PDF file worksheets to help comprehend light and color.

(<https://www.physicsclassroom.com/curriculum/light>)

**Solar sunglasses**

Solar glasses that can generate power from light may lead to new applications in sunglasses where the power could power microdisplays on the sunglass lenses.

(<https://www.sciencedaily.com/releases/2017/08/170802102800.htm>)

## Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article, and then locate and analyze information from the article.

* **Anticipation Guide (p 36):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**Rocking Shades in the Winter**

* Before reading, ask students why they might need sunglasses or goggles when going outside on a snowy day.
* As they read, students can compare their original ideas to information in the article. Ask students to write how chemistry can help protect their eyes when they are outside.
* **Graphic Organizer (p 37):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (pp 38–39):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Anticipation Guide

**Directions: *Before reading***, in the first column, write “A” or “D” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Your eyes need protection from UV radiation. |
|  |  | 1. Each color of visible light has a different wavelength. |
|  |  | 1. The longer the wavelength of light, the higher the energy of light. |
|  |  | 1. The atmosphere blocks most of the UV radiation coming from the sun. |
|  |  | 1. Polarized lenses block all UV radiation. |
|  |  | 1. The most energetic type of UV ray is UVA. |
|  |  | 1. Polycarbonate lenses block UV radiation. |
|  |  | 1. Polycarbonate lenses reduce glare. |
|  |  | 1. Photochromic lenses become dark when UV light is absorbed. |
|  |  | 1. The American Academy of Ophthalmologists recommends eyewear that provides 95% protection from UV rays. |

### Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read the article, complete the graphic organizer below to describe the materials used to make outdoor eyewear.

|  |  |  |
| --- | --- | --- |
| **Lenses** | **What are they made of?** | **How do they work?**  **Are they UV protective?** |
| **Polarized lenses** |  |  |
| **Polycarbonate lenses** |  |  |
| **Photochromic lenses** |  |  |

**Summary:** On the back of this paper, write a short email to a friend describing your choice for outdoor eyewear, with reasons.

### Student Reading Comprehension Questions

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

* 1. How should people protect their eyes from UV radiation?
  2. What are photons?
  3. How are (a) wavelength and (b) frequency of an electromagnetic wave defined?
  4. (a) Name the process of separating white light into different colors, and (b) explain how a prism can separate white light into those colors.
  5. In an electromagnetic wave, what is the relationship between its wavelength and its energy?
  6. What four injuries may occur to people’s eyes when they spend long hours in the sun or when their eyes are exposed to highly reflective surfaces like snow or water?

**Student Reading Comprehension Questions, cont.**

* 1. (a) How does polarization work to reduce glare, and (b) is polarization effective in protecting eyes from UV rays? Explain your answer to part (b).
  2. (a) Name the three types of UV light, and (b) identify the type that is primarily responsible for causing sunburns.
  3. List four reasons why polycarbonate is commonly used for lenses.
  4. Explain how the photochromic compound naphthopyran works to darken sunglasses in sunlight.
  5. What are five advantages of using naphthopyrans as darkeners in glasses?

**Critical-Thinking Questions**

***Write your answers on the back of this sheet or on a separate sheet of paper.***

1. List and explain five factors from the article that a wise consumer should consider when purchasing sunglasses to prevent possible cataract damage.
2. What part of the Earth’s atmosphere plays a role in the formation of cataracts in the human eye, and how does it do this?

### Answers to Reading Comprehension Questions

1. **How should people protect their eyes from UV radiation?**

To protect their eyes from UV radiation people should wear the right sunglasses or goggles that shield against UV rays.

1. **What are photons?**

Photons are bundles of energy that travel at the speed of light in electromagnetic waves.

1. **How are (a) wavelength and (b) frequency of an electromagnetic wave defined?**
2. The wavelength of an electromagnetic wave is the distance between one wave’s crest and the next.
3. The frequency of an electromagnetic wave is the number of cycles (or complete waves) that pass a reference point during a specified time period.
4. **(a) Name the process of separating white light into different colors, and (b) explain how a prism can separate white light into its different colors.**
5. A prism separates white light into different colors by the process of dispersion
6. The individual colors in white light have different wavelengths, frequencies, and energies, all of which allow the prism to bend or refract the individual colors differently. This bending causes the white light to separate into its different colors.
7. **In an electromagnetic wave, what is the relationship between its wavelength and its energy?**

In electromagnetic waves, as the wavelength gets shorter, the energy gets higher.

1. **What four injuries may occur to people’s eyes when they spend long hours in the sun or when their eyes are exposed to highly reflective surfaces like snow or water?**

Four injuries that may occur to people’s eyes when they spend long hours in the sun, snow, or water are

1. cataracts,
2. growths on the eyes,
3. cancers, and
4. blindness.
5. **(a) How does polarization work to reduce glare, and (b) is polarization effective in protecting eyes from UV rays? Explain your answer to part (b).**
6. Polarization works to reduce glare by filtering out some of the light waves.
7. Polarization is *not* effective in protecting eyes from UV rays; it only reduces the quantity of light reaching the eyes and does not block the wavelengths of UV that cause damage.
8. **(a) Name the three types of UV light, and (b) identify the type that is primarily responsible for causing sunburns.**
9. The three types of UV light are
10. UVA,
11. UVB, and
12. UVC, and
13. UVB is the type of UV light that is responsible for causing sunburns.
14. **List four reasons why polycarbonate is commonly used for lenses.**

Four reasons that polycarbonate is commonly used for lenses are that it is

1. clear,
2. lightweight,
3. durable (or impact resistant), and
4. a natural UV filter.
5. **Explain how the photochromic compound naphthopyran works to darken sunglasses in sunlight.**

Naphthopyran works to darken sunglasses in sunlight by absorbing sunlight’s energy, which causes the molecule’s structure to change. This change produces a new structure that absorbs the visible light and darkens the sunglasses.

1. **What are five advantages of using naphthopyrans as darkeners in glasses?**

Five advantages of using naphthopyrans as darkeners in glasses are

1. they are very sensitive to light,
2. they can be synthesized easily,
3. they are low cost,
4. they can be used in a variety of applications, and
5. their reaction to darkening is reversible.

**Critical-Thinking Questions**

1. **List and explain five factors from the article that the wise consumer should consider when purchasing sunglasses to prevent possible cataract damage.**

Factors that a wise consumer should consider when purchasing sunglasses to protect the eyes could include

1. the ability of the sunglasses to block 100% of both UVA and UVB rays because these rays are known to cause cataracts;
2. the composition of the sunglass lenses because lens materials like polycarbonate are natural UV inhibitors, as well as being shatter resistant;
3. the design and size of the sunglass lenses because styles that fully cover the eyes and restrict any light leaking into the eyes from around the edges of the glasses offer better protection;
4. the comfort of the glasses because glasses that are more comfortable will encourage people to wear them longer and more often;
5. the style of the sunglasses because, if people like and feel good wearing the glasses, they will be more likely to wear them;
6. whether the glasses are photochromic because, if they darken automatically in sunlight, they will offer effortless protection without needing to remember to put on special glasses; and
7. whether the sunglasses are polarized because polarization reduces glare (not UV) and makes it easier to see clearly and avoid accidents.
8. **What part of the Earth’s atmosphere plays a role in preventing the formation of cataracts in the human eye, and how does it do this?**

The Earth’s stratospheric ozone layer acts as a protective layer and filters out most of the UV rays traveling toward Earth. The UVC rays are absorbed by the atmosphere before they reach the surface, so, even though they are the highest energy UV rays, they are not as great of a concern for cataract formation. However, UVA and UVB rays do reach the surface of the Earth. UVA rays account for 95% of the UV rays reaching the surface, and they can penetrate to the second layer of the skin. Therefore, with this penetrating ability, they may be more likely to reach the lens of the eye where cataracts are formed. The UVB rays are not as numerous, but are higher in energy, so they, too, are concerns for cataract formation in human eyes. Without the ozone layer, which would allow UVC rays to reach Earth, there would certainly be many more cataracts and eye problems.



**Teacher's Guide for**

### “‘Beeting’ Icy Roads”

**December 2018/January 2019**

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## Tools and Resources

### Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Solubility** | The study of the solubility of ionic and molecular compounds can be enriched by including the information in the article that directly relates this concept to the daily lives of those who experience snow in winter and/or travel to ski resorts over icy roads. |
| **Chemical bonding** | Predicting the effectiveness of a solute, used to prepare a solution designed to prevent road icing—based on the number of particles the solute will donate to a solution—presents an opportunity to add relevance to the study of covalent and ionic chemical bonding. |
| **Colligative properties** | The study of colligative properties can help direct student focus to the particle level for understanding how the number of solute particles in a solution affects the melting of ice and snow. This article provides a useful, everyday (in the winter) application of colligative properties. |
| **Freezing point** | Once students recognize freezing point as a characteristic of a pure substance, using water as an example in articles such as this one provides evidence that characteristics change as the purity of a substance changes. |
| **Freezing point depression** | The information in this article can add relevance, meaning and importance to the world of students when they study freezing point depression. Rather than just a bunch of calculations, they can understand how chemical engineers use this information to reduce icy roadways. |

### Standards and Vocabulary

#### Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F:** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E:** Provide a concluding statement or section that follows from or supports the argument presented.

#### Vocabulary

* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Structural formulas
  + Crystalline structure
  + Environmental impacts of personal and societal decisions
  + Electromagnetic radiation
  + Colligative properties
  + Gas laws
* Consider asking students to read “Open for Discussion: A Slippery Slope” on page 4 to learn about concerns regarding using artificial snow prior to reading the article “What’s Artificial Snow, and How Is It Made?”
* Students from warmer climates may be unaware of the use of salt to melt ice on roadways. Ask them if they have ever traveled to cold climates and if they had trouble walking on icy sidewalks, or if they have seen this problem in movies or television. Show students the ACS Reactions video referenced on page 14 AFTER they have read the article to help them understand why salt is used to deice roads and how it works.
* Two of the articles relate to personal health (UV eye protection and cupping). Ask students how the articles might impact their decisions regarding their health and why.
* Two of the articles relate to environmental impacts of our decisions (artificial snow and salting roads). Ask students how the information from the articles might help them make decisions in the future, and factors they might consider as citizens asked to provide input on related projects.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles, and what they would like to explore further.
* Ask students if they have questions about some of the issues discussed in the articles.

### Possible Student Misconceptions

1. **“Sand and salt are both used to treat icy roads. I didn’t know sand melts ice just like salt.”** Actually, sand doesn’t melt ice; it is used to improve traction on icy roads. Sand crystals increase friction between automobile tires and road surfaces to prevent slipping. On the other hand, salt lowers the freezing point of water, thus melting ice.
2. **“I’m not from snow country, but I’ve heard that when salt is spread on snow and ice, it melts them quickly so cars can drive on the roads again.”** Actually when salt is spread on top of snow, each salt grain just melts the ice crystals around it. This forms little pools of salty water that begin to melt the ice around them. This process works, but it is actually slow. When the salt is spread before the snow falls, as soon as snow hits, the salt begins to melt the surface snow above it and vehicles driving over this accelerate the process by churning the mess and making it easier for snow plows to push the melting ice and snow off the road.
3. **“I’ve heard that sometimes it’s just too cold to snow.”** There is a maximum amount of water that air can hold at a particular temperature, and colder air has less capacity to hold moisture than warm air. However, there will be enough moisture in the air for snow until the temperature reaches below –40 oC. At this point the moisture content will be so low that snow can rarely occur. So a place where it’s just too cold to snow will be extremely cold!!
4. **“After our snow season, it looks like the concrete on our driveway is flaking away. The road salt must have damaged the concrete.”** Usually, road salt will not harmconcrete driveways. However, damage can occur if the concrete has not been properly mixed, installed and “finished”. Chemical additives (admixtures) should be added to cement just before or during mixing. These reduce water in the mixture, slow the rate of setting (especially in hot climates), inhibit corrosion, and add millions of microscopic bubbles (air pockets) in the concrete surface to increase cohesion and prevent damage during freeze-thaw cycles by allowing ice crystals to form and expand without breaking the surface. The flaking of the surface concrete is called spalling.
5. **“I understand the dangers of deicers increasing the salinity of lakes and streams, but I live in a wooded area far from any major waterways, so this is probably not a problem here.”** Salt left on the roads is a problem even in locations far from bodies of water. Animals such as moose and deer need salt during the winter to supplement their diet. Unfortunately, in winter they are often attracted to salty roads and highways that they use as “salt licks.” Here they may be hit by motorized vehicles causing severe damage to vehicles and possible death to animals.

### Anticipating Student Questions

1. **“Why doesn’t the salt that they put on our roads in the winter look white like table salt?”** Road salt (halite) is the natural, unrefined form of table salt, sodium chloride (NaCl). When mined, the salt contains natural mineral impurities that give it a brownish or gray color. To prepare table salt, halite is crushed after mining and impurities are removed.
2. **“Sea salt is used to cook. What is it?”** Food-grade sea salt is less refined than table salt. It has about the same nutritional value as table salt and is usually white. It can be recovered from ocean water or salt water lakes by evaporation. Highly refined table salt has trace minerals removed. Table salt is often “iodized” with small amounts of potassium iodide or sodium iodide to prevent iodine deficiency. Iodized salt can interfere with chemistry experiments, so you should use the non-iodized version in classroom experiments.
3. **“What is brackish water, where does it from and why is it a concern?”** Brackish wateris water that contains more salt than fresh water. It forms where seawater mixes with freshwater in locations such as estuaries, marshes, and swamps. Concerns include the inability of many plants and animals to survive in an extremely salty environment. In addition, these water areas are prime breeding grounds for mosquitoes.
4. **“Why do they pre-salt, or brine, our roads before the snow actually falls?”**Pre-salting means spreading a layer of salt or liquid deicer directly on the road, so when the snow falls it doesn’t freeze the road surface. The salt makes the snow slushy, vehicles tires mush it around, and the snowplow can push the whole mess off the road.
5. **“What kind of deicer is least harmful to grasses and plants?”** Unfortunately, this question can’t be answered easily because tests show that the toxicity of deicers depends upon the plant. For example, calcium magnesium acetate deicers are more harmful to the duckweed plants than sodium chloride. However, the opposite is true for barley plants.
6. **“The pH, as well as the salinity, of streams and rivers is increasing in the U.S. NaCl is a neutral salt, so how does it increase the pH?”** Research shows that both salinization and alkalinization (change in pH to make the solution more basic) are increasing in U.S. streams and rivers, due in varying degrees to each of these:

* Deicers increase salinity.
* Agricultural runoff often contains lime (calcium hydroxide), which is alkaline.
* Urbanization leads to an increased use of basic (alkaline) concrete that also contains lime, which leaches into groundwater when freshly poured.
* The widespread use and disposal of salts of bases such as ammonium hydroxide (ammonia cleaner) and carbonates such as sodium bicarbonate (baking soda) contribute to the alkalinity of our environment.

(<http://www.pnas.org/content/pnas/early/2018/01/03/1711234115.full.pdf>)

1. **“How do some little bugs keep from freezing in icy winters?**

Some bugs make their own antifreeze, often an alcohol (a solute), that mixes with their body fluids, thus lowering the liquid’s freezing point.

(<https://indianapublicmedia.org/amomentofscience/bug-antifreeze/>)

### Activities

**Labs and demos**

**“How does Salt ‘Melt’ Ice?” lab (90 min):** This lab activity is designed to help students understand why salt is used to clear snow; they also investigate which type of salt is best.

(Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/how-does-salt-melt-ice>.)

**“Molar Mass of a Molecular Compound by Freezing-Point Depression: A ‘Green’ Chemistry Activity” lab (90 min):** This Honors- or AP-level laboratory activity has replaced usual organic solutes (such as benzophenone and naphthalene) with glucose for a safer, greener process. The Teacher Preparation page shows sample calculations; teachers are given permission to duplicate materials for classroom use. (<https://www.carolina.com/teacher-resources/Interactive/molar-mass-by-freezing-point-depression/tr10799.tr>) This URL contains a link to the student worksheet.

**Simulations**

**“Salty Roads” simulation:** Students can add NaCl or CaCl2 to water and watch the animation as particles dissolve; students can choose solution concentrations and, as dissolving occurs, the temperature drops and the final freezing point depression (color coded by solute) is shown on a freezing point vs salt concentration graph. (Free CK-12 Foundation access requires sign-up with name, e-address and password; <https://interactives.ck12.org/simulations/chemistry/freezing-point/app/index.html>)

**Media**

**“Boiling Point Elevation and Freezing Point Depression” video (13:59):** This Khan Academy video uses particle-level diagrams to show how the addition of a solute (like road salt) to a pure substance (such as water) interferes with both the boiling point and the freezing point; the video begins with the boiling point elevated with the addition of a solute, then the video shows how the freezing point is lowered when salt is applied to snowy roads. The calculations of boiling point elevation and freezing point depression are shown as the explanation is developed. (<https://www.khanacademy.org/science/chemistry/states-of-matter-and-intermolecular-forces/mixtures-and-solutions/v/boiling-point-elevation-and-freezing-point-supression>)

**“The Effects of Salinity and Temperature on Dissolved Oxygen” YouTube video (8:17):** Aerated beakers at different salinities and temperatures are measured by a dissolved oxygen meter, data is collected and graphed. This video produced by the Ocean Research and Conservation Association (ORCA) shows the types of fish that can survive in the tested situations on the data graph. (<https://www.youtube.com/watch?v=ibaD-9KwSDM>)

**Lessons and lesson plans**

**“Alternative Deicers: An Application of Freezing Point Depression” (2 lab periods + outside research):** This lesson involves student research, an on-line simulation to learn about concentration and the van't Hoff factor, a chemistry lab (experimental design), a summary of findings, and a written proposal to be sent to the mayor for an alternative deicer. (<https://serc.carleton.edu/bioregion/examples/59182.html>)

**“Ecology Disrupted: Human impacts demonstrate ecological principles” lesson plan—Middle and High School Level— (6 lessons):** The American Museum of Natural History has produced a set of five 45-minute lessons (“Salting Winter Roads”, “Salt and Living Things”, “Water in Our Daily Lives: Coming and Going”, “Investigating and Graphing Salinity Data”, “[Presenting and Making Meaning from Salinity Data: Graphing and Drawing Conclusions](https://www.amnh.org/explore/curriculum-collections/ecology-disrupted/winter-roads/lesson-plans/representing-and-making-meaning-from-data)”), and a sixth, 90-minute lesson (“[Ecology Disrupted: Unexpected Consequences Of Human Daily Life On Abiotic and Biotic Ecosystem Components](https://www.amnh.org/explore/curriculum-collections/ecology-disrupted/winter-roads/lesson-plans/ecology-disrupted)”). Click on links for extensive teacher materials.

(<https://www.amnh.org/explore/curriculum-collections/ecology-disrupted/winter-roads/lesson-plans>)

**Projects and extension activities**

**“An Alternative to Road Salt” (A Science Fair Project):** The effectiveness of beet juice and a solution of beet juice and rock salt are compared to only rock salt in melting ice. Data includes time for each variable to melt ice plus conductivity measurements of each. This was designed as a middle school project. However, by adding more alternatives it can easily be adapted for use in the high school classroom.

(<https://www.education.com/science-fair/article/salting-icy-roads-alternative/>)

**“Effect of Salt Concentration on Plants” (2 class lab periods + observations of changes in plant material, as necessary):** This very well-written student laboratory exercise, with its ample student and teacher materials and a bit of lab design included, deals with the standard osmosis lab, which you could use to correlate (or ask students to correlate) with the effects of the runoff from salted roads on plant growth. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/summer.html>.)

### References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles published from the magazine’s inception in October 1983 through April 2013; all**

**available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [***http://www.acs.org/chemmatters***](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get 30 Years of *ChemMatters* Magazine!” (the icon on the right of the screen).**

**Selected articles and the complete set of Teacher’s Guides for all issues from the past three years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



“Salting Roads: The Solution for Winter Driving” emphasizes salting roads to save lives; the article explains freezing-point depression and the phase diagram for sodium chloride; it is suggested that corrosion is a small price to pay for the reduction in deadly winter vehicle accidents; the long term environmental effects of salinization of natural fresh and salt water were not addressed. (Kimbrough, D. Salting Roads: The Solution for Winter Driving. *ChemMatters*. 2006, *24* (1), pp 14–16)

Sprayed-on deicers save planes and their passengers; efforts to prevent environmental pollution from airline deicers are included such as collecting and recycling the anti-freeze running off plane wings are included in the article. (Banks, P. Weighting in the Wings *ChemMatters*. 1992, *15* (4), pp 10–12)

### Web Resources for More Information

**Salting roads—history**

This publication discusses the history of the use of salt for deicing roads and the effects on the health of humans, plants, and animals, due to changes in the salinity of wetlands and ground water. Graphs and cost/benefit analyses are used to illustrate the problem; possible solutions and alternatives are discussed.

(<https://www.caryinstitute.org/sites/default/files/public/reprints/report_road_salt_2010.pdf>)

This article discusses the early use of salt and cinders to add traction to slick roads. Graphs and cost/benefit analyses are used to illustrate the problem; possible alternatives are discussed.

(<https://www.vox.com/2015/1/13/7531833/road-salt-environment-alternatives>)

**Salting roads—problems**

Toxic effects of high chloride level in waterways are described in this article citing EPA data.

(<https://www.wired.com/2015/03/road-salt-polluting-rivers/>)

“Hidden Dangers of Road Salt” contains many links to journal articles that feature data from their original studies showing the harmful effects of increased levels of chloride from road salt to both aquatic and terrestrial animals, including trout, frogs and butterflies; it includes evidence photos showing normal animals next to those living in waters of high salt content.

(<https://www.smithsonianmag.com/science-nature/road-salt-can-disrupt-ecosystems-and-endanger-humans-180963393/>)

**Drinking water standards**

EPA national drinking water regulations include safe sodium and chloride concentrations, as well as risk values for cancer causing contaminants.

(<https://www.medicalnewstoday.com/articles/263371.php>)

This is an interactive map showing national unsafe drinking water areas and state actions taken for ensuring safety at school drinking fountains.

(<http://www.drinkingwateralliance.org/new-map>)

**Environmental problems**

This report investigates data for salt alternative, including cost and quantity. Results show alternatives work, and harm can be reversed if introduced.

(<https://mcspolicycenter.umaine.edu/wp-content/uploads/sites/122/2016/09/Winter-Road-Maint-Final.pdf>)

Chloride ions are not filtered out by the soil, are very soluble, and cannot be removed from the environment by natural means; the article is divided into seven topics, and road salt toxicity is explained.

(<https://www.des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/impacts.htm>)

**Salinity**

The study shows that high chloride levels in streams that flow from suburban and urban areas of Baltimore than in streams fed by water from forests and agricultural areas. Data is shown in graphical format.

(<http://www.pnas.org/content/102/38/13517.full>)

Short video and graphs describe results of studies on the variations and causes of ocean salinity. The salinity of surface water is affected by the climate—dilution from rain and concentration from water evaporation.

(<https://www.sciencelearn.org.nz/resources/686-ocean-salinity>)

**Alternatives**

**This article discusses the environmental problems in lakes of using both road salt and organic waste for deicing. In the future, solar panels to melt snow may replace asphalt on roads.**

(<http://theconversation.com/road-salt-is-bad-for-the-environment-so-why-do-we-keep-using-it-87860>)

This article discusses the pros and cons of using six alternatives to rock salt for deicing: beet juice, organic waste, fracking waste-water, cheese brine, pickle brine, and potato juice.

(<https://montrealgazette.com/news/local-news/a-look-at-the-alternatives-to-rock-salt-for-de-icing-roads>)

## Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article, and then locate and analyze information from the article.

* **Anticipation Guide (p 56):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**‘Beeting’ Icy Roads**

* Before reading, ask students why salt is added to roads in cold climates in the winter. (*Note*: Students from warm climates may be surprised to find out this is done.)
* Ask students why adding salt might be a problem, and what other materials they can think of to use instead of salt.
* As they read, students can find information to confirm or refute their original ideas.
* **Graphic Organizer (p 57):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (pp 58–9):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Anticipation Guide

**Directions: *Before reading***, in the first column, write “A” or “D” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Salt is used on roads to keep ice and snow from sticking to the roads. |
|  |  | 1. Salts are ionic compounds. |
|  |  | 1. So far, there is no scientific evidence that road salt has increased salinity levels in freshwater lakes. |
|  |  | 1. Salinization can increase the oxygen content in deeper parts of freshwater lakes. |
|  |  | 1. Most of the salt used on roads in the United States is calcium chloride. |
|  |  | 1. Most freshwater lakes have a lower salinity than drinking water. |
|  |  | 1. Impervious surfaces such as roads in the U.S. take up enough land to cover the state of Ohio. |
|  |  | 1. Cities have tried using the wastewater from local industries, including cheese-making. |
|  |  | 1. Solutes interfere with ice crystal formation. |
|  |  | 1. One mole of calcium chloride has the same effect on lowering the freezing point of water as one mole of sodium chloride. |

### Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read the article, complete the graphic organizer below to compare materials used to deice roads. Include at least 3 sources and 3 disadvantages for each material.

|  |  |  |
| --- | --- | --- |
|  | **Sources and Examples** | **Disadvantages**  (Use bullets or numbers for each) |
| **Chloride salts** |  |  |
| **Waste-based alternatives** |  |  |

**Summary**: On the back of this paper, write a tweet (280 characters or less) about the importance of finding alternatives for deicing roadways, based on what you learned from reading the article.

### Student Reading Comprehension Questions

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

1. (a) Under what conditions is salt sprinkled or beet juice sprayed on U.S. asphalt surfaces? (b) What does the salt or beet juice do? (c) Why is this important?
2. In addition to corrosion of vehicle parts, what is the more subtle impact on the environment from the long-term use of winter road salt?
3. What is meant by the subtitle “From streets to streams”?
4. (a) How did researchers discover that road salt has contributed to the rising salinity in freshwater lakes across the United States, and (b) what did they find?
5. Complete the following table to show the approximate concentration of dissolved salts in various sources of water.

|  |  |
| --- | --- |
| Source | Approximate dissolved salts (mg/L) |
| Fresh water |  |
| Drinking water |  |
| Sea water |  |

1. What is the range of salinity for brackish-water as shown on the map?

**Student Reading Comprehension Questions, cont.**

1. Provide one example of how increased salinity affects bottom-dwelling fish and plants.
2. List three sources of increasing salt levels in freshwater systems.
3. How does road salt prevent snow from sticking and freezing to road surfaces?
4. What is an impervious surface? (b) Give an example of an impervious road surface.  
   (c) How does the impervious surface contribute to the salinity of waterways?
5. What are three waste water alternatives tried by cities that contain lower amounts of sodium chloride than traditional road salt?
6. What are two problems with applying beet juice as a deicer?

### Answers to Reading Comprehension Questions

1. **(a) Under what conditions is salt sprinkled or beet juice sprayed on U.S. asphalt surfaces? (b) What does the salt or beet juice do? (c) Why is this important?**
2. Salt is sprinkled or beet juice sprayed on U.S. asphalt surfaces when temperatures drop and snow threatens.
3. The salt or juice prevents snow from sticking to asphalt streets and sidewalks.
4. This is important because it prevents streets and sidewalks from freezing and becoming too slick to safely drive or walk on.
5. **In addition to corrosion of vehicle parts, what is the more subtle impact on the environment from the long-term use of winter road salt?**

In addition to corrosion of vehicle parts, the more subtle impact on the environment from using road salt over long periods of time is that the salt may be affecting plant and animal life in lakes.

1. **What is meant by the subtitle “From streets to streams”?**

“From streets to streams” means that the salt doesn’t stay on streets; as snow and ice melt, much of the salt is washed into freshwater streams and rivers that then pour into lakes.

1. **(a) How did researchers discover that road salt has contributed to the rising salinity in freshwater lakes across the United States, and (b) what did they find?**
2. Researchers monitored the chloride levels as an indicator of salinity in 371 freshwater lakes in the United States, and
3. they found that 44% of the lakes monitored had elevated chloride levels.
4. **Complete the following table to show the approximate concentration of dissolved salts in various sources of water.**

|  |  |
| --- | --- |
| **Source** | **Approximate dissolved salts (mg/L)** |
| **Fresh water** | 500 |
| **Drinking water** | 20 |
| **Sea water** | 35,000 |

1. **What is range of salinity for brackish-water as shown on the map?**

The brackish-water is located between zero and 20 parts per thousand (ppt) salinity on the map.

1. **Provide one example to show how increased salinity affects bottom-dwelling fish and plants.**

Increased salinity changes the normal flow and mixing of water within lakes from the lake surface to the bottom. This restricts the oxygen available for plants and animals living in deeper parts of lakes.

1. **List three sources of increasing salt levels in freshwater systems.**

Three sources of increasing salt levels in freshwater systems are

deicing roads,

pollution from construction, and

run-off from chemicals used in agriculture and other industries.

1. **How does road salt prevent snow and ice from sticking and freezing to road surfaces?**

Road salt acts as a solute to lower the freezing point of water on road surfaces so that water will not freeze until the temperature reaches almost –4 oC.

1. **(a) What is an impervious surface? (b) Give an example of an impervious road surface. (c) How does the impervious surface contribute to the salinity of waterways?**
   1. “An impervious surface is one that does not let liquid pass through.”
   2. An example of an impervious surface is a paved road.
   3. A paved road cannot absorb the salt solution, so it runs off into waterways.
2. **What are three waste-water alternatives tried by cities that contain lower amounts of sodium chloride than traditional road salt?**

The three waste-water alternatives used by cities that were mentioned in the article are

1. beet processing
2. pickle production
3. cheese making
4. **What are two problems with applying beet juice as a deicer?**

Two problems with applying beet-juice as a deicer are

1. beet juice smells like soy sauce or stale coffee, and
2. its sugars can invite unwanted bacterial growth.



**Teacher's Guide for**

### “Cupping: Harmless Fad or Sound Science?”

**December 2018/January 2019**

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## Tools and Resources

### Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Gas pressure** | The article provides a good example of the effects of changing gas pressure. |
| **Charles’ law** | The preparation of the cups used in cupping therapy is a great application of Charles’ law if one considers the change in volume of the air from the cup as the heated air expands and spills out of the cup. |
| **Gay-Lussac’s (Amontons’) law** | The decrease in pressure inside a cup as the temperature of the warmed gas cools, serves as an example of the direct relationship between the temperature and pressure of a fixed volume of gas as defined by Amontons’ law also known as Gay-Lussac’s law. |
| **Vacuum/low pressure** | Cupping using a vacuum pump, rather than heat, provides an example of a low-pressure system in real life. |
| **Scientific inquiry** | The discussion about the lack of randomized control trials in studies evaluating the effectiveness of cupping can be used to support lessons about experimental design in a unit on scientific inquiry. |

### Standards and Vocabulary

#### Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F:** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E:** Provide a concluding statement or section that follows from or supports the argument presented.

#### Vocabulary

* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Structural formulas
  + Crystalline structure
  + Environmental impacts of personal and societal decisions
  + Electromagnetic radiation
  + Colligative properties
  + Gas laws
* Consider asking students to read “Open for Discussion: A Slippery Slope” on page 4 to learn about concerns regarding using artificial snow prior to reading the article “What’s Artificial Snow, and How Is It Made?”
* Students from warmer climates may be unaware of the use of salt to melt ice on roadways. Ask them if they have ever traveled to cold climates and if they had trouble walking on icy sidewalks, or if they have seen this problem in movies or television. Show students the ACS Reactions video referenced on page 14 AFTER they have read the article to help them understand why salt is used to deice roads and how it works.
* Two of the articles relate to personal health (UV eye protection and cupping). Ask students how the articles might impact their decisions regarding their health and why.
* Two of the articles relate to environmental impacts of our decisions (artificial snow and salting roads). Ask students how the information from the articles might help them make decisions in the future, and factors they might consider as citizens asked to provide input on related projects.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles, and what they would like to explore further.
* Ask students if they have questions about some of the issues discussed in the articles.

### Possible Student Misconceptions

1. **“When a burning splint or cotton ball is placed in a cupping container it uses up all the oxygen in the container creating a vacuum that draws the skin into the cupping container.”**

First of all, air contains other gases than just oxygen. Secondly, look at the equation for the combustion of alcohol—for every molecule of oxygen that is consumed two molecules of gaseous products are formed. Even though oxygen is being used in the reaction, more gas is being produced. So a vacuum is not created because of oxygen consumption.

**2 CH3OH (l) + 3 O2 (g) 🡪 2 CO2 (g) + 4 H2O (g)**

This is a good time to emphasize that it is the heat from the flame that causes the gases to expand and exit the cup before the cup is placed on the patient. After the cup is securely in place, the cup cools while the remaining gases contract creating the vacuum that causes the skin to rise into the cupping container.

1. **“When the air is heated in an open container it does not leave the container.”**

Since students cannot see air leaving an open container when it is heated, they might think that all the air being heated in the open cup stays there. Let students observe a burning candle placed in a shallow pan of water, and then cover it with a jar. They will see air bubbles coming from under the jar when the gas expands soon after the jar is put in place. This might help students visualize what is happening with the heated and cooled gases. (Letting the candle go out and watching the water level rise as the remaining gases inside the jar cool mimics the change in volume inside the cup as that air cools.)

1. **“Charles’ law was written by Jacques Charles—who else?”**

While it is true the Jacques Charles did experiments with gas relationships, some concerning the relationship between volume and temperature, he did not publish his results. Fifteen years after Charles did his experiments, Joseph Gay-Lussac performed experiments with gases and also discovered the relationship between the volume and temperature. He documented his work and published it, naming the relationship between gas volume and temperature Charles’ law in honor of Jacques Charles. (<https://www.sciencehistory.org/historical-profile/joseph-louis-gay-lussac>)

1. **“Cupping must hurt, eh?”**

Even though the bruises look like they would be painful, bruises caused by cupping are not. We are used to bruises accompanied by pain, but that is because the common bruise has been caused by blunt force trauma and it is that trauma which causes the painful muscle and tissue damage. In a *Medical News Today* article, “I Tried Cupping and This is How it Felt,” author Tim Newman describes his experience. There were moments during the experience that he said were a little painful. He also said that the bruises he acquired from the experience were not painful even the next day. Overall, he felt it was relaxing and seemed to make his back and neck feel better. (<https://www.medicalnewstoday.com/articles/320707.php>)

### Anticipating Student Questions

1. **“What conditions has cupping therapy been used to treat?”**

Cupping has been used to treat multiple ailments over the years. Athletes prone to sports injuries often use cupping to treat pain, ease scar tissue deep within muscles and connective tissues, and reduce swelling and muscle knots. Cupping is claimed to promote increased circulation so that circulating toxins can be drawn into the skin where they are more easily removed and the immune system is stimulated. As a consequence, cupping is used to treat colds, chest congestion, eczema, acne, viruses like herpes zoster in shingle attacks, fibromyalgia, diabetes, arthritis, and gout. Cupping has also been used to treat anxiety, depression, insomnia, high blood pressure, and varicose veins. There has even been an increase in the use of cupping for facial rejuvenation.

In a blog post from the Pacific College of Oriental Medicine the author reports that

Cupping is one of the best deep-tissue therapies available. It is thought to affect tissues up to four inches deep from the external skin. Toxins can be released, blockages can be cleared, and veins and arteries can be refreshed within these four inches of affected materials.

(<https://www.pacificcollege.edu/news/blog/2014/09/20/many-benefits-chinese-cupping>)

1. **“Are there any medical complications caused by cupping?”**

Cupping is a relatively safe procedure where patients encounter very few adverse medical complications. The bruising that is caused by the accumulation of blood under the cups on the skin is not painful like bruising that is the result of trauma. The possible side effects of cupping include light headedness and dizziness, sweating, and nausea. Blistering can be a problem if the cups are left in place for an extended period of time. If fire cupping is performed, then burns and resulting skin infection may be encountered. It is important that the practitioner follow precautions to prevent the introduction and spread of infection while performing a cupping. In wet cupping, where a lancet is used to pierce the skin so that blood will actually be removed from the body, there is an increased risk of skin infection. Cupping should not be used on patients who are on blood thinners, bleed easily or can’t stop bleeding, have skin ulcers or swelling. It is also unwise to cup over large blood vessels.

1. **“Why are small cups used on bony parts of the body, while larger cups are used on the fleshier parts?”**

Small cups are used on bony parts of the body because the cup needs to make a seal with the skin and it is harder for the larger cups to make a seal on areas of the body that are not flat. Smaller cups are typically used on the tops of the shoulders, the collar bone area, and on the vertebrae of the back.

Large cups are used on the flatter areas of the back and shoulders as well as the thighs.

1. **“How much does cupping typically cost?”**

A half-hour cupping session generally costs between $30 and $80.

1. **“The article mentions the science behind the placebo effect. What *is* the science behind this effect?**

The placebo effect is a psychological phenomenon that demonstrates the power of suggestion, where the act of treatment either in the form of taking a pill or injection that does not contain the active ingredient being studied produces results similar to those seen in persons taking the actual treatment. It is not entirely understood but underscores the power of positive thinking over brain chemistry. In studies evaluating drugs designed to treat Parkinson’s disease, pain, or depression, PET brain scans revealed that the expectation of benefit in the placebo group activated the same natural pathways in the brain as the medication. Therefore, in drug testing it is very important to have three groups of patients in the trial. One group receives the treatment, a second group does not receive any treatment, and a third group receives the same treatment as the first group without the active ingredient added to the pill or injection. In order for a medication to be judged effective, the group receiving the drug must perform statistically better than the group receiving the placebo.

Not all anticipatory effects are positive; sometimes a negative outcome can be anticipated. For example, if the patients are informed that headaches might be a side effect of the medication, some of the patients getting the placebo might develop headaches. This phenomenon of anticipating a negative outcome is referred to as a *nocebo* effect. The placebo effect is not entirely understood and is of interest to many brain researchers. If the power of the placebo effect could be harnessed, it could improve the treatment of some patients. Robert Buckman, a clinical oncologist and professor of medicine summarizes the interest in placebos in the following statement:

Placebos are extraordinary drugs. They seem to have some effect on almost every symptom known to mankind, and work in at least a third of patients and sometimes in up to 60 percent. They have no serious side-effects and cannot be given in overdose. In short, they hold the prize for the most adaptable, protean, effective, safe and cheap drugs in the world’s pharmacopeia. (<https://www.medicalnewstoday.com/articles/306437.php>)

1. **“Could you just use suction cups and pull the skin up that way?”**

Yes. While some practitioner’s still use fire cupping with glass jars or cups, others use plastic cups outfitted with a valve that can be attached to a small handheld pump to extract the air from the cup, effectively doing away with the need for fire. The suction is easier to adjust with these newer cups. Some cups are now made of flexible transparent silicone which can be squeezed to remove some of the air before placing them on the skin. They are shaped similarly to the traditional glass cups.

### Activities

**Labs and demos**

**“Make the Water Rise”:** A tea light floating on a shallow plate of water is covered by a glass cylinder. When the flame is extinguished, water rises into the cylinder carrying the tea light with it, similar to the way a person’s skin is drawn into a cupping cup. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/make-the-water-rise>.)

**“Gas Law Lab”:** Students rotate through 7–8 stations to perform a series of gas-law experiments. Complete instructions and a video to show the teacher how to set up each experiment is included.

(<https://betterlesson.com/lesson/638115/gas-laws-lab>)

**Simulations**

**“Gas Law Simulation”:** Students can manipulate the temperature, pressure, and volume of a sample of gas while watching the resulting graph of the changes. Questions and problems are provided for students to answer during their exploration. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/gas-laws-simulation>.)

**Virtual chemistry gas law lab**: In these Boyle’s law, Charles’ law, and Gay-Lussac’s law labs, students manipulate the knobs of the equipment and observe the response. Student instructions are linked to a lab manual, while the lab sheet is an Excel worksheet to graph the data. (<https://www.uccs.edu/vgclintro/gas-laws> )

**Media**

**“Cupping Therapy” video (2:50):** This video shows a practitioner giving a cupping massage using fire cupping and another giving cupping massage using a manual suction system. (<https://www.youtube.com/watch?v=lv0cp6RfO-0>)

**“6 Reasons Everyone Should Try Cupping Therapy” (3:27)**: Besides demonstrating cupping, this video discusses six conditions that cupping is used to treat. (<https://www.youtube.com/watch?v=56Kmw6AaFEM>)

**Lessons and lesson plans**

**“The Gas Laws Unit Plan”:** This 7–10 day unit plan is a compilation of several labs, activities, simulations, a video, and four demonstrations (including the egg-in-a-flask and balloon-in-a-flask demos that illustrate the effects of pressure changes) to help students explore and understand gas relationships. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/the-gas-laws-unit-plan>.)

**Gas-law lesson:** This three-day lesson plan involves a primary lesson covering the gas laws, followed by a hands-on exploration of activities that employ the laws, and concludes with a quiz over the gas laws.

(<http://www.cpalms.org/Public/PreviewResourceLesson/Preview/127952>)

**Projects and extension activities**

**Gas-pressure kinesthetic class activity:** Students gain a better understanding of what causes pressure in a container by role-playing gas molecules within a container as the volume and temperature of the gas change, while some of their classmates use a piece of rope around them to represent the container.

(<https://teachchemistry.org/classroom-resources/gas-pressure>)

**Experimental design activity:** Students could be assigned to different “research” groups where they design a study that would test the physical and psychological effectiveness of cupping. You may provide students with additional information on designing studies, like those below, to use while they formulate their ideas and, after the students complete an outline of their study, they can present it to the class for peer review.

* This article provides the basic steps of conducting a research study and gives numerous links at the end of the article for further exploration of conducting research in psychology. (<https://www.verywellmind.com/steps-of-the-scientific-method-2795782>)
* The experimental design chapter from the book *Research Methods in Psychology* provides extensive information about using a placebo in an experiment and is accompanied by a thorough explanation of the placebo effect in research studies. (<https://opentextbc.ca/researchmethods/chapter/experimental-design/>)

### References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles published from the magazine’s inception in October 1983 through April 2013; all**

**available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [***http://www.acs.org/chemmatters***](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get 30 Years of *ChemMatters* Magazine!” (the icon on the right of the screen).**

**Selected articles and the complete set of Teacher’s Guides for all issues from the past three years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



In “Model Rockets: Chemistry for Lift-off”, author Rohrig applies Charles’ law to rocketry, as he explains how escaping gases provide the thrust for lift-off.

(Rohrig, B. Model Rockets: Chemistry for Lift-off. *ChemMatters*. 2001, *19* (2), pp 13–15)

“Hot Air Balloons: Gas and Go” presents some history behind the discovery of Charles’ law and how it is applied to hot air balloons. Instructions for making a hot air balloon as a class activity follows the article. (Vanderborght, C. Hot Air Balloons: Gas and Go. *ChemMatters*. 2002, *20* (2), pp 4–6)

Author Michalovic includes considerable biographical information about Joseph-Louis Gay-Lussac in this article about the rivalry between Gay-Lussac and Humphrey Davy during the discovery of Iodine. (Michalovic. M. “ChemHistory”: The Race for Iodine. *ChemMatters*. 2006, *24* (4), p 18–19)

In “Fireworks!” author DeAntonis uses Charles’ law to help explain the chemistry of fireworks. (DeAntonis, K. Fireworks! *ChemMatters*. 2010, *28* (3), pp 8–10)

In “What Makes Magic Tricks Tick”, author Tinnesand includes a discussion of the demonstration of a hard-boiled egg being drawn into a flask that has been heated and is cooling (very similar to the result of cupping), in the section titled “Performing Under Pressure”.

(Tinnesand, M. What Makes Magic Tricks Tick. *ChemMatters*, 2010, *28* (3), pp 5–7)

### Web Resources for More Information

**History of cupping**

At this site, the history of cupping is presented as it was practiced in cultures around the world.

(<https://cuppingresource.com/history-of-cupping/>)

This site contains information about the history, as well as the practice, of cupping.

(<http://www.greekmedicine.net/therapies/Hijama_or_Cupping.html>)

**Cupping procedures**

“Cupping Therapy: An Overview from a Modern Medicine Perspective” contains information about cupping and proposes a classification scheme for the different types.

(<https://www.sciencedirect.com/science/article/pii/S2005290117302042>)

**Cupping studies**

This paper conducts a literature search and meta-analysis using six research trials to assess the effectiveness and safety of using cupping.

(<https://www.sciencedirect.com/science/article/pii/S2095754814000040>)

This abstract summarizes the biochemical reactions that are initiated by increased tissue blood flow to an area with resulting capillary rupture and the antioxidant, anti-inflammatory, and neuromodulatory effects observed in animal and human systems.

(<https://www.ncbi.nlm.nih.gov/pubmed/29122256>)

**Placebo effect**

This paper presents information on how placebos are used and cites some studies where the placebo effect refutes the effectiveness of the treatment.

(<https://www.medicalnewstoday.com/articles/306437.php>)

This site provides information about placebos and their role in medical research.

(<http://n.neurology.org/content/neurology/71/9/e25.full.pdf>)

**Scientific inquiry and experimental design**

The experimental design chapter from the book *Research Methods in Psychology* provides extensive information about using a placebo in an experiment. It is accompanied by a thorough explanation of the placebo effect in research studies.

(<https://opentextbc.ca/researchmethods/chapter/experimental-design/>)

This paper provides insight into scientific inquiry applied in psychological research, including links at the end of the article for further exploration.

(<https://www.verywellmind.com/steps-of-the-scientific-method-2795782>)

**Charles’ law**

This article is an explanation of the gas law.

(<https://www.scientificamerican.com/article/what-is-charles-law/>)

This site provides additional information including graphics about Charles’ law.

(<http://scienceprimer.com/charles-law>)

**Gay-Lussac’s (or Amontons’) law**

This site contains a tutorial, simulation, and video that demonstrate and explain examples.

(<https://www.ck12.org/c/chemistry/gay-lussacs-law/>)

This is a lesson on Amontons’ law, from Pearson education group. [Note that the Kelvin temperature data in the table is offset by one row.]

(<https://chemdemos.uoregon.edu/demos/Amontons-Law>)

This chapter on the gas laws from a free, online chemistry textbook refers to both Amontons and Gay-Lussac in the establishment of the pressure-temperature relationship.

(<https://chem.libretexts.org/Textbook_Maps/General_Chemistry/Book%3A_Chemistry_(OpenSTAX)/09%3A_Gases/9.2%3A_Relating_Pressure%2C_Volume%2C_Amount%2C_and_Temperature%3A_The_Ideal_Gas_Law>)

**Possible class discussion (debate?) on cupping as a legitimate treatment**

This BBC video (5:26) demonstrates dry cupping done by a chiropractor, while another invited guest refutes cupping and chiropractic as rubbish. This video might be a good segue into a pro-con discussion about cupping.

(<https://www.youtube.com/watch?v=JBnZdxCUXbk>)

In this video (9:00), an anatomy teacher and cupping practitioner explains the different aspects and results of cupping, including the interpretation of the color of the welts produced.

(<https://www.youtube.com/watch?v=FW6FXcDi5oM>)

**Articles that do not support the use of cupping in modern medicine**

This article presents a case, complete with photographs, where cupping created a life-threatening situation for the patient.

(<http://scienceblogs.com/insolence/2016/07/01/whats-the-harm-cupping-edition/>)

### Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article, and then locate and analyze information from the article.

* **Anticipation Guide (p 76):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**Cupping: Harmless Fad or Sound Science?**

* Before reading, ask students if they have noticed circular welts on athletes such as Michael Phelps on television and if they know what causes the welts.
* Ask them how they think cupping relates to chemistry concepts.
* As they read, students should relate how cupping works to gas laws.
* **Graphic Organizer (p 77):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (pp 78–9):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Anticipation Guide

**Directions: *Before reading***, in the first column, write “A” or “D” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Cupping has only been used for about 20 years to improve blood flow. |
|  |  | 1. Before being placed on the skin, the air inside the cups is heated so that the air molecules move further apart. |
|  |  | 1. Larger cups are placed on fleshy areas of the body. |
|  |  | 1. The air pressure inside the heated cup stays constant as long as the cup is open. |
|  |  | 1. When air molecules slow down, the air pressure rises. |
|  |  | 1. The cups used for cupping are made of flexible materials. |
|  |  | 1. Some cupping therapists today use vacuum pumps to change the air pressure on the skin. |
|  |  | 1. The red welts produced by cupping are due to broken blood capillaries. |
|  |  | 1. Cups remain on the skin until the pressure inside and outside the cup is equalized. |
|  |  | 1. The placebo effect makes it difficult to carry out a randomized control trial to determine whether cupping is effective. |

### Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions:** As you read the article, complete the graphic organizer below to describe how cupping is related to gas laws.

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Before cupping*** | ***During cupping*** | ***What materials are used?*** |
| **Temperature:**  *Low or high?*  *How is it changed?* |  |  |  |
| **Pressure**  *Low or high?*  *How is it changed?* |  |  |  |
| **Volume**  *Low or high?*  *How is it changed?* |  |  |  |

**Summary:** On the back of this paper, write a once-sentence summary (15-18 words) of how cupping works. Then write one sentence explaining whether you would try cupping, with reasons.

### Student Reading Comprehension Questions

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

1. What is cupping?
2. What is the placebo effect?
3. Where and when did cupping originate?
4. According to practitioners, how does cupping work?
5. What is a negative side effect of cupping?
6. (a) Name the gas law and (b) write the mathematical equation associated with the expansion of gases in direct proportion to their temperature.

**Student Reading Comprehension Questions, cont.**

1. Explain why the pressure inside the heated cup remains the same as before heating.
2. So, then why does the air pressure inside the cup after it is placed on the body decrease when the air inside the cup cools?
3. How does the type of container affect gas behavior during temperature changes?
4. What causes the discoloration, or ecchymosis, seen on the bodies of persons who are cupping?
5. What is the main reason doctors are skeptical of the effectiveness of cupping?

**Critical-Thinking Question**

***Write your answer on another piece of paper if needed.***

* + 1. Describe the design flaw in most studies that try to assess the effectiveness of cupping and propose how this flaw could be overcome.
    2. The air in a cup is heated to 60.0 °C, and the cup is placed on Michael’s shoulder. What will be the pressure inside the cup when the air inside cools down to a room temperature of   
       27.0 °C at 1.0 atmosphere pressure?

### Answers to Reading Comprehension Questions

1. **What is cupping?**

Cupping is an ancient medical practice that involves applying warm cups to the skin in an effort to improve blood flow to that area of the body and boost performance.

1. **What is the placebo effect?**

The placebo effect is where the mind convinces the body that a treatment is working.

1. **Where and when did cupping originate?**

Cupping originated in China and dates back to at least 1500 BCE.

1. **According to practitioners, how does cupping therapy work?**

Cupping practitioners claim that cupping boosts blood flow to the cupped sections of the body.

1. **What is a negative side effect of cupping?**

Cupping can cause blood vessels to break and clot, impeding blood flow.

1. **(a) Name the gas law and (b) write the mathematical equation associated with the expansion of gases in direct proportion to their temperature.**
2. Charles’ law defines the expansion of gases in direct proportion to their temperature.
3. It uses the mathematical equation V1 / T1 = V2 / T2, where T = the absolute temperature in Kelvin and V = volume.
4. **Explain why the pressure inside the heated cup remains the same as before heating.**

As the air inside the cup is heated, gas molecules speed up and some also exit the cup. Fewer gas molecules moving quickly can exert just as much pressure as a lot of air molecules moving slowly, so the pressure inside the heated cup remains the same as before heating. Students may also include this statement as part of a more complete answer: The pressure within the cup is due to molecules colliding against the walls of the container and with each other.

1. **So, then why does the air pressure inside the cup after it is placed on the body decrease when the air inside the cup cools?**

“As the air in the cup cools, the molecules slow down and collide less frequently with each other and the walls of the cup. The pressure within the cup therefore drops.”

1. **How does the type of container affect gas behavior during temperature changes?**

The behavior of a gas during temperature changes depends on the rigidity of the container. If the container cannot change its volume by expanding or shrinking, then a change in temperature in the container will lead to a change in pressure, while the volume stays constant. If the container walls are not rigid and can expand or shrink like a balloon, then a change in the temperature of the gas will lead to a change in the volume of the container, while the pressure remains the same.

1. **What causes the discoloration, or ecchymosis, seen on the bodies of persons who are cupping?**

Ecchymosis is caused by the pooling of blood underneath the skin due to the rupture of the capillaries there.

1. **What is the main reason doctors are skeptical of the effectiveness of cupping?**

Doctors are skeptical of cupping therapy because it is difficult to carry out a randomized control trial that would help evaluate whether the improvement the patient reports is due to the therapy or due to a placebo effect.

**Critical-Thinking Questions**

1. **Describe the design flaw in most studies that try to assess the effectiveness of cupping and propose how this flaw could be overcome.**

Answers will vary. The design flaw in most studies that try to assess the effectiveness of cupping is the absence of a randomized control trial. In this type of trial, the participants in the study are divided into two groups, one that receives the treatment and another that receives a placebo. Since those receiving treatment know they are being treated, it makes it difficult to know if the treatment—or their psychological response to the treatment—is causing their improvement.

* One way that this could be alleviated is to give a full treatment to one group while only going through the motions of the treatment without using full cupping suction. If the group that receives the full treatment reports the same improvement as the group only receiving the treatment with minimal suction then this would support the idea that cupping is not generating the participant’s improvement in their symptoms.
* Another way to improve the design of the experiment is to have a way to measure the improvement in symptoms rather than relying on the patient’s opinion. This might comprise measuring and comparing the degree of movement in a joint before treatment and then after treatment.
* Yet another way to try to create validity is by comparing the results of lots of studies as mentioned in the last paragraph of the Rohrig article.

1. **The air in a cup is heated to 60.0 °C and the cup is placed on Michael’s shoulder. What will be the pressure inside the cup when the air inside cools down to a room temperature of 27.0 °C at 1.0 atmosphere pressure?**

This is an application of Gay-Lussac’s law (also known as Amontons’ law):

P1 / T1 = P2 / T2

Pressure 1 = 1.0 atm, Temperature 1 = 60.0 °C or 333.1 K (60.0 + 273.1 = 333.1)

Pressure 2 = unknown, Temperature 2 = 27.0 °C or 300.1 K (27.0 + 273.1 = 300.1)

P1 / T1 = P2 / T2 and substituting,

1.0 atm / 333.1 K = P2 / 300.1 K and rearranging terms,

P2 = 300.1 K x 1.0 atm

333.1 K

P2 = 0.90 atm, the pressure inside the cup when the air cools down to room temperature

### About the Guide

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The DVD also includes Article, Title, and Keyword Indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.