

# ChemMatters<sup>®</sup>

Demystifying Everyday Chemistry

## Teacher's Guide

### DECEMBER 2019

<a href="#"><u>Vaping: What You Need to Know</u></a> .....	2
<a href="#"><u>The Battle Against Body Odor</u></a> .....	12
<a href="#"><u>The Measure of a Mole</u></a> .....	21
<a href="#"><u>The Future of Forensics</u></a> .....	32
<a href="#"><u>About the Teacher's Guide</u></a> .....	41



## Teacher's Guide

### Vaping: What You Need to Know

*December 2019*

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>3</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>4</b>
These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You'll find the questions ordered in increasing difficulty.	
<b><u><a href="#">Graphic Organizer</a></u></b>	<b>6</b>
This helps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.	
<b><u><a href="#">Answers</a></u></b>	<b>7</b>
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<b><u><a href="#">Additional Resources</a></u></b>	<b>10</b>
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>11</b>

# Anticipation Guide

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

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement with each statement. Complete the activity in the box.

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. As of publication date, more than 30 fatalities were linked to vaping in 2019.
		2. As of publication date, flavored e-cigarettes are illegal in all states.
		3. Smoking traditional cigarettes is the leading preventable cause of death in the United States.
		4. Nicotine e-cigarettes use tobacco for the nicotine.
		5. E-cigarettes produce aerosols (tiny droplets) that the user inhales.
		6. Alkaloids such as nicotine, caffeine, and fentanyl contain nitrogen.
		7. The conjugate base form of nicotine is readily absorbed by the lungs.
		8. Adding ammonium salts helps turn nicotine molecules into the conjugate base form.
		9. Flavor compounds in e-cigarettes may break down into formaldehyde.
		10. Nicotine is especially dangerous for teens because it induces a dopamine surge.

# Student Reading

## Comprehension Questions

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

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

1. Can you find all of the carbons in the THC structure on page 6? Verify that you found them all by comparing to the molecular formula.
2. How many bonds (indicate type) and how many lone pairs are on each nitrogen atom in the nicotine molecule?
3. Draw the complete Lewis structure for  $\text{NH}_3$  and  $\text{NH}_4^+$ .
4. When vaping, the user inhales an aerosol, rather than a vapor. What makes something an aerosol?
5. Classify each of the following as gas, vapor, or aerosol
  - a. Clouds in the sky
  - b. The gasoline smell from a gas station
  - c. Oxygen breathed in from the air
  - d. Cigarette smoke
  - e. Moisture in the atmosphere
  - f. Helium inside a balloon
6. How many grams of formaldehyde would be inhaled during the consumption of Gummy Bear flavored liquid in a 30 mL bottle, if its density is 1.25 g/mL?
7. Why is THC not in the same class of compounds as nicotine?
8. Biochemistry is the study of the chemical structures and processes that occur in living organisms. Small changes in the structures of molecules, like enzymes, can cause changes in how they function in an organism, which can disrupt the system. What structural change do tobacco companies utilize to increase the percentage of nicotine that the lungs will absorb from their cigarettes?

## Student Reading Comprehension Questions, cont.

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9. Look at the two chemical equations in the “One Proton Difference” box. Assume the second reaction is in equilibrium. Justify, using equilibrium principles, why adding ammonia salts will favor the conjugate base form of nicotine.
10. The Juul product is made to have a smooth feel, leading the user to think the nicotine level is low and making it popular among teens. However, it was found that the Juul liquids contained more than five times the nicotine as other similar brands. The Juul liquid contained a lower percentage of the harsher, but better-absorbing, base form of nicotine, but a higher amount of total nicotine. Propose a scientific experiment (assuming non-human test subjects) that could be done to determine how much more nicotine is absorbed when in base form as opposed to acid form.
11. A friend of yours is considering taking up vaping and says that it is totally safe, because she plans on getting the nicotine-free kind. Refute your friend’s claim using evidence from the article and reasoning to support it.

### **Questions for Further Learning**

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

1. Formaldehyde is a chemical typically used in embalming fluid. Research the effects formaldehyde has on a human body that makes it good for embalming.
2. One suggestion for helping reduce teen vaping is to pass a law that vaping liquids cannot have a pH less than 9. Explain why this proposal would likely help to reduce the numbers of teens who vape.
3. Watch a short video: <https://www.youtube-nocookie.com/embed/ELKUljEaIHl>  
Explain why vaping THC is even more dangerous than smoking it.

# Graphic Organizer

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

**Directions:** As you read, complete the graphic organizer below to compare e-cigarettes and traditional cigarettes.

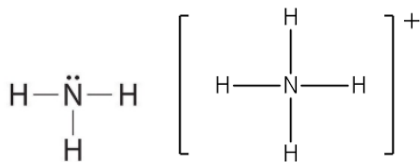
	E-cigarettes	Traditional Cigarettes
<b>Chemicals in the cigarettes</b>		
<b>Chemicals produced during use of the cigarettes</b>		
<b>Effects on the brain</b>		
<b>Flavors</b>		

**Summary:** On the back of this sheet, write a short letter to a friend who vapes describing what you learned about the harm e-cigarettes could be causing him/her.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

- Can you find all of the carbons in the THC structure on page 6? Verify that you found them all by comparing to the molecular formula.  
*In a line diagram, every angle or intersection represents a carbon (as long as there is not already another element there).*
- How many bonds (indicate type) and how many lone pairs are on each nitrogen atom in the nicotine molecule?  
*The N on the 6-membered ring has one single and one double bond and one lone pair. The N on the 5-membered ring has three single bonds and one lone pair.*

- Draw the complete Lewis Structure for  $\text{NH}_3$  and for  $\text{NH}_4^+$ .



- When vaping, the user inhales an aerosol, rather than a vapor. What makes something an aerosol?  
*An aerosol contains submicroscopic particles (if solid) or droplets (if liquid) suspended in air or another gas.*
- Classify each of the following as gas, vapor, or aerosol
  - Clouds in the sky *aerosol*
  - The gasoline smell from a gas station *vapor*
  - Oxygen breathed in from the air *gas*
  - Cigarette smoke *aerosol*
  - Moisture in the atmosphere *vapor*
  - Helium inside a balloon *gas*
- How many grams of formaldehyde would be inhaled during the consumption of the Gummy Bear flavored liquid in a 30.0 mL bottle with a density of 1.25 g/mL?

$$30.0\text{mL} \times \frac{1.25\text{g}}{\text{mL}} \times \frac{5500\mu\text{g} - \text{formaldehyde}}{1\text{g} - \text{liquid}} = 206,250\mu\text{g} \times \frac{1\text{g}}{1 \times 10^6\mu\text{g}} = 0.206\text{ g formaldehyde}$$

- Why is THC not in the same class of compounds as nicotine?  
*It does not contain a nitrogen atom.*

8. **Biochemistry is the study of the chemical structures and processes that occur in living organisms. Small changes in the structures of molecules, like enzymes, can cause changes in how they function in an organism, which can disrupt the system. What structural change do tobacco companies utilize to increase the percentage of nicotine that the lungs will absorb from their cigarettes?**

*They convert the nicotine to its base form, which is different from its acid form. The base form has been shown to absorb better into the lungs, so this change increases the amount of nicotine a user gets from the tobacco, which increases the chance of addiction.*

9. **Look at the two chemical equations in the “One Proton Difference” box. Assume the second reaction is in equilibrium. Justify, using equilibrium principles, why adding ammonia salts will favor the base form of nicotine.**

*When the ammonium salt is heated, ammonia gas forms. This ammonia will remove the acidic hydrogen on the acid form of nicotine, turning it to the base form. According to LeChâtelier’s Principle, adding more ammonia will shift the reaction toward the base form of the molecule.*

10. **The Juul product is made to have a smooth feel, leading the user to think the nicotine level is low and making it popular among teens. However, it was found that the Juul liquids contained more than five times the nicotine as other similar brands. The Juul liquid contained a lower percentage of the harsher, but better-absorbing, base form of nicotine, but a higher amount of total nicotine. Propose a scientific experiment (assuming non-human test subjects) that could be done to determine how much more nicotine is absorbed when in base form as opposed to acid form.**

*The experiment should include an independent variable (something like the amount or ratio of acid and base forms); a dependent variable (something related to the absorption in the lungs); controlled variables (all other conditions: type of heating element, dispenser, length of puff, etc.) and a plan to collect data.*

11. **A friend of yours is considering taking up vaping and says that it is totally safe, because she plans on getting the nicotine-free kind. Refute your friend’s claim using evidence from the article and reasoning to support it.**

*The discussion should contain evidence from the article, specifically that the flavors have been found to turn into many dangerous/toxic chemicals when heated.*

### Questions for Further Learning

1. **Formaldehyde is a chemical typically used in embalming fluid. Research the effects formaldehyde has on a human body that makes it good for embalming.**

*It works by irreversibly connecting cell proteins to other proteins or to DNA through covalent bonds. This stops the cells from being able to function and provides a firmness to the deceased person’s skin, so their body looks more normal for several days.*

2. **One suggestion for helping to reduce teen vaping is to pass a law that vaping liquids cannot have a pH less than 9. Explain why this proposal would likely help to reduce the numbers of teens who vape.**

*At a pH of 9, the base form of nicotine would be prevalent in the solution. Since this has a much harsher feel when inhaled, it is likely that younger people would be less inclined to use it.*

3. **Watch the short video at the following link: <https://www.youtube-nocookie.com/embed/ELKUljEaIHl> Explain why vaping THC is even more dangerous than smoking it.**

*It makes the user inhale a much more concentrated and pure form of the THC, which can be more dangerous.*



## Graphic Organizer Rubric

If you use the Graphic Organizer 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

## Additional Resources

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### Labs and demos

A demo of something that decomposes easily with heat would be useful to show students that the things that go into the e-cigarette are not the same as the thing that comes out. Try out this demo from AACT: Sterno – In this demo, students will observe a decomposition reaction that triggers a precipitate reaction that prevents a solution from conducting electricity. <https://teachchemistry.org/classroom-resources/sterno>

### Simulations

Understand the structure of acids and bases: [https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions\\_en.html](https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html)

### Projects and extension activities

This website: <https://teens.drugabuse.gov/> has a lot of good resources for both teens and teachers! This C&EN article has additional background information on this subject – Hunting for the cause of mystery vaping illnesses: <https://cen.acs.org/biological-chemistry/toxicology/Hunting-cause-mystery-vaping-illnesses/97/web/2019/10>

This FDA site has some infographics to discourage teen vaping: [https://digitalmedia.hhs.gov/tobacco/print\\_materials/search?tag=E-cigarettes%2Fvaping](https://digitalmedia.hhs.gov/tobacco/print_materials/search?tag=E-cigarettes%2Fvaping)

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Acids and Bases
  - Acid-base reactions
- Organic Chemistry
  - Functional groups
  - Pharmaceuticals
- States of Matter

## Correlations to Next Generation Science Standards

This article can be used to achieve the following performance expectations of NGSS:

**HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

### Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter

### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation.
- Scale, Proportion, and Quantity
- Structure and Function

### Science and Engineering Practices:

- Asking questions (for science) and defining problems (for engineering)

### Nature of Science:

- Scientific knowledge is based on empirical evidence.
- Science addresses questions about the natural and material world

See how *ChemMatters* correlates to the [Common Core State Standards online at www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Teaching Strategies

Consider the following tips and strategies for incorporating this article into your classroom:

- Alternative to Anticipation Guide: Before reading, ask students what they know about vaping, and possible dangers of vaping. As they read, students can find information to confirm or refute their original ideas.
- Ask students to find other consumer products containing glycerin and propylene glycol, two compounds found in the liquid for e-cigarettes, and compare their health effects.
- This article could be used during a unit on structure and bonding, as a phenomenon around which to base the lesson. (NGSS Connection: HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.)
- This could also be used to design a unit involving equilibrium (and possibly kinetics). The focus could be on why some liquids are much more harsh than others and why this is essentially tricking young people into using them. (NGSS Connection: HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.)

# ChemMatters™

Demystifying Everyday Chemistry

## Teacher's Guide

### The Battle Against Body Odor

***December 2019***

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<b><u><a href="#">Anticipation Guide</a></u></b>	<b>13</b>
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# Anticipation Guide

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

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement with each statement. Complete the activity in the box.

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. Hi-tech clothes that fight body odor include nanoparticles of silver.
		2. Reactive oxygen species (ROS) in cells can damage DNA.
		3. Strands of DNA are held together by hydrogen bonds.
		4. Sweat is mostly water.
		5. The pungent smell of sweat is caused by harmful bacteria.
		6. Compounds in sweat are broken down by enzymes in skin bacteria to produce less smelly shorter molecules.
		7. Silver has been used as an antibacterial agent for about 25 years.
		8. Research studies suggest that bacteria may evolve to become resistant to silver.
		9. Silver nanoparticles stay on clothes when they are washed.
		10. Everyone has basically the same species of bacteria on their skin.

# Student Reading

## Comprehension Questions

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

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

1. How much smaller is a nanometer compared to a meter? What could be measured using this tiny unit?
2. What are electrolytes? What are metabolites?
3. What substance in the body causes body odor? How does it work?
4. In DNA, how does hydrogen bonding work in guanine and cytosine bonds?
5. What happens to the effectiveness of antibiotics over time if used too much?
6. What exactly do silver ions “attack” to prevent odor from occurring?
7. Give a brief description of how bacteria live and produce odor. Explain how silver nanoparticles interrupt this process.
8. Compare the structure of guanine to 8-oxoguanine. What are the differences between the structures? How would that affect how guanine attracts to cytosine?
9. Research and sketch the basic structure of 8-oxoguanine. Compare it to thymine. Explain how they are similar and how that could affect DNA structure.
10. How can silver be used in health or medicine? Provide some examples.

## Student Reading Comprehension Questions, cont.

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11. In the 1800s, food utensils made of silver were popular, and not just for their nice looks. How would silver be useful in food preparation and eating?
12. If silver nanoparticles wash off easily, how may that affect the environment? What would be the most effective way to incorporate silver into clothing that would keep the chemical from washing off and going into the environment?

### Questions for Further Learning

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

1. Research how silver waste could affect water and aquatic life.
2. List the pros and cons for using silver nanoparticles in products. Use the article, but also do a little research of your own. What is your opinion on when and how much we should be using silver nanoparticles in products?

# Graphic Organizer

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

**Directions:** As you read, complete the graphic organizer below to describe how silver nanoparticles (AgNPs) used in specialty clothing fight body odor.

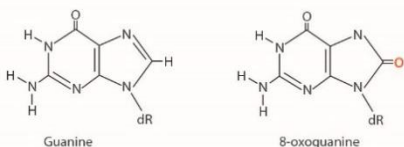
	Size	Effect on DNA	Effect on commensal bacteria
AgNPs			
Components of sweat			
Compare sweat from different people			
Possible problems with use of AgNPs			

**Summary:** In the space below, or on the back of this paper, write three new things you learned about using AgNPs in hi-tech clothing.



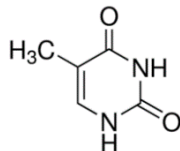
## Answers to Reading Comprehension Questions & Graphic Organizer Rubric

- 1. How much smaller is a nanometer compared to a meter? What could be measured using this tiny unit?**  
*A nanometer is one billionth of a meter ( $1 \times 10^{-9}$  meter). Sizes of objects on the atomic scale are measured with this unit (atoms, protons, neutrons). We also measure electromagnetic waves with this unity of length (wavelength).*
- 2. What are electrolytes? What are metabolites?**  
*Electrolytes are compounds that dissociate (split up) into ions when dissolved in water. Metabolites are specific molecules produced in your body through chemical processes.*
- 3. What substance in the body causes body odor? How does it work?**  
*Commensal bacteria that lives on skin react and convert chemicals in sweat into foul smelling substances.*
- 4. In DNA, how does hydrogen bonding work in guanine and cytosine bonds?**  
*The oxygen atom in guanine has a strong pull on its shared electrons. This gives oxygen a partial negative charge, which is attracted to the partial positive charge of the hydrogen on cytosine.*
- 5. What happens to the effectiveness of antibiotics over time if used too much?**  
*Some overuse of antibiotics has led to strains of bacteria that are resistant to the antibiotics. This leads to bacteria that cannot be killed through usual means.*
- 6. What exactly do silver ions “attack” to prevent odor from occurring?**  
*Silver ions “attack” (react with) DNA in bacteria that produces the odor-producing molecules.*
- 7. Give a brief description of how bacteria live and produce odor. Explain how silver nanoparticles interrupt this process.**  
*Instead of trying to destroy the odor producing molecules, scientists destroy the bacteria that create these molecules. Silver nanoparticles release silver ions, which produce reactive oxygen species (ROS). These ROS transforms guanine into 8-oxoguanine, which affects the genetic code in DNA.*
- 8. Compare the structure of guanine to 8-oxoguanine. What are the differences between the structures? How would that affect how guanine attracts to cytosine?**  
*When guanine is converted to 8-oxoguanine, one hydrogen atom is replaced by an oxygen atom (giving the molecule one extra oxygen atom). That gives the molecule a completely different structure that cannot properly combine with cytosine.*



9. **Research and sketch the basic structure of 8-oxoguanine. Compare it to thymine. Explain how they are similar and how that could affect DNA structure.**

*8-oxoguanine has two oxygen atoms in its structure, which makes it similar to the structure of thymine. It will then pair with cytosine. This changes the structure of the DNA, which changes the genetic code.*



10. **How can silver be used in health or medicine? Provide some examples.**

*Use this website: <https://www.silverhealthinstitute.com/> for examples.*

11. **In the 1800s, food utensils made of silver were popular, and not just for their nice looks. How would silver be useful in food preparation and eating?**

*Use this YouTube link for reference: <https://youtu.be/swSj0eAdA-k>. The antibacterial properties of silver would kill bacteria in the foods people ate then. This is the reason we are using silver now for anti-bacterial purposes.*

12. **If silver nanoparticles wash off easily, how may that affect the environment? What would be the most effective way to incorporate silver into clothing that would keep the chemical from washing off and going into the environment?**

*Silver that is washed off of clothes can go into nearby bodies of water. They can then be ingested by aquatic animals, or absorbed by aquatic plants. The silver can then alter the DNA of these organisms in the same way they alter the DNA of the odor producing bacteria. To limit this, the best way to incorporate silver into clothes is through electrostatic bonding or AgCl (silver chloride) coating.*

### Questions for Further Learning

*Student answers will vary, be sure each student discusses the points of emphasis in their response.*

## Graphic Organizer Rubric

If you use the Graphic Organizer 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

## Additional Resources

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### Labs and demos

What is the best way to remove silver ion from an aqueous solution?

[http://www.webassign.net/labsgraceperiod/tccgenchem1l1/lab\\_6/manual.html](http://www.webassign.net/labsgraceperiod/tccgenchem1l1/lab_6/manual.html)

Silver Test Tube Holiday Ornament – In this lab, students will carry out a reduction reaction in order to create a silver-plated test tube that can be used as a holiday ornament. <https://teachchemistry.org/classroom-resources/silver-test-tube-holiday-ornament>

### Simulations

Comparing attractive forces – This AACT simulation allows students to experience the difference between intermolecular forces, including hydrogen bonding: <https://teachchemistry.org/classroom-resources/comparing-attractive-forces-simulation>

### Videos

Medical uses of silver: <https://youtu.be/U3LwYzB41xc>

Seven facts about silver nanoparticles: <https://youtu.be/Yz6LuH-11II>

Microscope view of silver-killing bacteria: <https://youtu.be/AZrAOKBLG-Q>

History of antimicrobial silver: <https://youtu.be/swSj0eAdA-k>

### Lesson plan

Modeling DNA structure – In this lesson, students learn more about DNA structure and function:

[https://florida.pbslearningmedia.org/resource/tdc02.sci.life.repro.lp\\_dnastructure/modeling-dna-structure/](https://florida.pbslearningmedia.org/resource/tdc02.sci.life.repro.lp_dnastructure/modeling-dna-structure/)

### Further reading and research

How Nanosilver Zaps Germs: <https://cen.acs.org/articles/90/i30/Nanosilver-Zaps-Germs.html>

Silver nanoparticles in clothing wash out – and may threaten human health and the environment:

<http://theconversation.com/silver-nanoparticles-in-clothing-wash-out-and-may-threaten-human-health-and-the-environment-90309>

Infographics on silver: <https://www.compoundchem.com/?s=silver>

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Molecules & Bonding
  - Intermolecular forces
- Organic Chemistry
  - Molecular structure
- Quantitative Chemistry
  - SI Units

## Correlations to Next Generation Science Standards

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

### Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter
- ETS1.B: Developing Possible Solutions

### Crosscutting Concepts:

- Scale, Proportion, and Quantity
- Structure and Function

### Science and Engineering Practices:

- Constructing explanations and designing solutions
- Asking questions (for science) and defining problems (for engineering)

### Nature of Science:

- Science is a human endeavor.
- Science addresses questions about the natural and material world

See how *ChemMatters* correlates to the [Common Core State Standards](http://www.acs.org/chemmatters) online at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Teaching Strategies

Consider the following tips and strategies for incorporating this article into your classroom:

- Alternative to the Anticipation Guide provided: Before reading, ask students if they have seen specialty clothing designed to fight body odor. Ask them how they think the clothing might work, and if there may be drawbacks to using the clothing. As they read the article, students should look for answers to their questions.
- Encourage students to watch the video (Can Silver Nanoparticles Combat Your Stink?) after their reading. The video summarizes much of the information in the article, and presents pros and cons of using silver nanoparticles in workout clothing. Find the video here: <https://youtu.be/3UcnYMFTzFQ>.
- Have students do the Super Silver word puzzle below. Also found online at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Super Silver

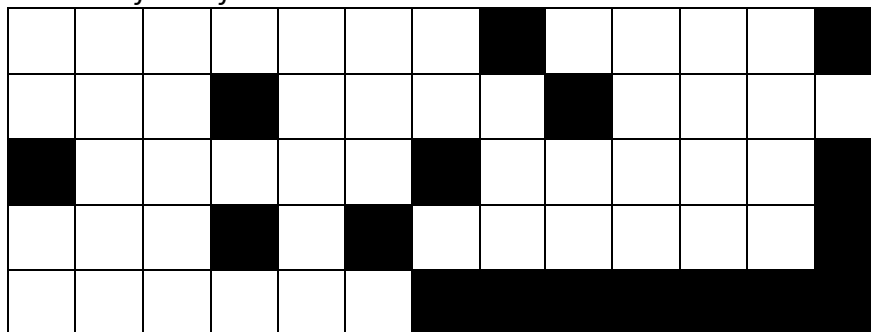
Silver's antimicrobial properties, amazing conductivity, and beautiful luster make it a go-to metal for a lot of uses. Find 16 of them hidden forwards, backwards, up, down, and diagonally in the letters below; note that some answers are plural. The remaining letters, when read left to right and top to bottom, will spell out why the werewolves were afraid of the thunderstorm.

S S C B E R A W T A L F C  
 T B O B A N G S N A P S L  
 A A M L E S R E T L I F O  
 I L P C A A S O L D E R U  
 N L A H Y R L E W E J U D  
 E B C S O E P T H E S Y S  
 D E T H A T D A R E E A E  
 G A D D T C O I N S V H E  
 L R I A T E V G E E O R D  
 A I S Y C L O U R D L H I  
 S N C A S A S I L A G S N  
 S G V R O R R I M E P R G  
 L S I C I R C U I T S H N  
 I N D E O D O R A N T G Y

Uses

1)		2)	
3)		4)	
5)		6)	
7)		8)	
9)		10)	
11)		12)	
13)		14)	
15)		16)	

Why were the werewolves afraid of the thunderstorm?



## Answers

S S C B E R A W T A L F C  
 T B O B A N G S N A P S L  
 A A M L E S R E T L I F O  
 I L P C A A S O L D E R U  
 N L A H Y R L E W E J U D  
 E B C S O E P T H E S Y S  
 D E T H A T D A R E E A E  
 G A D D T C O I N S V H E  
 L R I A T E V G E E O R D  
 A I S Y C L O U R D L H I  
 S N C A S A S I L A G S N  
 S G V R O R R I M E P R G  
 L S I C I R C U I T S H N  
 I N D E O D O R A N T G Y

## Uses

1)	Jewelry	Silver was first refined as early as 5,000 BCE; although prone to tarnish, its luster and shine has made it popular for jewelry and other decorative items.
2)	Flatware	Along with the “good china,” many families also have forks, spoons, etc., made from sterling silver for formal occasions. Sterling silver is an alloy of 92.5% silver by mass and another metal, usually copper, added increase hardness.
3)	Mirror	A thin layer coated on the back of a pane of glass forms an almost completely reflective surface. Additional coatings, such as SnCl <sub>2</sub> , Cu, and Al, help with adhesion and protect Ag from corrosion.
4)	Cloud seeding	Silver iodide and other salts are sometimes dispersed into clouds to become nucleation sites that encourage the formation of raindrops. Although the practice has been around since the 1940’s, evidence of whether it is actually effective in producing rain is mixed at best.
5)	Coins	Silver has been used as currency since 1100 BCE. Modern coins are made of zinc and other base metals, as silver has become too valuable.
6)	Compact disc	Silver is part of the thin layer of reflective metals used in CDs, DVDs, and other storage media..
7)	Photography	When photography first became popular, it relied on plastic film coated with silver halides that reduced to silver particles in the presence of light. While digital photography has largely replaced film, it is still used for high-resolution work and x-rays.
8)	Deodorant	Some “all-natural” deodorants rely on the antimicrobial properties of silver to minimize smells caused by bacteria.
9)	Circuits	Silver is the most efficient conductor of all the metals, making it useful for electrical contacts and printed circuits
10)	Ball bearings	A coating of silver acts as both a strengthener and lubricant on steel ball bearing surfaces.
11)	Bang snaps	Silver fulminate explodes under friction or pressure; small quantities are used in bang snaps and Christmas crackers to provide a little “pop.”
12)	Solar panels	Silver paste is coated onto solar panels to help transform light into electricity.
13)	Filters	Silver is a component in many filters and water-purifications systems to remove bacteria. It is removed from water before drinking to prevent

The Batter Against Body Odor, December 2019

		argyria (permanent blue-grey discoloration of the skin, due to ingestion of silver).
14)	Gloves	Tiny silver filaments are embedded in the fingertips of some gloves to allow the conductivity needed for touch-sensitive gloves.
15)	Stained glass	Used with certain paints and clays, silver compounds provide a range of yellow to orange colors.
16)	Solder	An alloy of tin, plus 3-4% silver and 0.5-0.7% copper, is a common alternative to lead solders.

*Why were the werewolves afraid of the thunderstorm?*

B	E	C	A	U	S	E		T	H	E	Y	
H	A	D		R	E	A	D		T	H	A	T
	E	V	E	R	Y		C	L	O	U	D	
H	A	S		A		S	I	L	V	E	R	
L	I	N	I	N	G							

# ChemMatters™

Demystifying Everyday Chemistry

## Teacher's Guide

### When Winter is Too Cold

***December 2019***

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>25</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>26</b>
These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You'll find the questions ordered in increasing difficulty.	
<b><u><a href="#">Graphic Organizer</a></u></b>	<b>28</b>
This helps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.	
<b><u><a href="#">Answers</a></u></b>	<b>29</b>
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<b><u><a href="#">Additional Resources</a></u></b>	<b>31</b>
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>32</b>



# Anticipation Guide

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

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

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. A polar vortex is a large mass of high-pressure cold air swirling above both the North and South poles.
		2. Air speeds in a polar vortex are as fast as a category-5 hurricane.
		3. The air in the jet stream travels more slowly than the polar vortex air.
		4. Oceans warm more quickly than land.
		5. There are two types of polar vortices.
		6. Rome, Italy, experiences several days of snow every year.
		7. The Arctic is warming more slowly than anywhere else in the world.
		8. Scientists hypothesize that when temperature differences are smaller, the jet stream is weaker and breaks, allowing a polar vortex to move into more temperate latitudes.
		9. Scientists have been collecting variations in polar outbreaks for 100 years.
		10. Weather news reporters may oversimplify polar outbreak explanations to make the phenomena easier to understand.

# Student Reading

## Comprehension Questions

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

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

1. What is a circumpolar vortex?
2. What are Rossby waves and how do changes in their location impact a jet stream?
3. List events that may cause Rossby waves to move to higher sections of the troposphere.
4. Which atmospheric layer contains the ozone layer?
5. What happens to air masses when a jet stream weakens?
6. What happened to the stratospheric polar vortex as a result of its warming in February of 2018?
7. Describe the subtropical jet stream and how it relates to the tropospheric polar vortex.
8. Compare and contrast the tropospheric polar vortex with the stratospheric polar vortex.
9. Explain the roles of conduction and density in the movement of air masses.
10. What is the primary cause of the strong polar jet stream?

## Student Reading Comprehension Questions, cont.

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### Questions for Further Learning

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

1. Examine the graph of average monthly arctic sea ice extent. What patterns do you notice? How might those patterns be explained?
2. Explain how the melting of sea ice may contribute to an increase in the surface temperature of water in the Arctic.
3. Review the graph of CO<sub>2</sub> during ice ages and warm periods. In parts per million, what is the difference in the level of carbon dioxide for 2018 and the highest previous concentration? Perform research to determine at least three activities that may contribute to high levels of carbon dioxide and how those causes could be mitigated.
4. While an occasional snow day may be cause for celebration, a polar vortex event is not. Research the impacts of a polar vortex on people, plants, and/or animals. Design a public service announcement (PSA) to inform others of these impacts and how they can be avoided.

# Graphic Organizer

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

**Directions:** As you read, complete the graphic organizer below to compare the two types of polar vortices and how they may move to more temperate areas of the Earth.

	Tropospheric Polar Vortex	Stratospheric Polar Vortex
<b>Location</b>		
<b>Effect on weather in a normal year</b>		
<b>How a polar outbreak can occur</b>		
<b>Rossby waves</b>		
<b>Severity of polar outbreak</b>		
<b>Hypothesis for polar outbreak</b>		

**Summary:** On the back of this paper, write a one-sentence summary (18 words or less) explaining how unusually cold weather may be caused by Arctic warming.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**1. What is a circumpolar vortex?**

*A circumpolar vortex is a large mass of low-pressure, cold air that swirls above the North and South poles.*

**2. What are Rossby waves and how do changes in their location impact a jet stream?**

*Rossby waves are large, slow-moving flows of air that are created at Earth's surface but can move higher up into the troposphere when they are excited. The waves can disrupt the flow of the subtropical jet stream, causing extreme cold weather.*

**3. List events that may cause Rossby waves to move to higher sections of the troposphere.**

*Uneven heating in Earth's surface may cause Rossby waves to rise into the atmosphere. Air particles of a Rossby wave that encounter a mountain can also be propelled into the atmosphere.*

**4. Which atmospheric layer contains the ozone layer?**

*The ozone layer is located in the stratosphere.*

**5. What happens to air masses when a jet stream weakens?**

*When a jet stream weakens, cold air masses move down into lower latitudes and warm air masses move into higher latitudes.*

**6. What happened to the stratospheric polar vortex as a result of its warming in February of 2018?**

*The stratospheric vortex warmed causing wind flow to reverse and split the vortex in two.*

**7. Describe the subtropical jet stream and how it relates to the tropospheric polar vortex.**

*The subtropical jet stream is a wind stream that moves at speeds around 200 miles per hour. It serves as a barrier between the cold air of the polar vortex and the warmer air in the midlatitudes.*

**8. Compare and contrast the tropospheric polar vortex with the stratospheric polar vortex.**

*Both are surrounded by a fast-moving jet stream. The tropospheric polar vortex extends from the surface of Earth to six miles above it while the stratospheric polar vortex is found 30 miles above Earth's surface. The tropospheric polar vortex is present year-round while the stratospheric polar vortex develops when temperatures cool in the fall and disappears when temperatures get warmer in the spring.*

**9. Explain the roles of conduction and density in the movement of air masses.**

*When land heats up, the heat from it transfers to the atmosphere through the process of conduction. Warm air expands and its pressure changes. This change in temperature and density causes the mass of air to move.*

**10. What is the primary cause of the strong polar jet stream?**

*The large temperature difference between the Arctic and the midlatitudes is the primary driver of the wind in the jet stream.*

### Questions for Further Learning

1. **Examine the graph of average monthly arctic sea ice extent. What patterns do you notice? How might those patterns be explained?**

*The graph shows cycles of an increase and decrease in extent over the years. The general trend is a loss of extent. The overall downward trend in extent may be caused by climate change.*

2. **Explain how the melting of sea ice may contribute to an increase in the surface temperature of water in the Arctic.**

*The ocean is darker than the bright sea ice, so it absorbs heat while the ice reflects it. As the ocean absorbs heat, the temperature of the water becomes warmer which causes the ice in the ocean melts.*

3. **Review the graph of CO<sub>2</sub> during ice ages and warm periods. In parts per million, what is the difference in the level of carbon dioxide for 2018 and the highest previous concentration? Perform research to determine at least three activities that may contribute to high levels of carbon dioxide and how those causes could be mitigated.**

*The difference in parts per million is 107.4. Greenhouse gases are emitted through the burning of fossil fuels for transportation, heat, etc. (EPA - <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>). Clearing land can also contribute to greenhouse gases because of the removal of natural carbon sinks.*

4. **While an occasional snow day may be cause for celebration, a polar vortex event is not. Research the impacts of a polar vortex on people, plants, and/or animals. Design a public service announcement (PSA) to inform others of these impacts and how they can be avoided.**

*Answers will vary.*

### Graphic Organizer Rubric

If you use the Graphic Organizer 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

## Additional Resources

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### Labs and demos

When Air Masses Collide – This quick demo can be used to help students understand how warm and cold air masses interact when they meet. <https://www.education.com/science-fair/article/when-air-masses-collide/>

### Simulations

Climate Time Machine – Students can use this interactive to visualize recent historical data about the change in levels of sea ice, sea level, carbon dioxide, and global temperature.

<https://climate.nasa.gov/interactives/climate-time-machine>

Giving Rise to the Jet Stream – This NOVA simulation explains the science behind the jet stream.

<https://www.pbs.org/wgbh/nova/education/earth/giving-rise-jet-stream.html>

### Lessons and lesson plans

Climate Change – A Human Health Perspective: In this set of lesson plans students explore how extreme changes in temperature impact human health.

[https://www.niehs.nih.gov/health/assets/docs\\_a\\_e/climate\\_change\\_and\\_human\\_health\\_lesson\\_plan\\_a\\_508.pdf](https://www.niehs.nih.gov/health/assets/docs_a_e/climate_change_and_human_health_lesson_plan_a_508.pdf)

Air Masses – This lesson introduces information about the types of air masses found in the United States.

<http://sciencenetlinks.com/lessons/air-masses/>

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Chemistry Basics
  - Physical properties
- States of Matter
  - Gases

## Correlations to Next Generation Science Standards

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-ESS-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

### Disciplinary Core Ideas:

- ESS2.D: Weather and Climate

### Crosscutting Concepts:

- Patterns
- Cause and Effect: Mechanism and explanation
- Systems and system models

### Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence

### Nature of Science:

- Scientific knowledge is based on empirical evidence.
- Scientific knowledge assumes an order and consistency in natural systems

See how *ChemMatters* correlates to the [Common Core State Standards online at www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Teaching Strategies

Consider the following tips and strategies for incorporating this article into your classroom:

- Alternative to the Anticipation Guide: Before reading, ask students if they have heard of a polar vortex and how they think it might affect the weather.
- Ask students what they found most interesting from reading article.



# ChemMatters™

Demystifying Everyday Chemistry

## Teacher's Guide

### The Great Molasses Flood

*December 2019*

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>34</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>35</b>
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<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>42</b>

# Anticipation Guide

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

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement with each statement. Complete the activity in the box.

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
		11. Molasses comes from sugar cane.
		12. Molasses is less than 50% sugar.
		13. Glucose and fructose have the same molecular formula but different structures.
		14. The fermentation process requires oxygen.
		15. Molasses has much greater intermolecular forces than water.
		16. Sugar molecules are polar, with partial positive and negative charges.
		17. Molasses is less dense than water.
		18. Molasses becomes more viscous as shear stress increases.
		19. The pressure of liquids is greater at the bottom of the container.
		20. Substances vaporize more readily at higher temperatures.

# Student Reading

## Comprehension Questions

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

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

1. Briefly describe how molasses is manufactured.
2. Define and give an example of isomers.
3. Define viscosity and rank three liquids of your choice in order of increasing viscosity.
4. Explain the term catalyst. How does a catalyst affect the fermentation process?
5. What factors contributed to the failure of the molasses tank causing a tragic sticky flood?
6. It is highly recommended to use diet soda instead of regular soda when conducting the now famous Mentos in soda experiment. Using concepts discussed in the article, why is diet soda the beverage of choice when conducting this demonstration?
7. Hydrogen bonding, dipole-dipole, and London dispersion forces are the three types of intermolecular forces (IMFs) discussed in chemistry courses. Briefly explain each force, rank the forces from strongest to weakest, and explain your ranking using your knowledge and understanding of chemistry.
8. Compare and contrast Newtonian fluids and non-Newtonian fluids, and give an example of each type.
9. Suppose you were assigned the task of designing a new molasses tank for the Purity Distilling Company. What materials/safety mechanisms would you implement in your tank to prevent a future disaster?
10. Research the chemical structures of three artificial sweeteners. Do you notice any similarities between the structure of sugar and artificial sweeteners? Would you predict the artificial sweeteners to be as sticky or less sticky compared to sugar? Explain your reasoning.

## Student Reading Comprehension Questions, cont.

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### Questions for Further Learning

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

Oobleck is a mystery substance used in science classes around the world. It is composed of cornstarch and water. Obtain a sample of Oobleck from your teacher and answer the following questions:

1. Make three observations about the mystery substance.
  
2. How would you classify the mystery substance: a solid, liquid, or gas? Newtonian fluid or non-Newtonian fluid? Explain your reasoning.
  
3. Compare and contrast Oobleck to quicksand. Would you expect to escape from Oobleck and quicksand using similar methods or would you utilize a different approach? Explain.

# Graphic Organizer

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

**Directions:** As you read, complete the graphic organizer below to describe the properties of molasses.

	<b>Properties of Molasses</b> Provide chemical explanation examples. Include formulas and equations when appropriate
<b>Chemical composition</b>	
<b>Use in fermentation</b>	
<b>Viscosity</b>	
<b>Adhesion to surfaces</b>	
<b>Non-Newtonian fluid</b>	

**Summary:** In the space below, or on the back of this paper, write a tweet (280 characters or less) describing what caused the tank to rupture, releasing molasses.

## Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**1. Briefly describe how molasses is manufactured.**

*When sugar cane is crushed during the process of making sugar, juice is released. The juice is then boiled until the sugar crystallizes, at which point it is removed. The leftover syrup from this process is molasses.*

**2. Define and give an example of isomers.**

*Isomers are compounds with the same chemical formula but different structures. An example of isomers are glucose and fructose, both have the same chemical formula ( $C_6H_{12}O_6$ ) but have different structures (see pg. 16).*

**3. Define viscosity and rank three liquids of your choice in order of increasing viscosity.**

*Viscosity is a liquid's resistance to flow. Students' rankings and liquid choice may vary but an example of a correct solution: Water, Cooking oil, Honey.*

**4. Explain the term catalyst. How does a catalyst affect the fermentation process?**

*A catalyst is a substance that speeds up a chemical reaction by providing an alternate mechanism for the reaction with a lower activation energy. A catalyst is not consumed during the reaction. The catalyst, Zymase, speeds up the process of glucose decomposing into ethanol and carbon dioxide.*

**5. What factors contributed to the failure of the molasses tank causing a tragic sticky flood?**

*The wall thickness was inadequate for the tank's load. The walls were also deficient in manganese, making it brittle and subject to fatigue. A buildup of carbon dioxide gas due to warming of the molasses was another contributing factor. Lastly, cyclical loading (filling and emptying) applied additional stress to the tank and contributed to its failure.*

**6. It is highly recommended to use diet soda instead of regular soda when conducting the now famous Mentos in soda experiment. Using concepts discussed in the article, why is diet soda the beverage of choice when conducting this demonstration?**

*Diet soda works the best because artificial sweetener results in lower surface tension than sugar- or corn syrup-containing solutions. The relatively strong IMFs in sugar do not allow as much carbonation to be released compared to diet soda, which contains no sugar. Using sugarless diet soda also makes clean-up much easier due to the lack of sticky sugar.*

**7. Hydrogen bonding, dipole-dipole, and London dispersion forces are the three types of intermolecular forces (IMFs) discussed in chemistry courses. Briefly explain each force, rank the forces from strongest to weakest, and explain your ranking using your knowledge and understanding of chemistry.**

*The forces are listed from strongest to weakest below:*

*H-bonding: A covalent molecule containing hydrogen bonded to another highly electronegative element (N, O, F). The relatively high difference in electronegativity values results in a permanent net dipole in the molecule. The permanent net dipole causes a strong electrostatic attraction between adjacent molecules.*

*Dipole-Dipole: A covalent molecule containing two elements with significant electronegativity differences resulting in a permanent net dipole. The permanent net dipole causes an electrostatic attraction between adjacent molecules.*

*London Dispersion Forces: A temporary dipole caused by the polarization of electrons in adjacent atoms based on the position of the electrons. LDFs are present in all molecules and the strength of the LDFs is dependent on the number of protons and electrons (polarizability) and the surface area of the molecule.*

*Hydrogen bonding is the strongest IMF due to the relatively large electronegativity difference between H and N, O, or F (the most electronegative elements). This results in a strong dipole and strong electrostatic attraction between molecules. Also, hydrogen has a small atomic radius, which causes a strong attraction. Dipole-dipole forces are stronger than LDFs due the permanent dipole compared to the temporary dipole present in LDFs.*

**8. Compare and contrast Newtonian fluids and non-Newtonian fluids, and give an example of each type.**

*A Newtonian fluid's viscosity will not be affected by a stress (stirring, movement) while a non-Newtonian fluid's viscosity will change due to a shear stress. An example of a Newtonian fluid is water, an example of a non-Newtonian fluid is ketchup.*

**9. Suppose you were assigned the task of designing a new molasses tank for the Purity Distilling Company. What materials/safety mechanisms would you implement in your tank to prevent a future disaster?**

*Student answers will vary. Some ideas could include safety pressure release, reinforced steel, level monitoring, and temperature control.*

**10. Research the chemical structures of two artificial sweeteners. Do you notice any similarities between the structure of sugar and artificial sweeteners? Would you predict the artificial sweeteners to be as sticky or less sticky compared to sugar? Explain your reasoning.**

*Student answers will vary but may include any artificial sweetener (aspartame, saccharin, etc.). Student may comment on any similarities they notice. Students may predict the artificial sweeteners to be less sticky due to experiences with "diet" and sugar-free drinks.*

**Questions for Further Learning**

To make Oobleck mix two parts cornstarch and one part water in a bucket or similar container. Give each student or group a sample in a bowl or plate.

**1. Make three observations about the mystery substance.**

*Student answers will vary but should include three observations*

**2. How would you classify the mystery substance: a solid, liquid, or gas? Newtonian fluid or non-Newtonian fluid? Explain your reasoning.**

*Oobleck is classified as a non-Newtonian fluid due to a change in viscosity when a stress is applied.*

**3. Compare and contrast Oobleck to quicksand. Would you expect to escape from Oobleck and quicksand using similar methods or would you utilize a different approach? Explain.**

*The viscosity of quicksand decreases with movement; individuals stuck in quicksand are told not to move and call for help. Oobleck becomes more viscous with movement and an individual may be able to climb out if they move fast enough and cause the fluid to become more rigid.*

## Graphic Organizer Rubric

If you use the Graphic Organizer 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



## Additional Resources

### Labs and demos

IMFs and Physical Properties – In this demonstration, students observe and compare the properties of surface tension, beading, evaporation, and miscibility for water and acetone.

<https://teachchemistry.org/classroom-resources/intermolecular-forces-and-physical-properties>

Demo: What Causes Yeast to Ferment? In this lesson, students will observe and verify molasses sugar content as a result of its ability to ferment yeast. They will compare how molasses allows yeast to ferment with other sugar solutions as well as a sugar-free solution.

<https://teachchemistry.org/classroom-resources/what-causes-yeast-to-ferment>

### Simulation

Solubility – In this animation, students will have an opportunity to visualize on the particulate level how solubility works. Examples of ionic compounds and a polar covalent compound show how when water is attracted to charged parts, they dissolve, and when they're not attracted to charged parts they stay solid. <https://teachchemistry.org/classroom-resources/solubility-animation>

### Lesson

Structure Matters – In this project, students will develop a presentation to explain how and why a specific material can solve a problem. The explanation will involve researching the properties of the material and how its properties are suited for solving a specific problem.

<https://teachchemistry.org/classroom-resources/problem-solving-with-materials>

### Projects and extension activities

What is Paint? In this activity, students watch a video and answer related questions about the composition of paint. During the video, students will learn about the differences between three common paint types, water colors, oil-based and acrylic paint as well as the chemistry of each.

<https://teachchemistry.org/classroom-resources/what-is-paint-video-questions>

### Articles

*Chemical & Engineering News* (ACS's weekly news magazine) recently published an article about sugar and sugar substitutes as a result of FDA requiring added sugar content to be included on nutrition labels.

<https://cen.acs.org/business/specialty-chemicals/sugar-wars-change-food-label/97/i41>

C&EN also has an article about the chemistry of artificial sweeteners. It's dated, but still accurate.

<https://pubsapp.acs.org/cen/whatstuff/stuff/8225sweeteners.html>

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Chemistry basics - Fermentation
- Gases – Pressure
- Kinetics – Catalysts
- Molecules & Bonding
  - Intermolecular forces
  - Polarity
  - Isomers
  - Molecular structure
- Solutions

## Correlations to Next Generation Science Standards

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

### Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter
- ETS1.C: Optimizing the design solution

### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation
- Structure and Function

### Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations (for science) and designing solutions (for engineering)

### Nature of Science:

- Scientific knowledge is based on empirical evidence.
- Scientific knowledge assumes an order and consistency in natural systems

See how *ChemMatters* correlates to the [Common Core State Standards online at www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Teaching Strategies

Consider the following tips and strategies for incorporating this article into your classroom:

- Alternative to the Anticipation Guide: Before reading, ask students if they know what molasses is, and what it is used for. Ask them how they think storing molasses could cause a steel tank to rupture. As they read, students should record information they find interesting and look for answers to their questions.
- Show the 26-second animated video (no sound) at [www.bit.ly/ChemMattersJetStream](http://www.bit.ly/ChemMattersJetStream) to students visualize the movement of the jet stream.
- Ask students what they found most interesting from reading article.

# About the Teacher's Guide

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Teacher's Guide team editors Dusty Carroll, Scott Hawkins, Matt Perekupka, and Jennifer Smith created the Teacher's Guide article material. Susan Cooper prepared the anticipation, reading guides, and connections to standards.

Christine Suh (Managing Editor), Emily Abbott (Administrative Editor), and Lis Gallegos (Production Editor) coordinated the production and development of the Teacher's Guides.

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