

Teacher's Guide

April 2022

<u>Bugs and the Future of Meat</u>	2
<u>Getting Rid of Unwanted Fuzz</u>	13
<u>Can You Power Devices With Your Body?</u>	24
<u>Bottled Water Wars</u>	34
<u>About the Teacher's Guide</u>	45

Teacher's Guide

Bugs and the Future of Meat

April 2022

Table of Contents

<u>Anticipation Guide</u>	3
Activate students' prior knowledge and engage them before they read the article.	
<u>Reading Comprehension Questions</u>	4
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.	
<u>Graphic Organizer</u>	6
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.	
<u>Answers</u>	7
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<u>Additional Resources</u>	10
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<u>Chemistry Concepts, Standards, and Teaching Strategies</u>	11

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. The edible bug market is growing.
		2. Our bodies can produce all 20 of the amino acids needed to stay healthy.
		3. Raising insects requires more resources than raising cattle, pigs, and chicken.
		4. Insects are a good source of micronutrients such as iron, zinc, calcium, and magnesium.
		5. Unlike most organisms, insects provide iron in two forms.
		6. Mexico, India, and China have a high number of recorded edible insect species.
		7. Insects are a good source of polyunsaturated fatty acids, which are healthier than saturated fatty acids.
		8. Saturated fatty acids contain both double and single bonds between carbon atoms.
		9. Insects provide very little fiber.
		10. Harvesting and eating insects to control the damage they cause to crops has been successfully done in several countries around the world.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. What is the definition of entomophagy?
2. What chemical group(s) are the main components in an amino acid? How many amino acids does a person need for their body to stay healthy? How many does the human body make on its own? How do we get the rest?
3. What roles do proteins have for our bodies?
4. Explain the difference between saturated and polyunsaturated fats.
5. Define micronutrients. Give some examples. Why do we need these micronutrients?
6. Compare/contrast the nutrition information for both meats from animals and from insects. Are insects a good substitute for meats? Why?
7. State/explain why some people believe that harvesting and eating insects is a replacement for pesticides.
8. The average amount of protein a person needs is about 56.0 grams/day (mayoclinichealthsystem.org). Calculate the water footprint and land use for 1 person's protein intake for 1 year using the data from insect protein and one animal protein.
9. Why are unsaturated fats considered healthier than polyunsaturated fats?
10. Examine the models of the molecular structures of chitin and cellulose. What makes chitin a good substitute for cellulose for a person's fiber intake?

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. Choose a country from the map in the article, and research on what insects are considered edible.
2. Research some common recipes for edible insects. Are there any you may want to try?

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe how insects can be part of a healthy diet.

Protein	Insect Advantages:
	Chemical example:
Fats	Insect Advantages:
	Chemical example:
Fiber	Insect Advantages:
	Chemical example:

Summary: On the back of this sheet, state whether you would consider adding insects to your diet and why. Also write three new things you learned from the article.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What is the definition of entomophagy?

Entomophagy is the practice of people eating insects.

2. What chemical group(s) are the main components in an amino acid? How many amino acids does a person need for their body to stay healthy? How many does the human body make on its own? How do we get the rest?

The 2 main components (functional groups) in amino acids are the amino groups (-NH₂) and carboxyl groups (-COOH). A person needs 20 amino acids, and our bodies can only produce 11 of the 20. The other 9 must come from foods, mainly protein based foods (meats, nuts, and some vegetables).

3. What roles do proteins have for our bodies?

The main use of proteins is to build muscle. They help with many reactions in our body, by providing structure and moving molecules to the right places in the body.

4. Explain the difference between saturated and polyunsaturated fats.

Saturated fats are long hydrocarbon chains with 12-20 carbon atoms, all containing single bonds. These are called "fatty acids". Monounsaturated fats and polyunsaturated fats are carbon chains that contain one or more double bond in its chain.

5. Define micronutrients. Give some examples. Why do we need these micronutrients?

Micronutrients are minerals that are in very small amounts in our body, but are still needed for us to be healthy. Some of these micronutrients are iron magnesium, zinc and calcium.

6. Compare/contrast the nutrition information for both meats from animals and from insects. Are insects a good substitute for meats? Why?

Both animal meats and insects are a good source of protein, which is essential for our bodies. However, insects contain more of the "good" polyunsaturated fats, as well as micronutrients our bodies need.

7. State/explain why some people believe that harvesting and eating insects is a replacement for pesticides.

Harvesting insects for eating is a new idea to prevent crop damage from insects. One issue is that pesticides used now can cause harm to other, more useful insects, such as bees. A benefit is that these harvested insects could provide an additional source of food for those in need.

8. The average amount of protein a person needs is about 56.0 grams/day (mayoclinichealthsystem.org). Calculate the water footprint and land use for 1 person's protein intake for 1 year using the data from insect protein and one animal protein.

Land use from insects: $18\text{m}^2/\text{kg} \times 1\text{kg}/1000\text{g} \times 56\text{g} = 1.08\text{m}^2$. (roughly 1m x 1m area)

Land use from beef: $201\text{m}^2/\text{kg} \times 1\text{kg}/1000\text{g} \times 56\text{g} = 11\text{m}^2$ (roughly 3.3m x 3.3 m area)

Water footprint from insects: $23\text{L}/\text{g} \times 56\text{g} = 1288\text{Liters}$ (converting to gallons: $1288\text{L} \times 1\text{gal}/3.79\text{L} = 339.8\text{gal}$)

Water footprint from beef: $112\text{L/g} \times 56\text{ g} = 6272\text{ Liters}$ (converting to gallons: $6272\text{L} \times 1\text{ gal}/3.79\text{ L} = 1655\text{ gal}$)

9. Why are unsaturated fats considered healthier than polyunsaturated fats?

Saturated fats could harm our heart and have other cardiovascular issues. Because they contain all single bonds, they are more stable and harder to break apart chemically. Polyunsaturated fats are the “good” fats, are needed in our diet for a healthy body. The double bonds make the polyunsaturated fats break down easier and provide more energy through the double bonds.

10. Examine the models of the molecular structures of chitin and cellulose. What makes chitin a good substitute for cellulose for a person’s fiber intake?

Some answers: They are both carbon based polymers. The molecular formulas are very similar. The structures are very similar as well (the $-\text{OH}$ and O are in similar areas). Because of these similarities, the chitin could be a good substitute for fiber in our bodies.

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

Power of Polymers

<https://teachchemistry.org/classroom-resources/the-power-of-polymers>

The right Polymer for the Job

<https://teachchemistry.org/classroom-resources/the-right-polymer-for-the-job>

Polymer Investigation

<https://teachchemistry.org/classroom-resources/polymer-investigation>

Lessons and lesson plans

Chem Matters article on trans fats

<https://teachchemistry.org/chemmatters/december-2007/the-solid-facts-about-trans-fats>

Chem Matters article on proteins:

<https://teachchemistry.org/chemmatters/april-2018/the-protein-myth-getting-the-right-balance>

Other Resources

Compound Chemistry: Different Types of Fats

<https://www.compoundchem.com/2015/08/25/fat/>

Compound Chemistry: A Brief Guide to the Twenty Common Amino Acids

<https://www.compoundchem.com/2014/09/16/aminoacids/>

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Structural formulas
- Functional groups
- Polymers
- Saturated vs. unsaturated

Correlations to Next Generation Science Standards

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

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Disciplinary Core Ideas:

- LS2.B: Cycles of matter and energy transfer in ecosystems
- LS1.A: Structure and function

Crosscutting Concepts:

- Structure and function
- Energy and matter
- Stability and change
- Systems and system models

Science and Engineering Practices:

- Using mathematics and computational thinking
- Obtaining, evaluating, and communicating information

Nature of Science:

- Scientific knowledge is based on empirical evidence.
- Science is a human endeavor.

See how *ChemMatters* correlates to the [Common Core State Standards online](#).

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students whether they have ever eaten bugs. Ask them what some advantages of eating bugs might be. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
 - As they read, students can find information to confirm or refute their original ideas.
 - After they read, ask students what they learned about eating insects and whether they would be willing to try them.
- **Chemists Celebrate Earth Week (CCEW), April 17-23.** This article correlates well with the theme for CCEW: The Buzz About Bugs – Insect Chemistry. You can find more information and resources at <https://www.acs.org/content/acs/en/education/outreach/ccew.html>

Teacher's Guide

How Hair Removers Get Rid of Unwanted Fuzz

April 2022

Table of Contents

<u>Anticipation Guide</u>	14
Activate students' prior knowledge and engage them before they read the article.	
<u>Reading Comprehension Questions</u>	15
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.	
<u>Graphic Organizer</u>	17
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.	
<u>Answers</u>	18
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<u>Additional Resources</u>	21
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<u>Chemistry Concepts, Standards, and Teaching Strategies</u>	22

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. Chemical hair removers have been used for about 100 years.
		12. Depilatory creams contain acid salts and bases.
		13. Keratin, a protein found in hair, is cross-linked by covalent bonds, hydrogen bonds, and ionic bonds.
		14. Chemical hair removers also affect cotton fibers.
		15. Skin has a pH of 7.
		16. The bad smell from depilatory creams is the cream itself.
		17. Sugaring and waxing both work by pulling out hairs.
		18. Sugaring wax can be made from table sugar, water, and lemon.
		19. Laser hair removal works best on dark hair against light skin.
		20. Hair removal methods are constantly being developed.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. Quicklime, CaO , is classified as a basic compound. Write the chemical equation that shows the reaction of quicklime with water.
2. A disulfide bond is characterized as covalent, while a hydrogen bond is not. Explain the difference between these two bond types.
3. Write the chemical formula for the potassium salt of thioglycolic acid and for the calcium salt of thioglycolic acid.
4. When a base acts on the thioglycolate to remove a proton from its thiol group, what is the charge on the remaining sulfur atom? Where do the electrons come from to make this charge?
5. Keratin is a structural protein that makes up over 90% of a strand of hair. What is the role of a structural protein?
6. The article states that cream hair removers should have a pH in the range of 12-12.5.
 - a. What would the concentration of hydroxide be in a cream with a pH of 12?
 - b. What would the concentration of calcium hydroxide be in this same cream?
 - c. Why is it important that the cream be basic, rather than acidic, to break down the keratin?
7. What is the purpose of breaking sucrose into glucose and fructose when creating sugaring wax?
8. In a hydrolysis reaction, a water molecule reacts with something to split it apart. The hydrolysis of sucrose is catalyzed by the hydrogen ion from an acid. Explain how the catalyst and water molecule work together to hydrolyze sucrose and then regenerate a hydrogen ion.

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. How is the chemical depilatory process described in the article similar to the process of perming hair?
2. Research the different types of lasers used for hair removal and explain how laser hair removal works.

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to compare different types of hair removers along with the advantages and disadvantages of each.

Hair Removal Method	How they work	Advantages and Disadvantages
Depilatory Cream		
Waxing		
Laser		

Summary: On the back of this sheet, write a short email to a friend explaining what you learned about hair removal, including your advice for the best hair removal method.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Quicklime, CaO, is classified as a basic compound. Write the chemical equation that shows the reaction of quicklime with water.
 $\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$ (calcium hydroxide is soluble, depending on concentration)
2. A disulfide bond is characterized as covalent, while a hydrogen bond is not. Explain the difference between these two bond types.
The disulfide bond involves an overlap of the valence shells of two sulfur atoms. This is a covalent bond. The hydrogen bond is an intermolecular force, or an attraction between a very electronegative atom on one molecule and a very positive hydrogen on another molecule. This type of bond does not involve overlapping of the valence shells.
3. Write the chemical formula for the potassium salt of thioglycolic acid and for the calcium salt of thioglycolic acid.
 $\text{KHSCH}_2\text{CO}_2$ and $\text{Ca(HSCH}_2\text{CO}_2)_2$
4. When a base acts on the thioglycolate to remove a proton from its thiol group, what is the charge on the remaining sulfur atom? Where do the electrons come from to make this charge?
The charge on the sulfur atom will be -1. The S-H bond contains 2 electrons. In this bond, one electron originated with the sulfur and one originated with the hydrogen. When the H is removed by the base, both electrons stay with the sulfur atom, giving it an extra negative charge.
5. Keratin is a structural protein that makes up over 90% of a strand of hair. What is the role of a structural protein?
A structural protein provides the firmness needed by a cell to maintain its structure. The keratin provides the structure for the hair shaft.
6. The article states that cream hair removers should have a pH in the range of 12-12.5.
 - a. What would the concentration of hydroxide be in a cream with a pH of 12?
 $\text{pOH} = 14 - \text{pH}$. $\text{pH} = 12$. $[\text{H}^+] = 10^{-2} = 0.010 \text{ M OH}^-$
 - b. What would the concentration of calcium hydroxide be in this same cream?
 Ca(OH)_2 has 2 hydroxides per formula unit, so the concentration is half the hydroxide concentration, $0.0050 \text{ M Ca(OH)}_2$.
 - c. Why is it important that the cream be basic, rather than acidic, to break down the keratin?
The base acts to remove a proton from the thiol group of the thioglycolate, which is necessary to begin the process of breaking the disulfide bond in the protein.
7. What is the purpose of breaking sucrose into glucose and fructose when creating sugaring wax?
The glucose/fructose mixture has a lower crystallizing temperature, which allows it to form a more spreadable wax than the sucrose would.
8. In a hydrolysis reaction, a water molecule reacts with something to split it apart. The hydrolysis of sucrose is catalyzed by the hydrogen ion from an acid. Explain how the catalyst and water molecule work together to hydrolyze sucrose and then regenerate a hydrogen ion.

The catalyst proton bonds to the oxygen atom that links the two rings in sucrose. This breaks the bond to one of the rings, which allows the oxygen from a water molecule to bond in its place. This removes one hydrogen from the water molecule, thus regenerating the H^+ .

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

- Use titration to determine the pH of a depilatory cream.
- Oxidation States of Manganese to show the pH dependence of reactions (this video shows a common demo): <https://www.youtube.com/watch?v=6UGrixD3yiQ&t=118s>

Simulations

- Simple simulation showing how an indicator reacts to an acid and a base: <https://www.acs.org/content/acs/en/education/resources/k-8/inquiryinaction/fifth-grade/acid-base-indicator.html>
- Video: Acid & Base Guys – short video showing the definitions of acids/bases <https://teachchemistry.org/classroom-resources/acid-base-guys-video>

Lessons and lesson plans

- Calculating pH- A Look at Logarithms: <https://teachchemistry.org/classroom-resources/calculating-ph-a-look-a-logarithms>
- Investigating Oxidation-Reduction Reactions: <https://teachchemistry.org/classroom-resources/investigating-oxidation-reduction-reactions>
 - Though not specifically described in the article, the breaking of the disulfide bond is classified as a redox reaction.

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Physical properties
- Intermolecular forces
- Molecular structure

Correlations to Next Generation Science Standards

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

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

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
- PS2.B: Types of interactions
- ETS1.C: Optimizing the design solution

Crosscutting Concepts:

- Structure and function
- Cause and effect
- Systems and system models

Science and Engineering Practices:

- Asking questions and defining problems
- Planning and carrying out investigations

Nature of Science:

- Science is a human endeavor.

See how *ChemMatters* correlates to the [Common Core State Standards online](#).

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students what hair removers they are familiar with, and how they think hair removers work. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.

- As they read, students can find information to confirm or refute their original ideas.
- After they read, ask students what they learned about removing unwanted hair.

Teacher's Guide

Can You Power Devices With Your Body?

April 2022

Table of Contents

<u>Anticipation Guide</u>	25
Activate students' prior knowledge and engage them before they read the article.	
<u>Reading Comprehension Questions</u>	26
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.	
<u>Graphic Organizer</u>	27
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.	
<u>Answers</u>	28
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<u>Additional Resources</u>	42
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<u>Chemistry Concepts, Standards, and Teaching Strategies</u>	43

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
		21. Static attraction occurs when dissimilar materials are separated after being in contact with each other.
		22. Research to develop consumer devices using constant everyday body movement has stalled.
		23. Insulators can conduct electricity.
		24. Electrons in metals can easily jump from one orbital to another.
		25. Human hair is a good insulator.
		26. The element germanium is an insulator.
		27. A conduction band and a valence band are the same for all materials.
		28. If you rub cotton on wood or rubber, electrons would load up on the wood or rubber.
		29. Power generated using soft materials would leak into the environment if it were not harnessed.
		30. Wearables using soft materials like knits are being developed to track heart or brain activity.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

Reading Comprehension Questions

1. In simple terms, explain triboelectrification.
2. Compare and contrast the properties of conductors, semiconductors, and insulators.
3. Describe how the “band gap” influences a substance's ability to conduct electricity.
4. Describe how insulators can exchange surface charges.
5. Use the triboelectric series figure on pg 14 to explain the importance of material pairings when attempting to generate triboelectricity.

Making Connections


6. Examine the triboelectric series on page 14 again. Do you notice any trends in the types of materials that tend to lose or gain electrons. Meaning, can you categorize these types of materials?
7. The article mentions mechanical energy created by sound waves (energy of movement). Provide an example of real world phenomena or example of sound creating mechanical energy of movement.
8. Triboelectricity and static electricity have a good deal in common. Explain how static electricity is created and provide a real world example.
9. The goal of any new energy source is to replace or reduce the consumption and reliance on fossil fuels. Provide advantages and disadvantages of both fossil fuels and triboelectricity.
10. Is triboelectricity a completely clean and renewable energy?
11. Create an advertisement for a theoretical device that uses tribo-electrical power. For example, a t-shirt or pants that can charge your cell phone. The advertisement can either be a printed advertisement (similar to an advertisement you would see on a billboard or in a magazine) or a video advertisement (as you would see on TV).

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe triboelectrification.

Definition in your own words	Examples from the article
Importance of Band Gap	Future uses mentioned in the article

**Triboelectrification**

Summary: On the back of this sheet, write a short summary (20 words or less) explaining the chemistry of triboelectrification.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

Reading Comprehension Questions

1. In simple terms, explain triboelectrification.

Triboelectrification involves harnessing energy from movement when two objects rub or move past one another. This energy is based on the flow electrons from one material to another, similar to static electricity but more controlled and calculated.

2. Compare and contrast the properties of conductors, semiconductors, and insulators.

Conductors: Materials that readily conduct electricity and heat, contain a sea of electrons or delocalized electrons that allow electrons to move freely.

Semiconductors: Materials that can conduct electricity with some assistance (boosted energy), a hybrid of conductors and insulators.

Insulators: Materials with fixed or localized electrons that do not conduct electricity.

3. Describe how the “band gap” influences a substance's ability to conduct electricity.

The band gap is the energy difference between the valence electrons that bond and the electrons not involved in bonding. In conductors the energies of the valence band and non-bonding electrons band overlap and allows electrons to move freely between the bands and therefore conduct electricity. Semiconductors and insulators have a wider gap between the two bands which either causes the electrons to need more energy to “bridge the gap” (as in semiconductors) or not flow at all between the two bands (as in insulators).

4. Describe how insulators can exchange surface charges.

Movement or rubbing of an insulator such as hair that gets brushed or wool socks on a carpet causes electrons to transfer between materials. However, since the materials involved are non-conducting insulators, the charge has nowhere to go until a conductor is introduced such as a door handle.

5. Use the triboelectric series figure on pg 14 to explain the importance of material pairings when attempting to generate triboelectricity.

Materials tend to either gain electrons or lose electrons when subjected to rubbing or movement. It is important to select a material that tends to lose electrons and pair it with a material that tends to gain electrons to generate a flow of electrons.

Making Connections

6. Examine the triboelectric series on page 14 again. Do you notice any trends in the types of materials that tend to lose or gain electrons. Meaning, can you categorize these types of materials?

Answer may vary

Lose Electrons: Fibrous materials such as hair and fur

Gain Electrons: Plastic materials

7. The article mentions mechanical energy created by sound waves (energy of movement). Provide an example of real world phenomena or example of sound creating mechanical energy of movement.

Answers may vary

Examples: House shaking after loud thunder

Singer breaking a wine glass

Feel vibrations in your chest at a loud concert

8. Triboelectricity and static electricity have a good deal in common. Explain how static electricity is created and provide a real world example.

Static electricity is created when two objects rub together and electrons are transferred to one object and there is nowhere for the additional charge to go until a conductor is introduced. An example of static electricity is shocking yourself on a doorknob after you walk across a carpeted floor or touching a child after they go down a plastic slide on the playground.

9. The goal of any new energy source is to replace or reduce the consumption and reliance on fossil fuels. Provide advantages and disadvantages of both fossil fuels and triboelectricity.

Answers may vary

Example:

Fossil fuels: Produce a great deal of energy, however pollute the environment and are non-renewable.

Triboelectricity: Produce a small amount of energy, however is relatively clean and is renewable.

10. Is triboelectricity a completely clean and renewable energy?

Answers may vary.

Not presently, many of the materials needed to create triboelectricity require fossil fuels or animal products to create.

11. Create an advertisement for a theoretical device that uses tribo-electrical power. For example, a t-shirt or pants that can charge your cell phone. The advertisement can either be a printed advertisement (similar to an advertisement you would see on a billboard or in a magazine) or a video advertisement (as you would see on TV).

Answers will vary. The teacher may decide expectations and grading criteria.

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

Static Electricity Activity

<https://teachchemistry.org/classroom-resources/understanding-static-electricity>

Electrochemistry Lesson Plan

<https://teachchemistry.org/classroom-resources/understanding-static-electricity>

Carbon Footprint Activity

<https://teachchemistry.org/classroom-resources/calculating-your-carbon-footprint>

Hybrid and Electric Cars

<https://teachchemistry.org/classroom-resources/hybrid-and-electric-cars-video-questions>

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Electrons
- Electrostatic forces
- Electron transfer
- Valence electrons

Correlations to Next Generation Science Standards

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

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Disciplinary Core Ideas:

- PS.1.A: Structure and Properties of Matter
- ETS1.B: Developing Possible Solutions

Crosscutting Concepts:

- Patterns
- Cause and effect
- Stability and change
- Systems and System Models

Science and Engineering Practices:

- Constructing explanations and designing solutions

Nature of Science:

- Scientific knowledge assumes an order and consistency in natural systems.

See how *ChemMatters* correlates to the [Common Core State Standards online](#).

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students how they think their bodies can be used to produce electricity, including what materials might be needed. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.

- As they read, students can find information to confirm or refute their original ideas.
 - After they read, ask students what they learned about triboelectrification.
- After students have read and discussed the article, ask students if they think they might use triboelectric devices in the future, and how.
- **Note:** Novice chemistry students may not be familiar with antibonding orbitals, which is important to understanding the band gap described in the article. Reviewing molecular orbital theory may aid understanding.

Teacher's Guide

Bottled Water Wars

April 2022

Table of Contents

<u>Anticipation Guide</u>	35
Activate students' prior knowledge and engage them before they read the article.	
<u>Reading Comprehension Questions</u>	36
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.	
<u>Graphic Organizer</u>	38
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.	
<u>Answers</u>	39
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<u>Additional Resources</u>	9
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<u>Chemistry Concepts, Standards, and Teaching Strategies</u>	10

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
		31. Once tooth enamel is eroded by acid, the enamel cannot be repaired.
		32. Carbonated water contains carbon dioxide gas dissolved in water.
		33. Naturally occurring springs add gas to water through biological processes.
		34. The solubility of a gas in a liquid depends on the partial pressure of the gas above the liquid.
		35. Gases dissolve better in liquids at high temperatures.
		36. Carbonated water is slight basic.
		37. Carbonated water has a higher pH than soda and juice.
		38. Alkaline water harms teeth and gums.
		39. The same enzyme that makes carbonated water taste tangy keeps your blood pH between 7.3 and 7.4.
		40. Acidic drinks can cause the main component of tooth enamel to lose calcium ions in solution.

Student Reading Comprehension Questions

Name: _____

Directions: Use the article to answer the questions below.

1. According to the World Health Organization, what is the leading cause of death globally?
2. What type of bonding causes water molecules to be attracted to one another?
3. What gas is dissolved into water to make carbonated water?
4. Explain how carbonated water may occur in nature.
5. Why are carbonated beverages pressurized?
6. What is the main component in tooth enamel?
7. Name two health conditions that you may be more at risk for if you consume a high-sugar diet.
8. Drinks that are high in sugar content tend to be acidic. How does this impact teeth?
9. Explain why flavored carbonated water may still lead to tooth decay even though its pH is in a safe range.
10. Name three actions you can take to protect your teeth from acidic beverages.
11. What is an aqueous solution?
12. Explain how Henry's Law relates to carbonated water.
13. What is the relationship between a solvent and a solute?
14. What is the function of carbonic anhydrase within your circulatory system?
15. Explain Le Chatelier's Principle.

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. Write a paragraph comparing pure water, carbonated water, and alkaline water in terms of pH and health benefits/drawbacks.
2. Look at the pH scale in the article. Identify three appropriate beverages that are not already on the chart. Perform research to determine the pH of each substance and note where each would be placed on the chart.

Graphic Organizer

Name: _____

Directions: As you read, complete the graphic organizer below to describe the different types of water explained in the article.

	Carbonated Water	Alkaline Water
How is it made? Include chemicals involved		
pH		
Effect on teeth enamel Include chemicals involved		
Advantages		
Disadvantages		

Summary: On the back of this sheet, write three interesting facts about flavored water you would like to share with a friend.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. According to the World Health Organization, what is the leading cause of death globally?
The leading cause of death globally is heart disease.
2. What type of bonding causes water molecules to be attracted to one another?
Hydrogen bonding causes water molecules to become attracted to one another.
3. What gas is dissolved into water to make carbonated water?
CO₂ is dissolved in water to produce carbonated water.
4. Explain how carbonated water may occur in nature.
Carbonation can be added to water through geological processes, such as volcanic activity.
5. Why are carbonated beverages pressurized?
Carbonated beverages are pressurized to prevent soda from going flat.
6. What is the main component in tooth enamel?
The primary component in tooth enamel is calcium hydroxyapatite.
7. Name two health conditions that you may be more at risk for if you consume a high-sugar diet.
Consuming a high-sugar diet may put you at risk for heart disease and diabetes.
8. Drinks that are high in sugar content tend to be acidic. How does this impact teeth?
Drinks that are acidic can dissolve tooth enamel and sugar content can cause tooth decay.
9. Explain why flavored carbonated water may still lead to tooth decay even though its pH is in a safe range.
Flavored carbonated water may still lead to tooth decay because it contains sugar.
10. Name three actions you can take to protect your teeth from acidic beverages.
You can protect your teeth from acidic beverages by limiting consumption, using a straw, and avoiding acidic drinks before bed.
11. What is an aqueous solution?
An aqueous solution is a solution in which a substance is dissolved in water.
12. Explain how Henry's Law relates to carbonated water.
Henry's Law states that the solubility of a gas is directly proportional to the partial pressure of the gas above the solution. If the partial pressure increases, the gas molecules are forced into the solution, which explains how CO₂ is added to water to produce carbonated water.
13. What is the relationship between a solvent and a solute?
A solute dissolves in a solvent.

14. What is the function of carbonic anhydrase within your circulatory system?

Carbonic anhydrase ensures that your blood pH remains constant.

15. Explain Le Chatelier's Principle.

Le Chatelier's Principle is the idea that when a system that is at equilibrium is stressed, the system responds by changing direction to relieve the stress.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. Write a paragraph comparing pure water, carbonated water, and alkaline water in terms of pH and health benefits/drawbacks.

Student answers should note that carbonated water is acidic while alkaline water is a weak base. Health benefits can be that these forms of water (carbonated and alkaline) are less harmful in reacting with tooth enamel, but they contain sugar which can still cause tooth decay.

2. Look at the pH scale in the article. Identify three appropriate beverages that are not already on the chart. Perform research to determine the pH of each substance and note where each would be placed on the chart.

Student choices will vary. Some websites include lists of beverages and their pH and sugar content, which can assist students in generating their chart. Alternately, the instructor could lead students in a lab designed to check the pH of the beverages students select.

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

[Designing a Greener Le Chatelier's Principle Lab](#) – This lab allows students to observe visualizations of equilibrium shifts through color changes by using non-toxic materials.

Simulations

[pH Scale](#) – This PhET simulation allows students to explore pH by manipulating the concentration of various liquids.

[Salts and Solubility](#) – In this PhET simulation students explore chemical equilibrium and Le Chatelier's Principle.

Lessons and lesson plans

[Brush Up Eggsperiment](#) – In this lesson plan students explore the impact of soda and fluoride on eggshells, which represent tooth enamel.

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Acids and bases
- pH
- Solutions
- Equilibriums
- Partial pressure
- Hydrogen bonding
- Ions

Correlations to Next Generation Science Standards

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

HS-PS1-3. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Disciplinary Core Ideas:

- PS1.B: Chemical reactions
- ETS1C: Optimizing the design solution

Crosscutting Concepts:

- Stability and change
- Structure and function

Science and Engineering Practices:

- Constructing explanations and designing solutions

Nature of Science:

- Scientific knowledge assumes an order and consistency in natural systems.

See how *ChemMatters* correlates to the [Common Core State Standards online](#).

Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, engage students by asking them if they enjoy drinking flavored water. Also ask if they know the ingredients found in different flavored waters,

and how they might affect their teeth and gums. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.

- As they read, students can find information to confirm or refute their original ideas.
- After they read, ask students what they learned about flavored waters, and how it will affect their water choices.

About the Teacher's Guide

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) coordinated the production and development of the Teacher's Guides.

E-mail: chemmatters@acs.org

Subscribe to *ChemMatters* magazine or purchase back-issues of the magazine at www.acs.org/chemmatters.