

**Teacher’s Guide**

**The Battle Against Body Odor**

***December 2019***

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Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 3

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.

[Graphic Organizer 5](#_Graphic_Organizer)

Thishelps 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.

[Answers 6](#_Answers_to_Reading)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 8](#_Additional_Resources)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# 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. Hi-tech clothes that fight body odor include nanoparticles of silver. |
|  |  | 1. Reactive oxygen species (ROS) in cells can damage DNA. |
|  |  | 1. Strands of DNA are held together by hydrogen bonds. |
|  |  | 1. Sweat is mostly water. |
|  |  | 1. The pungent smell of sweat is cause by harmful bacteria. |
|  |  | 1. Compounds in sweat are broken down by enzymes in skin bacteria to produce less smelly shorter molecules. |
|  |  | 1. Silver has been used as an antibacterial agent for about 25 years. |
|  |  | 1. Research studies suggest that bacteria may evolve to become resistant to silver. |
|  |  | 1. Silver nanoparticles stay on clothes when they are washed. |
|  |  | 1. 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.**

1. 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?
2. 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 (1x10-9 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).*

1. **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.*

1. **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.*

1. **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.*

1. **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.*

1. **What exactly do silver ions “attack” to prevent odor from occurring?**

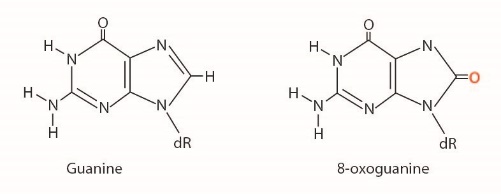
*Silver ions “attack” (react with) DNA in bacteria that produces the odor-producing molecules.*

1. **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.*

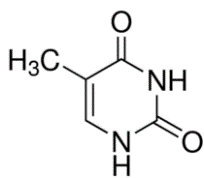
1. **Compare the structure of guanine to 8-oxoguanine. What are the differences between the structures? How would that affect how guanine attracts to cytosine?**

*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.*



1. **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.*



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

*Use this website:* [*https://www.silverhealthinstitute.com/*](https://www.silverhealthinstitute.com/) *for examples.*

1. **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*](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.*

1. **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

**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>

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/

**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** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html) at 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.

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| 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 |
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| S | N | C | A | S | A | S | I | L | A | G | S | N |
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Uses

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Why were the werewolves afraid of the thunderstorm?

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Answers

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| T | B | O | B | A | N | G | S | N | A | P | S | L |
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| 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 |
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| S | N | C | A | S | A | S | I | L | A | G | S | N |
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Uses

|  |  |  |
| --- | --- | --- |
|  | 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. |
|  | 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. |
|  | Mirror | A thin layer coated on the back of a pane of glass forms an almost completely reflective surface. Additional coatings, such as SnCl2, Cu, and Al, help with adhesion and protect Ag from corrosion. |
|  | 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. |
|  | 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. |
|  | Compact disc | Silver is part of the thin layer of reflective metals used in CDs, DVDs, and other storage media.. |
|  | 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. |
|  | Deodorant | Some “all-natural” deodorants rely on the antimicrobial properties of silver to minimize smells caused by bacteria. |
|  | Circuits | Silver is the most efficient conductor of all the metals, making it useful for electrical contacts and printed circuits |
|  | Ball bearings | A coating of silver acts as both a strengthener and lubricant on steel ball bearing surfaces. |
|  | Bang snaps | Silver fulminate explodes under friction or pressure; small quantities are used in bang snaps and Christmas crackers to provide a little “pop.” |
|  | Solar panels | Silver paste is coated onto solar panels to help transform light into electricity. |
|  | Filters | Silver is a component in many filters and water-purifications systems to remove bacteria. It is removed from water before drinking to prevent argyria (permanent blue-grey discoloration of the skin, due to ingestion of silver). |
|  | Gloves | Tiny silver filaments are embedded in the fingertips of some gloves to allow the conductivity needed for touch-sensitive gloves. |
|  | Stained glass | Used with certain paints and clays, silver compounds provide a range of yellow to orange colors. |
|  | 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?

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