ChemMatters®

Demystifying Everyday Chemistry

Teacher's Guide

October 2019

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ACS Chemistry for Life®

ChemMatters
Demystifying Everyday Chemistry

Teacher's Guide for

The Secret Life of Gold

October 2019

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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. Gold conducts electricity and keeps electrical components from corroding.
		2. Gold was formed during the Big Bang.
		3. Stars were formed during the Big Bang.
		4. During nuclear fusion, the hydrogen nuclei in stars fuse to form helium nuclei.
		5. Iron is the most stable form of matter.
		6. Neutron stars create heavy elements.
		7. There is gold in Earth's core.
		8. 24-karat gold is pure gold.
		9. Some gold mines are more than 10 miles deep.
		10. Some of Earth's gold came from meteorites.

Student Reading Comprehension Questions

Name: ______________________________

Directions: Use the article to answer the questions below.

1. What are positrons? How do they relate to neutron stars?

2. What is the composition of a neutron star?

3. Geologically speaking, where are the two places on Earth that gold is found?

4. What is an alloy?

5. List four characteristics that make gold and explain how at least one characteristic impacts gold's function in electronic devices.

6. How did neutron stars generate the energy they needed to survive?

7. Why is iron credited with causing the collapse of neutron stars?

8. What percent of pure gold is in 10-karat gold?

9. How did the gold that we are able to mine become part of Earth?

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. Describe how gold became part of Earth's core.

2. The article explains how white gold and pink gold are made. Research two other gold alloys and explain how they are made.

3. Describe the differences between gold and gold alloys. How does the structure of a gold alloy contribute to its function?

4. Describe the process of nuclear fusion in neutron stars.

5. Read the Open for Discussion article, "The Asteroid Next Door." Should we attempt to mine gold and other precious metals from asteroids? Why or why not?

6. Perform some research to determine how ownership rights in space are determined. How do you think ownership rights should be determined?

Graphic Organizer

Name: ______________________________

Directions: As you read, complete the graphic organizer below to describe how gold came to be found on Earth.

Process	Description	End result	How long ago?
Big Bang			
Nuclear Fusion			
Neutron Star Collision			
Meteorite Bombardment			

Summary: Write three new things you learned about gold from reading the article.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What are positrons? How do they relate to neutron stars?**
   Positrons are particles that are positively-charged electrons that are produced when neutron stars go through nuclear fusion.

2. **What is the composition of a neutron star?**
   A neutron star is composed of 95% neutrons and 5% protons.

3. **Geologically speaking, what are the two places on Earth that gold is found?**
   Gold is found in Earth's core and crust.

4. **What is an alloy?**
   An alloy is a mixture of two metals.

5. **List four characteristics that make gold and explain how at least one characteristic impacts gold's function in electronic devices.**
   Gold can be beaten into thin sheets, can be drawn into wires, is inert to most acids and oxidants, is a good conductor of heat and electricity, and forms stable nanoparticles. Gold can be made into small wires and sheets that conduct electricity in small electronic devices.

6. **How did neutron stars generate the energy they needed to survive?**
   Stars release energy through nuclear fusion.

7. **Why is iron credited with causing the collapse of neutron stars?**
   It prevents the star's core from producing energy. Without energy, the star collapses and dies.

8. **What percentage of pure gold is in 10-karat gold?**
   10-karat gold contains 10 g of gold per 24 g of total alloy, making it 41.7% pure gold.

$$\frac{10\ g\ of\ gold}{24\ g\ of\ total\ alloy} \times 100 = 41.7\%$$

9. **How did the gold that we are able to mine become part of Earth?**
   Research suggests that the gold that miners have access to on Earth came from meteorites that bombarded the Earth 200 million years after the planet was formed.

Questions for Further Learning

1. **Describe how gold become part of the Earth's core.**
   Earth's core of molten rock created gravity that was able to attract heavy elements, such as gold, from the atmosphere into its core.

2. **The article explains how white gold and pink gold are made. Research two other gold alloys and explain how they are made.**
   Blue gold is made by combining gold and indium.
   Green gold is made by combining gold with silver.
   Purple gold is made by combining gold with aluminum

3. **Describe the differences between gold and gold alloys. How does the structure of a gold alloy contribute to its function?**
   Gold alloys are cheaper, and they can be more useful. Pure gold is soft, so it bends and scratches easily when it is used in jewelry. Gold alloys can be used to make jewelry that is more durable than pure gold.

4. **Describe the process of nuclear fusion in neutron stars.**
   The force of gravity in the star fuses hydrogen nuclei. This sets off additional reactions that produce helium nuclei, energy, and positrons.

5. **Read the Open for Discussion article, "The Asteroid Next Door." Should we attempt to mine gold and other precious metals from asteroids? Why or why not?**
   Answers will vary

6. **Perform some research to determine how ownership rights in space are determined. How do you think ownership rights should be determined?**
   Answers will vary. Ownership rights in spare are still unclear. Check out this article from space.com to get started. www.space.com/26644-moon-asteroids-resources-space-law.html

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

Turning Copper Pennies into Gold and Silver lab – In this lab student will use chemical processes to create alloys. Teacher instructions are included.
www.flinnsci.com/api/library/Download/674479ccda964683ac6201381ffbdb89

Simulations

The Structure of Metal – This online interactive demonstrates the molecular bonds of metals and how they behave when heated.
https://illinois.pbslearningmedia.org/asset/phy03_int_metal-fla/

Videos

In this video, the author of *The Disappearing Spoon* Sam Kean tells stories about hydrogen:
https://teachchemistry.org/classroom-resources/hydrogen-video

In this video, the author of *The Disappearing Spoon* Sam Kean tells stories about gold:
https://teachchemistry.org/classroom-resources/gold-video

Lessons and lesson plans

The Creation of Silver – In this online lesson plan, students learn how another precious metal, silver, was created when neutron stars explode.
www.khanacademy.org/partner-content/big-history-project/stars-and-elements/creation-complex-elements/v/bhp-stars-galaxies-crashcourse

Fusion and Fission – This lesson plan helps students better understand the differences between fusion and fission. www.texasgateway.org/resource/fusion-and-fission

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Nuclear Chemistry
- Atomic Structure
  - Model of the atom
  - Subatomic particles

Correlations to Next Generation Science Standards

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

HS-PS1-8
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Disciplinary Core Ideas:
- PS1.A: Structure and Properties of Matter
- PS1.C: Nuclear Processes

Crosscutting Concepts:
- Scale, Proportion, and Quantity
- Energy and Matter
- Stability and Change

Science and Engineering Practices:
- Developing and using models
- Asking questions (for science) and defining problems (for engineering)

Nature of Science:
- Science models, laws, mechanisms, and theories explain natural phenomena.
- Science addresses questions about the natural and material world

Student Reading Comprehension Questions – connections to NGSS Crosscutting Concepts:
- Q7: Structure and function
- Q8: Stability and change
- Further learning Q3: Structure and function
- Further Learning Q4: Energy and matter, Stability and change

Correlations to Common Core State Standards

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 the Anticipation Guide** provided: Before reading, ask students where they might find gold in their everyday lives. Also ask them to think about where gold comes from and how it got there. As they read the article, students should look for answers to their questions.
- The article fits well with the theme of National Chemistry Week: Marvelous Metals. Visit the website for ideas about how to incorporate the reading with other activities.
- Ask students to read “Open for Discussion: The Asteroid Next Door” (page 4) before or after their reading to help them place the concepts from the article in perspective, especially issues related to mining asteroids for gold and other valuable resources.

- Ask students if they have ever panned for gold, or if they have seen pure gold nuggets. Be sure to point out the "Chemistry in Pictures" photo and caption on page 2.
- Encourage students to watch the video "Why We Are Made of Star Stuff" mentioned in the article.
- Encourage students to do the puzzle on page 8. The answers are below. You can also find a printable version for your students online at www.acs.org/chemmatters.

Where's the gold?

Not only is gold beautiful, it can be beaten into sheets 0.18 μm thick, drawn into wires 1 μm in diameter, and is inert to most acids and oxidants. Plus, it's a good conductor of heat and electricity and forms stable, uniform nanoparticles.

Below are some of the uses of gold, but each letter has been randomly substituted with another letter of the alphabet. The letter substitutions are the same for each word. Can you identify all the uses of gold?
(Starting hint: N stands for C and R stands for L)

1) YHZHRAM
2) NEKUX
3) NDUNHA VAHDVPHUVX
4) PHBDRX
5) XPDAVLCEUH NKANFKVX
6) HRHNVAKNDR NEUVDNVX
7) DAVKSKNKDR RHQX
8) AHSRHNVKJH NEDVKUQ KU XLDNH CHRPHVX

Answers

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

1) JEWELRY
2) COINS
3) CANCER TREATMENTS
4) MEDALS
5) SMARTPHONE CIRCUITS
6) ELECTRICAL CONTACTS
7) ARTIFICIAL LEGS
8) REFLECTIVE COATING IN SPACE HELMETS

Where's the gold? Puzzle – In Spanish:

¿Donde Esta el Oro?

El oro no solo es hermoso, sino que se puede convertir en láminas de 0.18 µm de grosor, se enrolla en cables de 1 µm de diámetro y es inerte para la mayoría de los ácidos y oxidantes. Además, es un buen conductor de calor y electricidad y forma nanopartículas estables y uniformes.

A continuación se presentan algunos de los usos del oro, pero cada letra ha sido sustituida aleatoriamente con otra letra del alfabeto. Las sustituciones de letras son las mismas para cada palabra. ¿Puedes identificar todos los usos del oro?
(Sugerencia inicial: la D representa A y la A representa R)

1) YEMHAKD
2) PEUHBDX
3) VADVDPKHUVEX BH NDUNHA
4) PHBDRRDX
5) NKANFKVEX LDAD VHRHSEUEX KUVHRKQHUVHX
6) NEUVDNVEX HRHNVAKNEX
7) LKHAUDX DAVKSKNKDRHX
8) AHNFOAKPKHUVE AHSRHNVDUVH HU NDXNEX HXLDNKDRHX

Respuestas

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

1) JOYERÍA
2) MONEDAS
3) TRATAMIENTOS DE CÁNCER
4) MEDALLAS
5) CIRCUITOS PARA TELÉFONOS INTELIGENTES
6) CONTACTOS ELÉCTRICOS
7) PIERNAS ARTIFICIALES
8) RECUBRIMIENTO REFLECTANTE EN CASCOS ESPACIALES

ChemMatters™

Demystifying Everyday Chemistry

Teacher's Guide for

Cash, Chemistry, and Counterfeit

October 2019

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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. The oldest surviving paper banknote is from Mexico.
		2. Isaac Newton and Benjamin Franklin worked to devise various ways to prevent counterfeiting.
		3. At the time of the Civil War, it is estimated that almost half of the paper money in circulation in the U.S. was counterfeit.
		4. Originally photographs were black and white, so paper money was made green to avoid counterfeiting.
		5. Counterfeit detecting pens can only tell if the paper contains starch.
		6. It is easy to fake a watermark.
		7. All U.S. currency has a blue line that can be seen under a black light.
		8. U.S. currency is made from 100% cotton.
		9. The "20" printed on new $20 bills will change colors when the bill is tilted at different angles.
		10. Plastic currency is more difficult to counterfeit.

Student Reading Comprehension Questions

Name: ______________________________

Directions: Use the article to answer the questions below.

1. Throughout history, governments have utilized various methods of altering currency to help limit the production of counterfeit bills. List five alterations/improvements made to currency in hopes of stopping counterfeiting discussed in the article.

    1. ____________________________________
    2. ____________________________________
    3. ____________________________________
    4. ____________________________________
    5. ____________________________________

2. Compare and contrast a historical method of reducing counterfeiting currency to a modern technique used by governments worldwide.

3. Briefly explain the chemistry involved in the iodine-starch test

4. Briefly explain the chemistry involved in UV features on currency.

5. How does an electron in an “excited” state return to “ground” state?

6. The United States Department of Treasury estimates there is $70 million dollars of counterfeit bills in circulation, as of September 2019. Therefore, approximately there is one counterfeit bill for every 10,000 genuine bills. Suppose Bill Gates withdrew his entire $104.5 billion dollar fortune in $100 bills. Calculate how much of his $104.5 billion dollars would be counterfeit money.

7. Explain the advantages of using plastic as the basic material for currency. What are the potential limitations and obstacles (economic, social, environmental) a nation would face in hopes of transitioning to plastic currency?

Student Reading Comprehension Questions, cont.

8. The article mentions it is necessary for governments to constantly improve currency security methods to avoid counterfeit money as a result of technology advances. Make a claim, provide evidence, and use some reasoning to decide whether you think governments should continue to fund discovery and implementation of new techniques to limit currency counterfeiting.

   Claim:

   Evidence:

   Reasoning:

9. Digital currency and transactions (credit and debit cards, Venmo, online banking, etc.) have reduced the use of paper bills. What are the pros and cons of using digital currency and transactions compared to traditional cash?

Questions for Further Learning

Write your answers on another piece of paper if needed.

Suppose the government, due to advancements in digital currency and transactions such as credit and debit cards, Venmo, etc., decides they can no longer justify allocating time and money to prevent circulation of counterfeit paper money. You have been selected to lead the task force that will devise a plan to phase out the use of paper currency in the country. Explain in detail the plan you would implement to accomplish your mission. Consider the following when constructing your plan:

- What percentage of transactions are completed using cash?
- How would you ensure all the paper currency is collected and properly stored or destroyed?
- How would you account for people who do not have bank accounts or means to use digital currency?
- What are the dangers associated with eliminating paper currency?
- Would eliminating paper currency solve the majority of financial fraud in the U.S.? Why or why not?
- Now that currency counterfeit detection has been eliminated, what new problems could arise from a cashless society?

Graphic Organizer

Name: ______________________________

Directions: As you read, complete the graphic organizer below to describe counterfeiting methods over the years and how to test for them.

	Description	Test
Nonchemical Methods		
Ingredients in paper currency		
Inks		
Watermarks		
UV features		
Optically variable ink		
Plastic		

Summary: Write a tweet (280 characters or less) about how to detect counterfeit bills.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Throughout history, Governments have utilized various methods of altering currency to help limit the production of counterfeit bills. List 5 alterations/improvements made to currency in hopes of stopping counterfeiting discussed in the article.**
   Counterfeit detection pen (iodine starch test), cotton/linen composition, ink improvements, embedding colorful fibers, watermarks, UV features, color-changing features, plastic money.

2. **Compare and contrast a historical method of reducing counterfeiting currency to a modern technique used by governments worldwide.**
   Historical: Threats on currency, intricate patterns, misspelled words, colored ink
   Modern: holograms, UV features, plastic currency

3. **Briefly explain the chemistry involved in the iodine-starch test**
   The iodine solution in the pen reacts with the starch, which causes the formation of a charge transfer complex. The electrons in the charge complex molecules are easily excited by light and emit a dark-blue color on a genuine bill. The natural color of the iodine solution is brown and will remain brown if starch is not present in the bill.

4. **Briefly explain the chemistry involved in UV features on currency.**
   Special fluorescent pigments absorb one form of electromagnetic radiation and emit another type. The absorbed radiation is emitted as UV radiation, which is visible under a black light. These pigments can be used to make various hidden designs and markings, making the bills more difficult to counterfeit.

5. **How does an electron in an "excited" state return to "ground" state?**
   An excited electron returns to ground state by emitting energy in the form of electromagnetic radiation. This can be in the form of visible light, or a nonvisible form such as UV light or IR light.

6. **The United States Department of Treasury estimates there is $70 million dollars of counterfeit bills in circulation, as of September 2019. Therefore, approximately there is one counterfeit bill for every 10,000 genuine bills. Suppose Bill Gates withdrew his entire $104.5 billion dollar fortune in $100 bills. Calculate how much of his $104.5 billion dollars would be counterfeit money.**
   $104,500,000,000 ÷ $100 Bills = 1,045,000,000 individual $100 Bills
   1 counterfeit bill out of 10,000 genuine bills equates to 0.01% of all bills being counterfeit
   0.01 % of 1,045,000,000 = 104,500 fake bills
   104,500 fake bills x $100 bill (value of each bill) = ***$10,450,000 ($10.45 Million) in fake currency.***

7. **Explain the advantages of using plastic as the basic material for currency. What are the potential limitations and obstacles (economic, social, environmental) a nation would face in hopes of transitioning to plastic currency?**
   Student answers will vary. Example:
   Economic: Cost of producing new currency using plastic.
   Social: Phasing out the old currency. Citizens favoring old currency.
   Environmental: Source of plastic (oil vs recycled material)? Getting rid of old currency creates waste.

8. **The article mentions it is necessary for governments to constantly improve currency security methods to avoid counterfeit money as a result of technology advances. Make a claim, provide evidence, and use some reasoning to decide whether you think governments should continue to fund discovery and implementation of new techniques to limit currency counterfeiting.**
   Student answers will vary, example:
   Claim: Governments should still allocate funds to limit counterfeiting.
   Evidence: 18% of all transactions in the U.S. are completed using cash currency according to the US Department of Treasury.
   Reasoning: I feel the government should continue to allocate funds to limiting counterfeiting because data shows that cash continues to be a significant source of currency transactions in the U.S. despite advancements in technology and digital currency.

9. **Digital currency and transactions (credit and debit cards, Venmo, online banking, etc.) have reduced the use of paper bills. What are the pros and cons of using digital currency and transactions compared to traditional cash?**
   Students answers will vary, Examples
   Pros: Limits counterfeiting of paper money, Do not have to carry cash, Reduced cost for government to produce new money.
   Cons: Cyber crime, fraud, identity theft, stolen information, prone to technology issues and failures.

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

In this lab, students perform an iodine clock reaction to determine how concentration and temperature effect the reaction rate. https://teachchemistry.org/classroom-resources/starch-iodine-clock-reaction

You can also try this lab with triiodide: https://teachchemistry.org/classroom-resources/diy-triiodide

Simulations

Excited Electrons. In this simulation, students will explore what happens when electrons within a generic atom are excited from their ground state. They will see that when an electron relaxes from an excited state to its ground state, energy is released in the form of electromagnetic radiation. https://teachchemistry.org/classroom-resources/exciting-electrons

Projects and extension activities

"The Disappearing Spoon" book by Sam Kean. Follow up questions provided by AACT: https://teachchemistry.org/classroom-resources/the-disappearing-spoon-reading-questions

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Chemistry Basics
  - Chemical and physical changes
  - Chemical and physical properties
- Atomic Structure
  - Emission spectrum

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:

- Patterns
- Structure and Function
- Stability and Change

Science and Engineering Practices:

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

Nature of Science:

- Scientific investigations use a variety of methods.
- Scientific knowledge assumes an order and consistency in natural systems.
- Science is a human endeavor

Correlations to Common Core State Standards

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 the Anticipation Guide: Before reading, ask students what is done to cash money to try to prevent counterfeiting. As they read, students should record information they find interesting and look for answers to their questions.
- Ask students what they found most interesting from reading article.

ChemMatters
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Teacher's Guide for

The Measure of a Mole

October 2019

Table of Contents

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 mole is a metric unit used to count things.
		2. The mass of a kilogram was set as the mass of an iridium-platinum cylinder (IPK) made in 1889.
		3. Today's definition of a mole is related to carbon-12.
		4. A unit cell of silicon has 18 atoms inside.
		5. The concept of a mole is based on a fundamental constant of nature (Avogadro's constant).
		6. To simplify the math, Einstein used the Avogadro constant in his doctoral thesis.
		7. Natural silicon has only one isotope.
		8. The silicon sphere used to determine the Avogadro constant had the same mass as the IPK that defined the kilogram for more than a century.
		9. The silicon spheres used to calculate the Avogadro constant in the 21st century required the collaboration of scientists from Russia, Germany, and Australia.
		10. The new definition of the kilogram is based on Planck's constant.

Student Reading Comprehension Questions

Name: ______________________________

Directions: Use the article to answer the questions below.

1. How many atoms are in 2-dozen atoms? How many molecules are in 1.5-dozen molecules?

2. What physical object was used to define a kilogram before the new system was created?

3. Why is the old definition of a mole related to the definition of a kilogram?

4. Why can't you work with a single water molecule in your lab?

5. How do you calculate the volume of a cube?

6. What is the difference between ^{28}Si and ^{29}Si?

7. Why did scientists use only one of silicon's three isotopes to make the new standard sphere?

8. Why is the silicon sphere a better measurement standard than the original IPK?

9. Explain how density is used to calculate the number of atoms in a mole.

Student Reading Comprehension Questions, cont.

Questions for Further Learning

Write your answers on another piece of paper if needed.

1. Pure solids often have well-known structures based on how the atoms or ions are arranged. If the arrangement is orderly and repeating, it is crystalline. If there is no regular or repeating arrangement, it is amorphous.
   a. Research the following allotropes of carbon and classify them as having crystalline or amorphous structure:

Allotrope	Crystalline or Amorphous?
Diamond	
Coal	
Graphite	
Buckminsterfullerene	

   b. Silicon has two allotropes, simply called crystalline silicon and amorphous silicon. Propose a reason that scientists would choose to use silicon instead of carbon when creating an ideal crystal.

2. Many units that are used in science are derived units. That means that they are dependent on two or more of the seven base SI units. Some of these have a special name and others are simply a derivation of the units. When redefining the kilogram, a different method was used to set the standard. This method used an instrument called a watt balance. The watt balance relies on the interrelationships between several of the SI units. The equation used was:

$$UI = ma_g v$$

where U = electric potential; I = current; m = mass; a_g = gravitational acceleration; and v= velocity.

Using the tables below, show that the units on each side of the equation are equivalent to watts.

SI Base Units

Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

Quantity	Name	Symbol	SI units
Energy	Joule	J	$\frac{kg \cdot m^2}{s^2}$
Power	Watt	W	$\frac{J}{s}$
Electric charge	Coulomb	C	A•s
Electric potential	Volts	V	$\frac{J}{C}$
Velocity	-	v	$\frac{m}{s}$
Acceleration	-	a	$\frac{m}{s^2}$

3. Write an essay with at least two resources cited to answer the question: Why is it important for scientists to develop definitions for standard measurements that do not rely on a physical object?

Graphic Organizer

Name: ______________________________

Directions: As you read, complete the graphic organizer below to describe a mole in chemistry.

	Description, including chemicals used and problems encountered (if applicable)	**Year**
International Prototype of the Kilogram (IPK)		
Jean Perrin's experiments		
Ideal Crystal –Attempt by NIST		
Ideal Crystal – Effort by International Avogadro coordination		
New definition of the kilogram		
New definition of the mole		

Summary: Write a short summary (18 words or less) explaining why the standard for the kilogram (and therefore the mole) had to change.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **How many atoms are in 2 dozen atoms? How many molecules are in 1.5 dozen molecules?**
24 atoms; 18 molecules. These can be calculated as follows:

$$2\ dozen \times \frac{12\ atoms}{1\ dozen} = 24\ atoms$$
$$1.5\ dozen \times \frac{12\ molecules}{1\ dozen} = 18\ molecules$$

2. **What physical object was used to define a kilogram before the new system was created?**
The International Prototype of a Kilogram (IPK), which was an iridium-platinum cylinder created in 1889 and kept in a vault.

3. **Why is the definition of a mole related to the definition of a kilogram?**
A mole is based on the mass of a sample of carbon atoms. If the definition of a kilogram were changed, then the mass of those carbon atoms would change, and therefore the definition of a mole would change.

4. **Why can't you work with a single water molecule in your lab?**
One water molecule is extremely tiny. You are not able to see or feel it, so it is impossible to manipulate it or measure it in any way.

5. **How do you calculate the volume of a cube?**
Take the length of one side and cube it. (length x width x height, with all sides equal).

6. **What is the difference between ^{28}Si and ^{29}Si?**
Both have 14 protons, but ^{29}Si has one more neutron (15) than ^{28}Si (14). This makes ^{29}Si heavier than ^{28}Si.

7. **Why did scientists use only one of silicon's three isotopes to make the new standard sphere?**
If multiple isotopes were allowed in the sphere, there would be no way of knowing with certainty how many of each there were, thus preventing an accurate accounting for the mass.

8. **Why is the silicon sphere a better measurement standard than the original IPK?**
The silicon sphere can be measured by scientists and related to some fundamental constants of nature. Once the relationship is known reliably and consistently, there is no further need to use the sphere, because the definition will not be based on the sphere (which could change) but on the constants (which remain stable). Anyone with the right equipment could reproduce these results.

9. **Explain how density is used in calculating the number of atoms in a mole.**
Density here is used in two ways, atoms/cm^3 and mol/cm^3. The number of atoms in one cubic centimeter can be derived from the unit cell, which is a repeating unit of a specific crystal structure. The number of atoms in the unit cell are known, as is the length of the sides of the cube comprising the unit cell. The number of moles in one cubic centimeter can be derived using a measured density, along with molar mass. Dividing density (g/cm^3) by molar mass (g/mol) gives mol/cm^3. If you know both the atoms and the number of moles in a cubic centimeter, then these two quantities are also equivalent, giving the number of atoms per mole.

Questions for Further Learning

1. **Pure solids often have well-known structures based on how the atoms or ions are arranged. If the arrangement is orderly and repeating, it is crystalline. If there is no regular or repeating arrangement, it is amorphous.**
   a. **Research the following allotropes of carbon and classify them as having crystalline or amorphous structure:**

Allotrope	Crystalline or Amorphous?
Diamond	*Crystalline*
Coal	*Amorphous*
Graphite	*Crystalline*
Buckminsterfullerene	*Crystalline*

   b. **Silicon has two allotropes, simply called crystalline silicon and amorphous silicon. Propose a reason that the scientists would choose to use silicon instead of carbon when creating their ideal crystal.**

   There are several allotropes of carbon as well as several isotopes of carbon, so it would be difficult to coax the atoms into a single crystalline structure containing mostly pure ^{12}C (which is the most abundant isotope of carbon). With silicon, there are only the amorphous and the crystalline arrangement, so with careful conditions, and after enriching it to be almost entirely ^{28}Si, there is only one crystalline form for the atoms to take on. Techniques involving pure silicon crystallization are already known from the semiconductor industry.

2. **Many units that are used in science are derived units. That means that they are dependent on two or more of the seven base units. Some of these have a special name and others are simply a derivation of the units. When redefining the kilogram, a different method was also being used in setting the standard. This method used an instrument called a watt balance. The watt balance relied on the interrelationships between several of the SI units. The major equation used was**

$$UI = ma_gv$$

where U = electric potential; I = current; m = mass; a_g = gravitational acceleration; and v = velocity.
Using the tables below, show that the units on each side of the equation are equivalent to watts.

SI Base Units

Quantity	Name	Symbo
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

Quantity	Name	Symbol	SI units
Energy	Joule	J	$\frac{kg\cdot m^2}{s^2}$
Power	Watt	W	$\frac{J}{s}$
Electric charge	Coulomb	C	A· s
Electric potential	Volts	V	$\frac{J}{C}$
Velocity	-	v	$\frac{m}{s}$
Acceleration	-	a	$\frac{m}{s^2}$

UI would have units of V ·A; V can be reduced to J/C, and C= A · s, so (J/ A · s) · A = J/s = Watt.

ma_gv *would have units of kg* $\cdot\frac{m}{s^2}\cdot\frac{m}{s}$ = $\frac{kg\cdot m^2}{s^3}$ = *J/s = Watt.*

3. **Write an essay with at least two resources cited to answer the question:**
   Why is it important for scientists to develop definitions for standard measurements that do not rely on a physical object?

   Some good points to mention:

   - *It is impossible to predict what will happen over time to a physical object. It is impossible to claim that a physical object can be kept safe from all disasters.*
   - *If there are fundamental constants that can be used to reliably and consistently describe a standard measurement, then that is a better method to use because the constants will not change.*
   - *So many of the measurements we use rely on other measurements that it is important to have one standard way of measuring the base units or every other unit will be inconsistent.*
   - *There are many sources that discuss the various measurements and how they have historically changed. Students can reference these as examples.*

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

Target Mole Lab: A common chemical reaction used in chemistry class is zinc and hydrochloric acid. In this lab, students calculate how many zinc and chlorine atoms take place in the reaction, and then predict the mass of the solid product. The final grade will be determined by the electronic balance.
www.flinnsci.com/target-mole-lab/dc91660/

Simulations

Simple interactive showing the relationship between mass, moles, and particles.
http://employees.oneonta.edu/viningwj/sims/compounds_molecules_moles_s.html

Visualize some different crystal structures:
www.chemtube3d.com/category/inorganic-chemistry/solid-state-cubic-structures/

Videos

Excellent and simple description of how the kilogram was redefined using the watt balance. The mole and the kilogram redefinitions were linked together. www.youtube.com/watch?v=Oo0jm1PPRuo

Short video about various types of crystals in our world.
www.acs.org/content/acs/en/pressroom/reactions/videos/2014/salt-diamonds-and-dna-5-surprising-facts-about-crystals.html

Short video that shows representatives from the many countries involved in this long-term project. This could serve to engage students for a research project on the contributions of the 60 countries to this project.
www.youtube.com/watch?v=V7myhT_CwYc

Lessons and lesson plans

Short video on Avogadro with an accompanying worksheet:
https://teachchemistry.org/classroom-resources/amedeo-avogadro-video

AACT Lesson: Calculating moles in daily life:
https://teachchemistry.org/classroom-resources/calculating-moles-in-daily-life

Projects and extension activities

For a simple activity that explains some different crystal systems, students can read the information, answer the questions, and follow the link from this site: https://courses.lumenlearning.com/cheminter/chapter/unit-cells/

Several Mole Day activities here:
www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/mole-day.html

Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Chemistry Basics
  - Accuracy
  - Physical properties
- Quantitative Chemistry
  - Mole concept
  - Measurement
  - SI units

Correlations to Next Generation Science Standards

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

HS-PS1-8
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter
- PS1.C: Nuclear Processes

Crosscutting Concepts:

- Scale, Proportion, and Quantity
- Energy and Matter
- Stability and Change

Science and Engineering Practices:

- Developing and using models
- Asking questions (for science) and defining problems (for engineering)

Nature of Science:

- Science models, laws, mechanisms, and theories explain natural phenomena.
- Science addresses questions about the natural and material world

Student Reading Comprehension Questions – connections to NGSS Crosscutting Concepts:

- Q3 + Q4: Scale, Proportion, and Quantity
- Q7 Further Learning Q1: Structure and Function

Correlations to Common Core State Standards

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:

- Encourage students to complete the calculation to determine Avogadro's constant provided in the article. The calculation is outlined below:

> If you know how many atoms are in a cubic centimeter, and you know how many moles are in the same volume, then the number of atoms per mole—the **Avogadro constant N_A**—is just the ratio of these two numbers:

$$N_A = \text{Atoms per cm}^3/\text{mol per cm}^3$$
$$= (4.994033964 \times 10^{22}\ \text{atoms/cm}^3)/(0.08292788506\ \text{mol/cm}^3)$$
$$= 6.02214076 \times 10^{23}\ \text{atoms/mol}$$

- Discuss the meaning of "viscosity" with students prior to reading the article.
- Use this with a lesson on calculations involving units, like unit conversions or creating and using complex units. Density is an easy complex unit that students will know, but may not recognize as "complex", or made of other units. Speed is another. These can lead to a demonstration of other more complicated units they will use in chemistry.
- Use this as an engagement for a lesson on isotopes.
- This could lead to a lesson on how structure affects properties, where different crystal packing arrangements are shown, and this can be identified as another factor (other than atom size and electronegativity) involved in the strength of interaction between atoms in a metal or nonmetal. This could be related to properties of solids in terms of melting point or lattice energy for ionic compounds.
- **Engagement Ideas**
    - Alternative to Anticipation Guide: Before reading, ask students why the mole is so important in chemistry, and how the mole is defined. As they read, students can find information to confirm or refute their original ideas.
    - You could do a short activity to have the students use their (hands, feet, fingers, whatever you choose) to measure something in the classroom, maybe a desktop or a textbook. Have them all report their measurements. You could also give a few examples of historical measurements like a cubit or using "hands" to show that this really is how measurements started. Let this begin a discussion of the importance of standardized measurements.

Teacher's Guide

The Future of Forensics

October 2019

Table of Contents

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 word "forensic" means debate.
		2. Most wrongful convictions are due to false or misleading forensic evidence.
		3. Ideally, forensics should connect evidence and a specific individual or source.
		4. Bite-mark analysis, microscopic hair analysis, and firearms examination have been scientifically validated as outstanding forensic evidence.
		5. Many traditional forensics methods are subjective.
		6. DNA evidence can be linked to a specific, unique source.
		7. Substances found at a crime scene can be identified in a lab using instruments to analyze samples from the crime scene.
		8. Gas chromatography identification depends on the polarity of a sample.
		9. Color-based field tests used by law enforcement must be followed up by additional testing in a lab.
		10. Fingerprint analysis is no longer used in forensics.

Student Reading
Comprehension Questions

Name: ______________________________

Directions: Use the article to answer the questions below.

1. What is the scientific method? How is the scientific method applied in a criminal investigation?

2. Explain the differences between class evidence and individual evidence. Give an example of each and give reasons for your choices.

3. State the pros and cons of field tests.

4. What are the top three factors that lead to false convictions?

5. What evidence was found that exonerated Santae Tribble?

6. Explain how gas chromatography works. Assuming the stationary phase in the gas chromatography machine contained a polar medium, how would that affect a polar molecule like water? How would it affect a nonpolar molecule such as benzene (C_6H_6)?

7. Briefly describe the FTIR instrument. Give reasons why this analysis would be more accurate than using gas chromatography analysis.

8. Some forensic techniques lack in scientific validation. Fingerprints are one example. Research and state some issues with fingerprint analysis that could result in false positives.

9. Is forensic evidence infallible? If you were a member of a jury on a murder trial, what other evidence would make you doubt the forensic evidence? What questions/concerns would a jury member be concerned about when they consider forensic evidence?

Student Reading Comprehension Questions, cont.

10. How would bias affect evidence gathering? What factors would be most susceptible to bias (use graph to support your answer)? How?

11. What is unique about forensic evidence that limits bias? How could forensic evidence be faulty and lead to wrong convictions?

<u>Questions for Further Learning</u>

Write your answers on another piece of paper if needed.

1. Research the differences between natural and synthetic substances. A great site to look at is http://www.drugpolicy.org/drug-facts/synthetic-cannabinoids-spice-k2-facts. Why do you think the tests that forensic scientists use on natural substances do not work on synthetic substances?

2. Below are the links of three different cases of false convictions and their exonerations. What evidence was used to convict them? What was found that exonerated them? If you were the investigator on this case, how would you handle the evidence differently?

   Patrick Pursley:
   http://www.law.northwestern.edu/legalclinic/wrongfulconvictions/exonerations/patrick-pursley.html

   Charles Johnson:
   http://www.law.northwestern.edu/legalclinic/wrongfulconvictions/exonerations/il/charles-johnson.html

   Daniel Anderson:
   http://www.law.northwestern.edu/legalclinic/wrongfulconvictions/exonerations/daniel-andersen.html

Graphic Organizer

Name: ______________________________

Directions: As you read, complete the graphic organizer below to explain what evidence you would give more weight to as a juror.

Evidence	***Description***	***Advantages***	***Disadvantages***
Fingerprints			
Microscopic hair analysis			
Firearm examinations			
DNA Analysis			
Instrumentation analysis			
Field tests for illicit substances			

Summary: Write a short email (three sentences) to a friend who has been called for jury duty telling them what types of evidence might be presented at a trial that are more reliable than others.

Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What is the scientific method? How is the scientific method applied in a criminal investigation?**
   The scientific method is the process used to solve scientific problems. The scientific method is applied in criminal investigations by: Making observations at the scene of the crime, collecting evidence, and develop a hypothesis based on the evidence. They do further tests to prove the hypothesis.

2. **Explain the differences between class evidence and individual evidence. Give an example of each and give reasons for your choices.**
   Class evidence refers to evidence with characteristics that are common to a group of people. Hair strands are one example. Many people can have the same type of hair. Individual evidence is linked one specific source. DNA is an example. Everybody has their own DNA "fingerprint" that is different from everyone else.

3. **State the pros and cons of field tests.**
   Field tests are good because you can do the tests at the scene of the crime (in the "field"). They also provide results quickly. The down side of field tests is that they may provide false positive results. Therefore, more testing needs to be done in a laboratory.

4. **What are the top three factors that lead to false convictions?**
   According to the graph on page 16:
   1. perjury/false accusations
   2. Official misconduct
   3. Mistaken witness ID

5. **What evidence was found that exonerated Santae Tribble?**
   The evidence that was found to exonerate Santae was DNA testing on the hairs in the mask. The DNA on the mask did not match Santae's DNA. Additionally, one of the hairs thought to be Santae's was actually from a dog.

6. **Explain how gas chromatography works. Assuming the stationary phase in the gas chromatography machine contained a polar medium, how would that affect a polar molecule like water? How would it affect a nonpolar molecule such as benzene (C_6H_6)?**
   In a gas chromatography analysis, a liquid is vaporized and passed thru the "stationary phase". The stationary phase binds to the sample in varying degrees based on the polarity of the sample, compared to the stationary phase. If the stationary phase was polar, it would bind with any polar substances in the sample, thus slowing down their travel. The nonpolar substances would move faster thru the phase. Scientists can determine what chemicals are in a sample based on how easily they move thru the phase.

7. **Briefly describe the FTIR instrument. Give reasons why this analysis would be more accurate than using gas chromatography analysis.**
   FTIR is more specific than gas chromatography. Infrared rays pass thru the sample, which stretches and bends the bonds in ways unique to the molecules. This is considered the "fingerprint" of the molecule.

8. **Some forensic techniques lack in scientific validation. Fingerprints are one example. Research and state some issues with fingerprint analysis that could result in false positives.**
   One site to use is: https://www.pbs.org/wgbh/frontline/article/forensic-tools-whats-reliable-and-whats-not-so-scientific/. One quote: "According to the National Academies of Sciences, no peer reviewed scientific studies have ever been done to prove the basic assumption that every person's fingerprint is unique."

9. **Is forensic evidence infallible? If you were a member of a jury on a murder trial, what other evidence would make you doubt the forensic evidence? What questions/concerns would a jury member be concerned about when they consider forensic evidence?**
   Answers will vary

10. **How would bias affect evidence gathering? What factors would be most susceptible to bias (use graph to support your answer)? How?**
    Someone who is biased will look for evidence or present evidence in a way that will favor a specific outcome. Bias could play a big role in official misconduct, perjury, and mistaken ID. These factors are not scientific, and they are only effective if the person is neutral or does not have a pre-formed opinion.

11. **What is unique about forensic evidence that limits bias? How could forensic evidence be faulty and lead to wrong convictions?**
    Forensic evidence can limit bias because it is based on facts and physical evidence. "Neutral" scientific instruments process the evidence, and they do not have any pre-conceived opinions. Forensic evidence could be faulty if the physical evidence was contaminated, or not properly collected. There could be some bias in interpreting the results of the forensic testing as well, such as misreading fingerprint samples or hair samples.

Questions for Further Learning
Student 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

Labs and demos

How to Extract DNA From a Strawberry: This activity demonstrates how DNA can be isolated from a strawberry using common household materials. Watch a video of the experiment to get started.
https://www.genome.gov/Pages/Education/Modules/StrawberryExtractionInstructions.pdf
https://www.youtube.com/watch?v=hOpu4iN5Bh4

Powder Analysis: A forensic scientist may discover powder at a crime scene. To determine if it is illegal or not the crime lab will identify the substance using chemistry. Have your students take the role of a forensic chemist to identify unknown substances.
http://stem-works.com/external/activity/173

Recasting Chemistry Labs with Forensic Themes. This is a forensics investigation that involves analysis of spectra:
https://teachchemistry.org/periodical/issues/march-2018/recasting-chemistry-labs-with-forensic-themes

Videos

Why Are Synthetic Drugs So Dangerous?: This ACS Reactions video takes a look into the science of why synthetic drugs are so dangerous. It answer this question by examining the chemistry of two kinds of synthetic drugs: bath salts and synthetic marijuana.
https://www.acs.org/content/acs/en/pressroom/reactions/videos/2016/why-synthetic-drugs-are-as-scary-as-you-think-video.html

Lessons and lesson plans

Modeling Polarity: This AACT resource teaches through movement in two activities. In the first activity, students will kinesthetically demonstrate the use of electronegativity to determine covalent bond types. In the second activity, students will model bonds in a compound to determine the overall polarity of a molecule.
https://teachchemistry.org/periodical/issues/may-2019/modeling-polarity

Projects and extension activities

Challenge your students to solve this forensic chemistry crossword puzzle:
https://teachchemistry.org/classroom-resources/forensic-chemistry-crossword

Chemistry Concepts, Standards, and Teaching Strategies

Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Molecules and bonding
- Molecular structure
- Instrumentation

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:**
  - Patterns
  - Cause and Effect
  - Structure and Function
  - Stability and Change
- **Science and Engineering Practices:**
  - Planning and carrying out investigations
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communication information
- **Nature of Science:** Scientific knowledge is based on empirical evidence.

Correlations to Common Core State Standards

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 forensics tests are done in order to solve crimes, and which tests are best. As they read, students should add to their original list.
- Encourage students to watch the video "TV Forensics: What do CSIs Actually Do?" mentioned in the article.
- Students can learn more about how to become a forensic chemist and what they do by reading "Investigate the Career Path of a Forensic Chemist" on page 19.
- Ask students what a "false positive" test means and how it relates to forensics (as well as health screening).

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