

**Teacher’s Guide**

**The Secret Life of Gold**

***October 2019***

**Table of Contents**

[Anticipation Guide](#_Anticipation_Guide) 2

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](#_Additional_Resources_1) 8

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

[Chemistry Concepts, Standards, and Teaching Strategies 9](#_Chemistry_Concepts,_Standards,)

# 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. |
|  |  | 1. Gold was formed during the Big Bang. |
|  |  | 1. Stars were formed during the Big Bang. |
|  |  | 1. During nuclear fusion, the hydrogen nuclei in stars fuse to form helium nuclei. |
|  |  | 1. Iron is the most stable form of matter. |
|  |  | 1. Neutron stars create heavy elements. |
|  |  | 1. There is gold in Earth’s core. |
|  |  | 1. 24-karat gold is pure gold. |
|  |  | 1. Some gold mines are more than 10 miles deep. |
|  |  | 1. 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.*

1. **What is the composition of a neutron star?**

*A neutron star is composed of 95% neutrons and 5% protons.*

1. **Geologically speaking, what are the two places on Earth that gold is found?**

*Gold is found in Earth’s core and crust.*

1. **What is an alloy?**

*An alloy is a mixture of two metals.*

1. **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.*

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

*Stars release energy through nuclear fusion.*

1. **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.*

1. **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.*

1. **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.*

1. **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*

1. **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.*

1. **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.*

1. **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*

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

**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](https://www.acs.org/content/acs/en/education/outreach/ncw.html). 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](https://www.acs.org/content/acs/en/pressroom/reactions/videos/2014/why-we-are-made-of-star-stuff.html)” 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](http://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