

**Teacher’s Guide**

**Cash, Chemistry, and Counterfeit**

***October 2019***

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

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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.

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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. The oldest surviving paper banknote is from Mexico. |
|  |  | 1. Isaac Newton and Benjamin Franklin worked to devise various ways to prevent counterfeiting. |
|  |  | 1. 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. |
|  |  | 1. Originally photographs were black and white, so paper money was made green to avoid counterfeiting. |
|  |  | 1. Counterfeit detecting pens can only tell if the paper contains starch. |
|  |  | 1. It is easy to fake a watermark. |
|  |  | 1. All U.S. currency has a blue line that can be seen under a black light. |
|  |  | 1. U.S. currency is made from 100% cotton. |
|  |  | 1. The “20” printed on new $20 bills will change colors when the bill is tilted at different angles. |
|  |  | 1. 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.
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. Compare and contrast a historical method of reducing counterfeiting currency to a modern technique used by governments worldwide.
8. Briefly explain the chemistry involved in the iodine-starch test
9. Briefly explain the chemistry involved in UV features on currency.
10. How does an electron in an “excited” state return to “ground” state?
11. 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.
12. 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.**

1. 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:

1. 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.*

1. **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*

1. **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.*

1. **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.*

1. **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.*

1. **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.***

1. **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.*

1. **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.*

1. **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](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: 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.