

The Museum of Gold

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Abstract

For centuries humans have been fascinated with the element gold. Gold is considered to be a noble metal, meaning that it is highly resistant to chemical action such as corrosion. Gold permeates our everyday life, from idioms (“the gold standard”), the jewelry we wear, and the technology that powers the world. Societies and governments even build their economies around the value of gold. There is no question that we as people deem gold as important to our existence, but how much is it really worth to our advancement, and how can our complicated past with this metal help us shape how we continue to use it? Middle school students are exposed to gold everyday, but do they really understand its significance? This unit is designed to help students understand its chemical, economic, and societal value.

Unit Content

Problem Statement

With social media, the internet, and the increased availability and popularity of cell phones, middle-school age students interact with each other on a global level. Advanced technology has brought students access to content around the world, however many students (and even adults) do not think about the supply of raw materials that makes such technology available. Considering the climate crisis, many students are also not aware of the nuance of switching from fossil fuels to alternative energy, and what is involved in making that switch. Sometimes it feels as if we are trading in one “evil” for another. Developmentally, it is often hard for middle-school age students to connect with such vast and often abstract issues. My unit hopes that through a very focused topic - gold - students can see how just one element on Earth has such profound and far-reaching impacts on not only the individual level (the inner workings of their cell phone) but also a global level. We as people have a long and complicated history with gold, and it has often shaped us physically (gold fillings and grills) to how we value ourselves and each other. Gold fills our popular culture when we think of money and status and students are familiar with its appearance and worth. My unit seeks to help students dig deeper and understand gold on the elemental, societal, and economic level.

Students will be taught a series of mini-lessons centered around the topic of gold. These mini lessons will cover the following topics:

Chemical and Physical Properties of Gold

The chemical symbol for gold is Au and its atomic number is 79. Gold is considered a noble element because it can not corrode or oxidize under normal conditions. Gold can also be naturally found in its native or “pure” state; not mixed with any other elements. Among its other unique properties are its malleability, or ability to be easily shaped and bent. Gold can be hammered or stretched into extremely thin sheets and wires and is very electrically and thermally conductive. Additionally, gold is resistant to being dissolved in acids, reflective to infrared radiation, and non-toxic.

The Ancient Value of Gold

Humans have fashioned items out of gold as far back as 6500 years. Bulgaria currently claims to have uncovered the oldest artifact - a 4mm gold bead found in the ruins of a small home (Krasimirov, 2016).¹ Between 1972 and 1991 scientists uncovered the necropolis of Varna, also from Bulgaria. This archeological discovery totaled about 13 pounds in weight, and mostly jewelry and other items of adornment (Daley, 2016).² Gold’s earliest uses were ornamental and it was used and revered for its beauty. At around 550 BCE gold was made into coins and the Romans assigned a monetary value to these gold pieces (Amadeo, 2021).³ The Ancient city-state of Ur, located in present-day Iran, had a vast gold collection. Some of the pieces were bowls or other vessels, and some gold was fashioned into tools or weapons, but because of the highly malleable state of the metal, were probably used purely as a display of wealth (Horne, 1998).⁴ The Egyptians are famously known for their gold, oftentimes fashioning jewelry and other ornaments out of an alloy of gold and silver called electrum. The Egyptians even associated gold with religion, saying that it descended from the heavens and was thus indestructible. The sun God Ra is often depicted as a mountain of gold. The Egyptians also used gold in a variety of ways, from casting it to applying it to glass and other pieces of art in the form of super-fine sheets known as leaf (Schorsch, 2017).⁵

Modern Uses of Gold

Today, gold is used primarily for jewelry (50%), official coins (8%), and electronics (37%). Because of its conductivity and resistance to corrosion, gold is found in most electronics such as cell phones and computers. Gold is still coveted for its beauty and shine as it was in the ancient civilizations, but because of its high level of malleability, it

¹ <https://www.reuters.com/article/us-bulgaria-archaeology-gold/tiny-bead-from-bulgaria-may-be-worlds-oldest-gold-artifact-idUSKCN10L0YQ>

² <https://www.smithsonianmag.com/smart-news/oldest-gold-object-unearthed-bulgaria-180960093/>

³ <https://www.thebalance.com/gold-price-history-3305646#citation-9>

⁴ <https://www.penn.museum/sites/expedition/ur-and-its-treasures/>

⁵ https://www.metmuseum.org/toah/hd/egold/hd_egold.htm

is often mixed with other metals or used as a plating. A popular reference to gold used internationally for ornamental reasons are the medals used in the World Olympics. The gold medal is not actually pure gold but primarily silver and coated with a layer of gold on the outside. Although jewelry is still the single-largest use of gold, as the world moves toward electronic and renewable energy sources, the use of gold in electronics has steadily increased. Gold is even used for space travel and NASA currently uses thin layers of gold to shield equipment against radiation and heat from the sun (NOAA, 2016).⁶

Gold Mining Methods

Gold is considered to be one of the ten rarest elements in the Earth's crust and is estimated at 0.005 parts per million. Some scientists believe that there is a significant amount of gold in the world's oceans, either dissolved in seawater or buried beneath the ocean floor. Ancient mining methods included open-pit excavations but because gold can be found in its native state, prospectors could also find visible gold pieces or nuggets at the bottoms of streams and rivers. Geographically today, most of the world's gold is sourced from Australia, China, and South Africa (USGS, 2021).⁷ The extraction of gold requires several methods. The most popular of these methods uses cyanide to leach gold from ore. Leaching falls into two categories: heap or vat. Amounts of crushed ore, or crushed rock containing gold are either placed in piles (heaps) or large holding tanks (vats). The cyanide is added to the ore and dissolves the surrounding rock, leaving the gold behind. Another modern method of gold mining is called artisanal mining. Artisanal mines are small-scale mines that employ the neighboring villagers of the mines, often children. In these open pit mines the villagers will dig and "wash" the ore with mining chemicals such as mercury to extract the gold within. Mercury is one of the elements on the periodic table, and is considered to be a heavy metal that is highly toxic to humans. Prolonged exposure to mercury results in a vast number of health complications, such as permanent neurological damage, difficulty breathing, and cardiovascular disease.

Mining for Gold in the United States

One of the most well-known accounts of gold mining in the United States is the California Gold Rush. In 1848 gold was found at Sutter's Mill, California. John Sutter was building a sawmill along the American river in Coloma. His carpenter, John W. Marshall, found gold flakes in the riverbed. At first the two tried to keep it a secret, but soon word spread of the discovery. Hundreds of thousands of people flocked to California in hopes of getting rich by panning for gold. However, there was very little payout - although \$2 billion was found, very few individual prospectors became wealthy

⁶ <https://www.nesdis.noaa.gov/news/good-gold-are-satellites-covered-gold-foil>

⁷ https://www.usgs.gov/faqs/how-much-gold-has-been-found-world?qt-news_science_products=0#qt-news_science_products

(Britannica, 2021).⁸ The Gold Rush also drastically changed the demographic of the region and introduced negative social implications. For example, before 1848 the majority of the population was Native Americans, but with the huge influx of immigration, many natives were forced out of communities or succumbed to disease brought by the newcomers. Another complication involved racial discrimination. Chinese immigrants made up one fifth of the incoming prospectors and in 1852 California passed a Foreign Miners Tax, directed at Chinese and other immigrant miners (PBS, 2021).⁹ Many American miners would blame the Chinese and immigrant miners for hardships they faced, such as robberies and harsh living conditions. This increased an anti-Chinese sentiment and led to violence and murders of Chinese workers. On a larger government scale, the gold rush also contributed to hastening of California becoming a state in the Union.

Mansa Musa

Mansa Musa is known as the richest man in history, a Black man who was the ruler of the Mali Empire beginning in 1312. Mansa Musa became ruler after his predecessor went missing at sea, and while European nations during this time period were struggling, the Mali Empire had acquired enormous wealth through its natural resources of salt and gold. Mansa Musa is most famous for his pilgrimage to Mecca, a practice of the Muslim faith. He took a caravan of animals, servants and slaves, and hundreds of pounds of gold. Along the way he gifted many of his valuables to neighboring rulers and merchants, and word of his immense wealth spread along the countryside. During his pilgrimage he also acquired land, and expanded the size of his kingdom. He is an important figure in history, and has been a source of inspiration in modern-day popular culture, such as in the story of Black Panther. It is difficult to calculate his exact net worth due to the pricelessness of land and items he accumulated, however many scholars report that he is far more wealthy than any person today. The story of Mansa Musa also starkly contradicts many stereotypes of Africa and Africans, as being a place that is “uncivilized” and “primitive” in comparison to civilizations in Asia and Europe (Morgan, 2018).¹⁰

“The Gold Standard”: How Gold is Used to Power the Economy

The idiom “gold standard” began when the price of gold was directly linked to the economy. The price of gold would be fixed, and the value of printed or paper money of that system would be linked to that price of gold at the time. The value of one dollar would be directly connected to the value of one ounce of gold. This also means that when the value and price of gold goes up, so does the value of the dollar in that system. During the 18th century in Europe printed paper money began to dominate the economy over

⁸ <https://www.britannica.com/topic/California-Gold-Rush>

⁹ <https://www.pbs.org/wgbh/americanexperience/features/goldrush-chinese-immigrants/>

¹⁰ <https://www.history.com/news/who-was-the-richest-man-in-history-mansa-musa>

gold coins and bullion, and the “gold standard” system was introduced as a way to balance the two systems (paper vs. gold coins). Silver, although more abundant, was also a part of the coin economy and needed to be accounted for. This system of converting the value of gold and silver into paper currency lasted until World War I and the Stock Market Crash, when political clashes between nations made the global economy fragile. Today we do not use gold as a way to determine the economy, and its value is based upon demand and access as opposed to it having an inherent value that then determines the rest of an economic system. However, it is still considered to be an asset and important resource, especially for its uses in modern technology (Lioudis, 2021).¹¹

Environmental and Societal Implications

Today much of the global gold supply is more difficult to access. Gold that was considered as “easy” to obtain has mostly been mined. Many countries and mining companies have to use more difficult mining locations, or dig deeper than before to collect less gold (Folger, 2021).¹² Mining gold also has a tremendous impact on the communities in which these mines exist. Most gold is mined in China, Australia, and South Africa (USGS, 2021).¹³ Many methods that are used involve harsh chemicals to dissolve the surrounding ore and leave the gold behind. One of these chemicals is cyanide. The cyanide has potential to leach into groundwater and thus polluting the environment and serving as a hazard to wildlife, such as birds and bats. Some mining methods, such as artisanal mining, also involve employing villagers, many times from under-resourced communities, to work in open-pit mines with steady exposure to the mining chemicals such as mercury. There are also physical hazards when mining, not to mention the back-breaking work for meager compensation. This creates a cycle of dependency, where being an artisanal miner often provides a higher income than other jobs such as farming, but that “higher income” is still well below the value that manufacturers and companies would consider a “living wage” in places such as the United States. The miner is often not compensated for quality health care, while experiencing daily exposure to conditions that compromise their health. There are often different regulations for environmental impact and pollution mitigation, according to the regulating bodies of that area. For example, the government regulations for mines in the United States are different from the regulations in China. Different regulations create inconsistency in sustainable and ethical sourcing of gold in various products.

¹¹ <https://www.investopedia.com/ask/answers/09/gold-standard.asp>

¹² <https://www.investopedia.com/financial-edge/0311/what-drives-the-price-of-gold.aspx>

¹³ https://www.usgs.gov/faqs/how-much-gold-has-been-found-world?qt-news_science_products=0#qt-news_science_products

Teaching Strategies

The following teaching strategies will be used to implement this unit:

1. Research - Students will research on their own for the culminating project but will also learn how to select valid and accurate research sources and analyze those sources for validity and accuracy. Students will practice and use citations for their writing and documentation.
2. Mineral/element classification and categorization- Students will learn how geologists classify and identify minerals and elements. Students will then use those same methods to categorize/identify gold and differentiate gold from other minerals such as pyrite and elements such as tungsten.
3. Presentation - students will need to be able to present their research both using writing but also orally in the form of a museum exhibit. Students will act as docents and will need to answer candid questions about the exhibit they have created.
4. Creative representation/display - students will need to be able to create a hands-on exhibit to display and showcase their work that includes visual elements
5. Small-group collaboration - students will need to collaborate with others, sharing materials and roles while they perform tests on different minerals/elements as well as designing the museum as a whole
6. JEDI - students will examine the topic of gold through the lens of justice, equity, diversity, and inclusion, especially when examining the social and environmental impacts of gold mining
7. Identity, Criticality, Knowledge, and Skill - this unit was written with the intention of applying Gholdy Muhammad's educational framework throughout. Students will see themselves through the content and real-life examples of gold and its use. Students will have the knowledge of resources, elements, and supply chain. Students will use the skills of mineral identification/classification and research. Students will critically analyze the practices of mining and how that relates to the local and global economy and societal ramifications (Muhammad, 2020).¹⁴

Learning Objectives

¹⁴ Muhammad, G. (2021). *Cultivating genius: An equity framework for culturally and historically responsive literacy*. Scholastic.

1. Students will conduct research on the various aspects of gold: history, elemental composition, influence on economy, mining and extraction methods, sustainability impact, uses, and supply chain. Students will analyze and evaluate the validity and accuracy of different sources while researching.
2. Students will synthesize their research into the form of a written summary on a topic of their choice when constructing their culminating project piece.
3. Students will use proper bibliographic citation and notation for their written piece.
4. Students will conduct a series of tests on a sample of gold and compare it to other rocks and minerals and their physical and chemical properties.
5. Students will analyze Earth's resources, how we obtain those resources, and how we use them.
6. Students will trace the supply chain of gold in their electronics such as a cell phone or Chromebook.
7. Students will analyze the chemical and physical properties of various elements and apply those findings to the analysis and identification of gold.
8. Students will discuss the environmental and social implications of mining and the extraction/use of Earth's resources.
9. Students will create an interactive visual display of their research findings.
10. Students will present their display and research to a live in-person or virtual audience.

Classroom Activities

Lesson 1: Earth's resources

Students will learn the vocabulary word “resource,” what a resource is and how we use the resources around us. The lesson opens with the teacher asking students to look at the tags of each other’s shirts. The students analyze what information is on each other’s tags - size, materials, washing instructions, and where the garment was made. The teacher asks students which of those pieces of information is the “resource.” Students will gain an understanding that their shirt is not the resource, but the raw material is. Students will then discuss where their shirt was made, and whether or not just because their shirt is made there, if the raw material, such as cotton, silk, or polyester was also made or grown there as well. This will provide an introduction to supply chain, which will be revisited in lesson 7. Students will discuss how everything we have in the classroom and in our homes is made by resources, and how some resources are materials we use to make goods, and other resources are services such as the worker in the factory that uses those materials to make an item. Resources are included in the food we eat, the clothes on our backs, and the structure of the homes we live in. Additionally, resources are often determined about what is available - if I live in a place that is surrounded by water, for

example, I might be eating what I can catch from that water. Students are told that we will be focusing on the element gold for this unit, but at times will also examine the manufacturing companies and workers themselves. Students will be tasked with going home and finding one item that they can report the materials that are in the item, where the item was made, and what kind of resource that item is. Most students will feel comfortable looking inside their cupboards, refrigerators, or bathrooms where items like cereal, shampoo, and soap have labels listing ingredients and where that item was manufactured. However, some students might embrace the challenge of using an item that does not have an explicitly written source. For example, the student's family friend or relative may have a product (like baked goods or self care products) that s/he/they made themselves with locally (or non-locally) sourced ingredients. (See "Energy for Life" article in the anchor texts section of the appendix)

Lesson 2: Living and nonliving resources

For this lesson students will group resources we might have as either living or nonliving. Students will begin with a McDonald's BigMac and fries. They research what ingredients are in a BigMac and analyze which of those are living (like the cow in the patty) and non-living (like the salt on the fries). Students will research where those ingredients might be sourced, especially an ingredient like salt or iron (in the enriched flour in the bun). Students will gain an understanding that the lettuce is grown, while salt and iron are minerals extracted from the Earth. Students will also understand that some minerals naturally occur in plants and animals, but others, like the salt on the fries, are added to processed foods. This will lead into the discussion about how all of Earth's resources are made up of matter, and matter is combined in different ways throughout the universe to make substances. When matter is broken down to its simplest and smallest form, you have atoms, and those atoms are classified into specific elements. Students will understand that as different combinations of atoms of elements are made, all of the physical things that exist on Earth are made, including humans.

Lesson 3: The periodic table

Students will be introduced to the periodic table and how it is arranged and how certain resources such as iron are an element, but other resources like salt, are a combination of elements. Students will complete a periodic table scavenger hunt to familiarize themselves with the organization of the table.

Lesson 4: Element and mineral classification

Students will focus on rocks and minerals and how they are classified and identified by geologists using various characteristics such as streak, luster, hardness, cleavage, melting point, specific gravity, density, crystal structure, color, corrosivity, and buoyancy.

Students will perform a series of tests on pyrite to practice using these identifying characteristics and then later apply this method to the identification of gold.¹⁵ See “Rock Identification Sheet” in the handouts section of the appendix.

Lesson 5: Resource sourcing

Students will learn how we are able to obtain various resources, both resources that are a combination of elements and those that are pure elements. Students will use the virtual mining flashcards to examine various methods for element extraction such as different methods for mining. (See “Mining Flashcards” in the virtual resources section of the appendix)

Lesson 6: Resource scarcity

Students will learn about how some resources are renewable and some are not and what that means. Students will play a game to show how certain resources take longer to replenish and are therefore ‘non renewable’ while others are renewable because they are replenished more quickly or are more readily available. For the game, there are two “resources” - grapes and Hot Cheetos. Grapes represent renewable resources and Hot Cheetos represent non-renewable. During the game, students begin with a budget, and must purchase enough resources to power their town. They also must decide what kind of resources they want - renewable or non-renewable. The grapes are much more expensive than the Hot Cheetos, but they replenish more quickly in the “bank” of resources. During timed intervals students must use and purchase resources to keep their towns alive. Students will see as the game continues that they are waiting, sometimes in long lines, for more Hot Cheetos while they are not waiting as long for the grapes. Students discuss the importance of using renewable resources to avoid exhausting an available resource.

Lesson 7: Supply chain

Students will revisit lesson one, but this time learn how many finished products, such as a laptop or cell phone, have various parts working within that system that are made from various resources we have. Some of those resources are manufactured such as plastics, while others are sourced from the Earth such as the metals and elements in the batteries. Students learn that there is a supply chain system to get materials from the source to the finished product they are using. Students will analyze how when there is an issue such as a shortage in one part of the chain, the rest of the system is affected. The example of toilet paper during the pandemic can be used - because the demand was so high, people were stockpiling certain products such as toilet paper and PPE. Because the demand was

¹⁵ http://www.johnbetts-fineminerals.com/jhbnyc/articles/specific_gravity.htm

atypical, companies had trouble keeping up with the manufacturing demand and some companies or individuals began to price gouge.

Lesson 8: Resource sustainability and social/environmental impact

Students learn current ways that governments and companies are mitigating the impacts of resource scarcity and pollution. Students examine different methods of extracting resources including the reduction of waste, electronics recycling, and landfill mining. Students analyze the benefits and disadvantages of the various methods and explain why people, companies, and governments continue to use unsustainable practices to source Earth's materials. Students will also analyze how and why certain communities are disproportionately affected by mining, waste, and landfills. One such case study is the Covanta incinerator in Chester, a city just outside of Philadelphia. Students can examine how landfills and mines are often situated near lower-income communities that are also mostly populated by people of color. Students can analyze how practices today such as redlining and the housing gap force certain populations to live amongst polluted conditions. (See "We want to live. They want to burn trash" in the anchor texts section of the appendix)

Lesson 9: Museums

Students learn and explore the basic concept of a museum and how items are curated in a museum to tell a story and/or fit into a theme. Students analyze how different works are displayed and the various ways that curators make exhibits interactive and interesting for the public. This activity can be done through virtual museum tours or an in-person museum visit. Students use this information to inspire their later creation of a museum exhibit. (See "Oakland Museum of California," "Penn Museum," and "Natural History Museum: Los Angeles County" in the virtual resources section and "The Gold Museum of Bogota, Columbia" in the anchor texts section of the appendix)

Lesson 10: Be a Better Researcher

Students learn about bias and how writers and publishers can be biased when presenting information to their readers. They examine a collection of articles and videos on the same topic and discuss how each of the sources of information are a bit different although they are about the same thing. They then explain why a writer or publisher might be biased and how s/he/they/the institution uses bias for a purpose (to persuade, sell something, push a political agenda). Students learn how to identify the source of information and make a decision on whether the source is biased and is valid and accurate. (See "Be a Better Researcher" in the Slides and Handouts section of the appendix)

Lesson 11: Research citation and bibliography

Students learn how to use APA formatting to create an annotated bibliography and cite sources within their own summaries that will be used for their museum exhibits. Students learn why citation is important to avoid plagiarism, and why plagiarism should be avoided. Students practice citing sources for mantis shrimp and octopuses and apply that knowledge to citing sources for the gold museum exhibit. (See “APA Formatting Cheat Sheet” and “Bibliography Practice” in the Handouts section of the appendix)

Lesson 12: Exhibit creation

Students spend independent time researching their topic and creating a display exhibit for the class museum. Exhibit topics are: Chemical properties of gold, physical properties of gold, ancient uses and mining of gold, Mansa Musa, California gold rush, the value of gold, modern gold mining practices, environmental impacts, and social impacts. Students also spend a small amount of class time voting on the collective museum name, logo design, and layout of the museum (how a guest should travel through the exhibits). The exhibit must have a summary, annotated bibliography, and interactive element. Students should also prepare themselves to explain to museum guests their exhibit and answer any questions guests may have. (See Anchor Texts section of the appendix for suggested sources for students)

Lesson 13: Museum grand opening day

The class has a museum “grand opening” and invites guests to the opening. These guests can be another class, a class of younger students, parents and family members, or school administration. Students are invited to dress either professionally or appropriately for their exhibit. For example, if a student’s exhibit is about the gold rush, s/he/they may choose to dress as a gold prospector. Light refreshments can be offered as they often are during a gallery or museum opening, and visitors are invited to travel through the museum. The students will set up their exhibits on their desks and the classroom can be rearranged according to the design the students have decided upon. Students are expected to stay with their exhibit to serve as docents for museum visitors. At the end of the experience students are expected to fill out a peer and self-evaluation, in which they talk about one of their classmates’ exhibits and give feedback, as well as their own. (See “Museum of Gold: Peer and Self Reflection” and “Museum of Gold: Assessment Rubric” in the Handouts section of the Appendix)

Resources

Materials

- sample of gold

- sample of pyrite (1 per 4 students)
- streak plate (1 per 4 students)
- white distilled vinegar (1 ounce per 4 students)
- cup of water (1 per 4 students)
- metric ruler
- scale/balance (1 per 4 students)
- internet access and device to access internet browser
- paperclip (1 per 4 students)

materials for the exhibit creation (this is specific to each student. Students should be invited to supply these materials on their own but can share their vision with their teacher in advance in case they need help obtaining supplies such as posterboard, tri-folds, etc.)

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Appendix

Academic Standards (NGSS)

- MS-PS1-2 Matter and its Interactions: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- MS-PS1-3 Matter and its Interactions: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society

- MS-ESS3-3 Earth and Human Activity: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

Slides

[Be a Better Researcher](#)

Handouts

[APA Formatting Cheat Sheet](#)

[Be a Better Researcher Response Sheet](#)

[Bibliography Practice](#)

[Periodic Table of Elements](#)

[Mineral Classification Sheet](#)

[Museum of Gold: Peer and Self Reflection](#)

[Museum of Gold: Assessment Rubric](#)

Virtual Resources

[Mining Flashcards](#)

[Natural History Museum: Los Angeles County](#)

[Oakland Museum of California](#)

[Penn Museum](#)

Anchor Texts

[Energy for Life](#)

[Gold Fever](#)

[Indigenous groups seek justice for California Gold Rush Massacre](#)

Mansa Musa and the Empire of Mali by P. James Oliver

[Mansa Musa, one of the wealthiest people who ever lived - Jessica Smith](#)

Mansa Musa: the Lion of Mali by Khephra Burns

[The dark history of the Chinese Exclusion Act - Robert Chang](#)

[How much of California was built by Chinese immigrants during the gold rush?](#)

[The Gold Museum of Bogota, Columbia](#)

[The Secret Life of Gold](#)

[We want to live. They want to burn trash](#)