Science & Literacy Activity

GRADES 9-12

OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to minerals. Students will read content-rich texts, visit the Harry Frank Guggenheim Hall of Minerals and use what they have learned to complete a CCSS-aligned writing task, creating an illustrated text about the composition, properties and formation of a select mineral.

Materials in this activity include:

- Teacher instructions for:
  - Pre-visit student reading
  - Visit to the Guggenheim Hall of Minerals and student worksheet
  - Post-visit writing task
- Text for student reading "Studying Minerals"
- Student Worksheet for the Guggenheim Hall of Minerals visit
- Student Writing Guidelines
- Teacher rubric for writing assessment

Common Core State Standards:
WHST.9-12.2, WHST.9-12.8, WHST.9-12.9
RST.9-12.1, RST.9-12.2, RST.9-12.4, RST.9-12.7, RST.9-12.10

New York State Science Core Curriculum:
PS 3.1a; PS 3.1b

Next Generation Science Standards:
PE HS-PS1-1
DCI PS1.A: Structure and Properties of Matter
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

SUPPORTS FOR DIVERSE LEARNERS: An Overview

This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the exhibit) may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. We have provided ways to adapt each step of the activities for students with different skill-levels. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

1. BEFORE YOUR VISIT

This part of the activity engages students in reading a non-fiction text about mineral composition, properties, and formation. The reading will prepare students for their visit by introducing them to the topic and framing their investigation.

Student Reading

Have students read "Studying Minerals." Have them write notes in the large right-hand margin. For example, they could underline key passages, paraphrase important information, or write down questions that they have.

Discussion Questions:

Ask:

- What is the relationship between minerals and rocks? *(Answers many include: minerals are naturally occurring crystalline solids and are the building blocks of rocks.)*
- What is meant by chemical composition and crystalline structure? *(Answers may include: Chemical composition refers to the arrangement, type and ratio of atoms in molecules of substances. An example from the reading is SiO_2, the formula for quartz, in which atoms of silicon and oxygen are arranged in a precise geometry. Crystals are orderly arrangements of atoms, crystalline structure refers to the pattern or structure that atoms that make them up take.)*
- Why is it important to understand the chemical composition and crystalline structure of minerals? *(Answers may include: These are the factors for how minerals are classified, determine how we understand their physical properties and the conditions under which they were formed/)*

- What role does environment play in mineral formation? Provide examples from the text to support your answer. *(Answers may include: Environmental conditions determine how minerals crystalize or react chemically with each other, determining what minerals will form. For example, in high temperature or pressure, atomic structure of minerals within rocks can be transformed, turning them into other minerals. In a magmatic environment, minerals form based on what the magma is made of, how deep in Earth they are and what the temperature is when crystallization is happening. In a hydrothermal environment, the make up of the metal deposits that are left behind depends on how close to the surface they are.)*

They can work in pairs, small groups, or as a class. During discussion, remind students to use evidence from the text to explain their thinking, and to use specific examples.

SUPPORTS FOR DIVERSE LEARNERS: Student Reading
- "Chunking" the reading can help keep them from becoming overwhelmed by the length of the text. Present them with only a few sentences or a single paragraph to read and discuss before moving on to the next "chunk."
- Provide "wait-time" for students after you ask a question. This will allow time for students to search for textual evidence or to more clearly formulate their thinking before they speak.
- After the reading, show students the activity "Grow Rock Candy" to illustrate crystal pattern and composition: amnh.org/ology/features/stufftodo_earth/rockcandy_main.php

2. DURING YOUR VISIT

This part of the activity engages students in exploring the hall.

Museum Visit & Student Worksheet
Explain to students that they will be focusing on three exhibits: "Introduction to Mineralogy" and the related cases directly to the right of it, "Properties of Minerals," and "Mineral Forming Environments". To allow for easier data collection, you may want to break the students into groups and have them start their exploration at different exhibits. You may want to provide students with a copy of the hall map so that they know where these are located. Students will use the worksheet to gather all the necessary information about four minerals that are featured in the Earth Science Reference Table: hematite, fluorite, pyrite, and calcite. Back in the classroom they will refer to these notes when completing the writing assignment

SUPPORTS FOR DIVERSE LEARNERS: Museum Visit
- Review the Student Worksheet with students, clarifying what information they should collect during the visit.
- Have students view the hall in pairs, with each student completing their own Student Worksheet.
- Encourage student pairs to ask you or their peers for help locating sources of information. Tell students they may not share answers with other pairs, but they may point each other to places in the hall where answers may be found.

3. BACK IN THE CLASSROOM

This part of the activity is to engage students in an informational writing task that draws on the pre-visit reading and on observations made at the Museum.

Writing Task
Distribute the Student Writing Guidelines handout, which includes the following prompt for the writing task:

> Based on the article "Studying Minerals," your visit to the Guggenheim Hall of Minerals, and your discussions, select one of the minerals that you gathered notes on during your Museum visit and write an illustrated essay in which you describe define and describe its properties.
>
> Be sure to include:
> - its composition and chemical group
> - a description of the environment that it formed in
> - a labeled illustration of the selected mineral
>
> Support your discussion with evidence from your reading and the Guggenheim Hall of Minerals.

Go over the handout with students. Tell them that they will use it while writing, and afterwards, to evaluate and revise their essays.

Before they begin to write, have students use the prompt and guidelines to frame a discussion around the information that they gathered in the Guggenheim Hall of Minerals, and compare their findings. They can work in pairs, small groups, or as a class. Referring to the writing prompt, have students underline or highlight all relevant passages and information from the reading, and their notes from the hall that can be used in their response to the prompt. Instruct each student to take notes on useful information that their peers gathered as they compare findings. Students should write their essays individually.

SUPPORTS FOR DIVERSE LEARNERS: Writing Task

- Re-read the "Before Your Visit" assignment with students. Ask what they saw in the hall that helps them understand properties and mineral forming environments.
- Allow time for students to read their essay drafts to a peer and receive feedback based on the Student Writing Guidelines.

Student Reading:
Studying Minerals

What is a mineral?

A mineral is a naturally occurring crystalline solid. Crystals are orderly arrangements of atoms. Minerals are the building blocks of rocks, which make up most of the planet. Some minerals, like gold and silver, consist of essentially just one element, while others combine two or more.

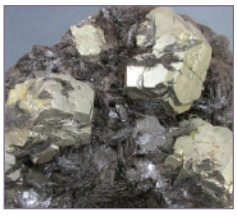
Minerals are classified by their chemical compositions, which are defined by formulas and by the way the atoms of those chemical elements are arranged into crystals. For example, Si02 is the formula for quartz, in which atoms of silicon and oxygen are arranged in a precise geometry. Gems are minerals that are beautiful, rare, and durable, and which have been cut and/or polished to enhance their beauty.

quartz (SiO_2)

What are the properties of minerals?

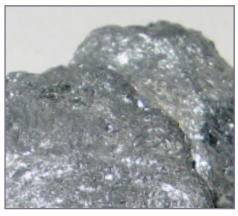
The physical properties of minerals are determined by their chemical composition and crystal structure. Scientists magnify, crush, illuminate, scratch, and break specimens in order to determine these properties.

- **Luster** is the way a mineral's surface interacts with light — how brilliant or dull it appears, for example. Lusters are either metallic (like pyrite) or non-metallic (examples include talc, which is pearly; quartz, which is glassy; and sulfur, which is earthy). Some minerals (like graphite) fall in between and are called submetallic.



metallic: pyrite (FeS_2)

non-metallic: talc ($Mg_3Si_4O_{10}(OH)_2$)



submetallic: graphite (C)

- Scientists crush a mineral by swiping it across a ceramic "streak plate" to reveal the color of its powder — its **streak**. This can help distinguish between minerals with the same color but different streak, like hematite and magnetite.

- **Hardness** is the degree of resistance to being scratched. It's determined by rubbing substances of known hardness against minerals and calibrating the results on the Mohs Scale. Diamond, the hardest mineral, is 10 on the scale, while quartz is 7 and talc is 1.

- **Fracture** and **cleavage** describe the way minerals break apart. Fracture is the tendency to break along rough or curved surfaces, while cleavage is the tendency to break along planes of weakness. Cleavage can help identify crystal symmetry, which can be useful in telling similar-looking minerals apart.

The properties of minerals determine how we can use them. For example, diamond and corundum (ruby) are used as abrasives because they're very hard, while soft and slippery graphite and molybdenite can be lubricants.

How do minerals form?

Minerals form when elements crystallize and/or react chemically with each other in response to environmental conditions such as changing pressure and temperature. They grow by adding layers to a starting point or surface, and well-formed crystals most commonly grow in an open space in the presence of a fluid. Minerals form everywhere on Earth — from thousands of meters deep to its surface and atmosphere — over time frames ranging from seconds to millions of years. The same mineral may even form in different environments. The conditions under which minerals formed tell geologists important things about the planet.

When minerals form from other minerals within Earth:

In a metamorphic environment, conditions of high temperature, high pressure, or both can rearrange the atomic structures of minerals within rocks, transforming them into other minerals. In this environment, the minerals never become a liquid. Examples of minerals that formed in this way include pyrite, talc, and graphite.

When minerals form in igneous rock deep in Earth:

In a magmatic environment, mineral crystals grow as magma cools and hardens into solid rock. The particular minerals depend on the chemical composition of the magma, its depth, and the temperature when it crystallizes. For example, minerals that make up gabbro rock, rich in calcium and magnesium, form at higher temperatures. Minerals that make up granite rock, rich in silicon and aluminum, form at lower temperatures.

This pink granite crystallized from magma. It contains potassium feldspar (pink), albite feldspar (white), quartz (gray), and biotite mica (black). The chemical composition is similar to that of the granite pegmatite.

In a pegmatite environment, when magma becomes almost entirely crystalized, rare crystals can form and grow to large sizes. This happens because certain elements normally in lower abundance become concentrated, and also because volatile components build up. The volatiles create vapor pockets that allow larger crystals to form.

This granite pegmatite illustrates the growth of extremely large crystals from a magma. It is composed of large feldspar (white) and biotite mica (silver-black) crystals in a groundmass of small crystals of quartz (gray), microcline, and albite (both white).

When metals are deposited in rocks:
In a hydrothermal environment, water with high concentrations of metals moves through rock, and can leave rich deposits. This creates veins containing metals such as gold, copper, and zinc, both deep in Earth's crust and closer to its surface. Hotter temperatures at greater depth result in certain types of deposits, like pyrite, while shallower, cooler temperatures result in deposits of gold and silver.

Why are minerals important?
Studying rocks and minerals helps us understand the greater physical world, including Earth's history and dynamics. By analyzing a rock's mineral content and texture, scientists can learn about the conditions at which it formed. Earth materials are resources. We rely on minerals found in Earth for many products, including metals, ceramics, fillers, semiconductors, glass, and fertilizer. Minerals are also a source of nutrients that all living things require.

Student Worksheet

Visit the following stops to fill out the data table. **Be sure to note color at every stop.**

Stop 1: "Introduction to Mineralogy" case

- Use the text panels on either side of this case to find the chemical symbols and chemical group of the mineral that you are looking for.

Stop 2: To the right of the "Introduction to Mineralogy" case, find the display case for the chemical group that your mineral belongs to.

- Read information about the chemical group that your mineral belongs to. Note that additional property information can be found in these descriptions:
    - hematite: cleavage/fracture
    - pyrite: cleavage/fracture, luster

Stop 3: "Properties of Minerals" case

- Visit the "Physical Properties of Minerals" case. Look at these displays for information about your mineral.
    - Look at the Mohs Scale of Hardness" display
        - Note that only hardness for pyrite and hematite is found here
    - Look at the Cleavage and Fracture display
        - Note that only cleavage/fracture information for fluorite and calcite is found here
- Visit the "Optical Properties" case. Look at these displays for information about:
    - luster
    - streak

Stop 4: "Mineral Forming Environments" case

- Visit the mineral forming environment(s) for your mineral. Listen to the narration and read the labels to get your information. If you need more room, use the back of the worksheet.

Mineral Name	Composition (Chemical Symbol)	Chemical Group	Color	Luster	Hardness	Cleavage/ Fracture	Streak	Forming Enviroment	Description of Forming Environment
hematite									
fluorite									
pyrite									
calcite									

ANSWER KEY

Student Worksheet

Visit the following stops to fill out the data table. **Be sure to note color at every stop.**

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Mineral Name	Composition (Chemical Symbol)	Chemical Group	Color	Luster	Hardness	Cleavage/ Fracture	Streak	Forming Enviroment	Description of Forming Environment
hematite	Fe_2O_3	*oxide*	*silver/ red*	*metallic*	*variable: soft to hard*	*splintery fracture*	*red/ brown*	*pegmatitic environment*	answers will vary
fluorite	CaF_2	*halides*	*variable*	*non-metallic*	*4*	*cleavage*	*white*	*hydrothermal environment*	answers will vary
pyrite	FeS_2	*sulfides*	*brassy*	*metallic*	*6.5*	*fracture*	*black*	*hydrothermal environment*	answers will vary
calcite	$CaCO_3$	*carbonate/ borate*	*variable*	*non-metallic*	*3*	*cleavage*	*N/A*	*hydrothermal environment*	answers will vary

Student Writing Guidelines

Based on the article "Studying Minerals," your visit to the Guggenheim Hall of Minerals, and your discussions, select one of the minerals that you gathered notes on during your Museum visit and write an illustrated essay in which you describe define and describe its properties.

Be sure to include:
- its composition and chemical group
- a description of the environment that it formed in
- a labeled illustration of the selected mineral

Support your discussion with evidence from your reading and the Guggenheim Hall of Minerals.

Use this checklist to ensure that you have included all of the required elements in your essay.

- ☐ I introduced the topic of mineral properties.
- ☐ I clearly named my selected mineral and described and defined its properties.
- ☐ I included a labeled illustration of the selected mineral.
- ☐ I only included relevant information about my selected mineral.
- ☐ I used information from "Studying Minerals" to explain my selected mineral in detail.
- ☐ I used information from the Guggenheim Hall of Minerals to explain my selected mineral in detail.
- ☐ I used academic, non-conversational tone and language.
- ☐ I included a conclusion at the end.
- ☐ I proofread my essay for grammar and spelling errors.

Assessment Rubric

	Scoring Elements	1 Below Expectations	2 Approaches Expectations	3 Meets Expectations	4 Exceeds Expectations
RESEARCH	**Reading**	Attempts to present information in response to the prompt, but lacks connections to the texts or relevance to the purpose of the prompt.	Presents information from the text relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the text relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the text.
	AMNH Exhibit	Attempts to present information in response to the prompt, but lacks connections to the Museum exhibit content or relevance to the purpose of the prompt.	Presents information from the Museum exhibit relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the Museum exhibit relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the Museum exhibit.
WRITING	**Focus**	Attempts to address the prompt, but lacks focus or is off-task.	Addresses the prompt appropriately, but with a weak or uneven focus.	Addresses the prompt appropriately and maintains a clear, steady focus.	Addresses all aspects of the prompt appropriately and maintains a strongly developed focus.
	Development	Attempts to provide details in response to the prompt, including retelling, but lacks sufficient development or relevancy.	Presents appropriate details to support the focus and controlling idea.	Presents appropriate and sufficient details to support the focus and controlling idea.	Presents thorough and detailed information to strongly support the focus and controlling idea.
	Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics.	Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features.	Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the purpose and specific requirements of the prompt.	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt.
SCIENCE	**Content Understanding**	Attempts to include science content in explanations, but understanding of the topic is weak; content is irrelevant, inappropriate, or inaccurate.	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of the topic; minor errors in explanation.	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of the topic.	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of the topic.