Science & Literacy Activity

GRADES 9-12

OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduce students to scientific knowledge and language related to poisons and the effects of poisons on organisms. Students will read content-rich texts, visit *The Power of Poison* exhibition, and use what they have learned to write and illustrate a CCSS-aligned document that investigates poison.

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

Wisconsin Standards for Science:
Performance Indicators HS-LS1-3
SCI.LS1.A.h Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.

Materials in this activity include:

- Teacher instructions for:
  - o Pre-visit student reading
  - o Visit to *The Power of Poison* and student worksheet
  - o Post-visit writing task
- Text for student reading: "The Power of Poison as Medicine"
- Student Worksheet for *The Power of Poison* visit
- Student Writing Guidelines
- Teacher rubric for writing assessment

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 exhibition) 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 activity engages students in reading a non-fiction text about poison. The reading will prepare students for their visit by introducing them to the topic and framing their investigation.

Student Reading

Have students read "The Power of Poison as Medicine." Have them write notes in the large right-hand margin. For example, they could underline key passages or paraphrase important information.

Ask:

- What is a poison? *(A poison is any substance that interferes with the normal functions of life. This may mean changing the way that cells or molecules function, or preventing natural processes from happening. Poisons may stop organs from functioning, or even shut down entire organ systems, killing the organism.)*
- Why are poisons so common in nature? What role do they play? *(Poisons are common in nature because they play an important role; poisons are used to capture prey, and in turn to resist predation. Many poisonous organisms, such as the Chilean rose tarantula, subdue or even kill prey by injecting them with poisons. Others, such as the dart frogs of the Amazon, deter predators with poisons. In both cases, the poisons help these organisms survive and reproduce, and are evolutionary adaptations.)*
- The author states that nature is "one huge laboratory." What does the author mean by this? *(During the course of evolution, many molecules are used by organisms both internally and externally. Organisms are constantly producing new molecules as they evolve, in response to the environment and each other.)*

- How can a single substance be both deadly and a helpful medicine? *(Because poisons can alter the function of body systems within an organism, or even stop these functions, they can be both harmful and helpful. Some poisons can fight off disease, while others can reduce the harm caused by diseases and their symptoms.)*

During class discussion, remind students to use evidence from the text to explain their thinking, and to use specific examples, including specific poisons and poisonous organisms, as well as real examples of poisoning events.

Have students create a chart to communicate the sources of different poisons, as well as ways that poisons can both harm and help a living organism's internal systems. They can work in pairs or small groups.

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.

2. DURING YOUR VISIT

This activity engages students in exploring the exhibition.

Museum Visit & Student Worksheet

Explain to students that they will be focusing on poisons in both nature and culture, and the ways that these poisons can harm an organism. They will use worksheets to gather all the necessary information about poisons. Tell students that 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 explore the exhibition 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 exhibition 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 "The Power of Poison as Medicine," your visit to *The Power of Poison* exhibition, and your discussion, write an essay in which you:
>
> - define "poison"
> - explain how poisons can harm an organism
> - provide at least three examples of poisons, describing their effects on an organism
>
> Support your discussion with evidence from the reading and notes from your visit to *The Power of Poison*.

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 Power of Poison*, 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 exhibition, 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 then 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 exhibition that helps them understand how each of the plants or animals uses their poison and an explanation of the poison's effects.
- Allow time for students to read their essay drafts to a peer and receive feedback based on the Student Writing Guidelines.

Student Reading

The Power of Poison as Medicine

The yew tree, *Taxus*, has a legendary connection to death. Its seeds, leaves, and bark are highly poisonous to humans. In recent decades, however, this long-lived plant genus has earned a different reputation: as a potential preserver of life. In the 1960s, researchers working for the U.S. National Cancer Institute discovered that the bark of *Taxus brevifolia*, the Pacific yew, contained a toxic ingredient that could be harnessed on a cellular level to inhibit the progress of some cancers. A derived compound known as paclitaxel, produced in the laboratory and available commercially since the late 1990s, has been found to be effective in the treatment of breast, lung, and other cancers, as well as AIDS-related Kaposi's sarcoma. It has also been found useful in preventing a re-narrowing of coronary arteries in stent recipients. The drug is a prime example of the use of poisons in the service of medicine, a challenge to the modern view of poison as an instrument of death, whether by accident, suicide, or murder most foul.

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Mercury

Of course, nature's poisons have been used for medicinal purposes for millennia. Small doses of opium, mandrake, henbane, and hemlock numbed the pain of surgery for more than 1,000 years. In William Shakespeare's time, 400 years ago, poisonous extracts were combined into cough medicine. Well into the 20th century, mercury was an ingredient in popular remedies, from purgatives to infants' teething powder.

But modern scientific techniques have allowed researchers to better understand, and then take advantage of, the underlying mechanisms by which plant toxins and animal venoms attack normal metabolic processes. For example, some neurotoxins block the release of chemical messengers called neurotransmitters; some stop neurotransmitter messages from being received; some send false signals; and still others disrupt nerve cell activity by opening channels in cell walls. If muscles in the heart or lungs fail to get the proper signal to function, the results are fatal. But applying the same effect in nonlethal doses can stem tremors or the registering of pain.

"What is a poison?" asks Mark Siddall, curator in the Division of Invertebrate Zoology who is also curator of the special exhibition *The Power of Poison*. "It's a substance that interferes with normal physiological processes, that alters or stops them, or makes things happen. That is essentially what medicines are, too."

The potential for tapping nature is staggering. By conservative estimates, some 100,000 animals, from lizards and snakes to sea anemones and jellyfish, produce venom, which in turn can contain hundreds of different toxins. So far, only about 10,000 animal toxins have been identified, and 1,000 of these have been studied in depth, with a view to developing drugs. The anticoagulants tyrofabin and hirudin were derived from animal sources, respectively, the blood-thinning venom of the African saw-scaled viper and a substance secreted by leeches. The diabetes drug Exenatide, which lowers blood sugar

and increases the body's production of insulin, is a synthetic version of a component in the saliva of Gila monsters, large venomous lizards found in the southwestern U.S. and northwestern Mexico. The development of the first oral ACE (angiotensin-converting enzyme) inhibitor, which treats hypertension, was based on an understanding of how the venom of the Brazilian pit viper, *Bothrops jararaca*, causes a drastic drop in blood pressure in its prey.

Gila monster

Plants are an even richer mine, with more than 400,000 identified species and many of them toxic to one degree or another. Fixed in place, plants are especially adept at producing chemical defenses against insects, larger plant-eaters, and even other plants — a process that has allowed land plants to flourish for about 450 million years. Caffeine and nicotine are both plant-based products with well-known pleasurable effects on the body until taken in excess, revealing their essentially poisonous nature. But just as with animal toxins and venoms, plant compounds that affect the human body can be employed for medicinal purposes. Salicylic acid, the active ingredient in aspirin, for example, is found in a number of plants, including the willow tree Salix, from which it takes its name. Similarly, the antimalarial drug artemisinin is derived from the herb sweet wormword, *Artemisia annua*.

"Plants and animals are doing complex biochemistry all the time, creating things we couldn't imagine making without the temperature of the Sun and the pressure of the center of Earth," says Dr. Siddall.

In many ways, nature is one huge laboratory, making and testing countless plant and animal substances in each species' efforts to prevail. In what has been called an evolutionary arms race, as predators up the potency of their poisons, prey strengthen their resistance. This is especially apparent at the microscopic level, where microbes compete endlessly by developing their own antibiotics to fight off other microbes, teaching us in turn what works and what doesn't. Bacteria, algae, and fungi, including molds, that produce toxins could all potentially yield medicines. As it turned out, *Taxus*, the yew tree, was not the original source of the toxic compound used to create the chemotherapy drug: it was a fungus living in the yew tree's bark. Other examples of small but powerful agents abound. The microbe *Clostridium botulinum*, one of the most toxic substances, is known to most of us as a deadly source of food poisoning in improperly sterilized canned foods. One-millionth of a gram can kill a person, causing fatal paralysis by blocking the release of acetylcholine, a neurotransmitter used by the nerves to signal muscles to contract. In carefully controlled doses, it is famously used as Botox to eliminate wrinkles by paralyzing muscles that, when tensed, cause folds in the face. But it can also be used selectively to treat cerebral palsy spasms, stop uncontrolled jaw clenching, correct crossed eyes, or moderate sweating or twitching.

Whether at the microscopic level or the level of plants and animals, researchers are in a race against time as they seek to unlock the potential of poisons. "Habitat loss from overpopulation, climate change, and other factors have put more species of plants and animals at risk," says Siddall. Consider those toxin-rich snakes: by conservative estimates, one in five reptiles is now threatened with extinction, a loss that could radically diminish a promising source for healing. "If the world was populated by only pine trees and pandas," says Siddall, "we wouldn't have this rich diversity of resources to help us understand the physiology of diseases and find out what's out there that might target them."

This article first appeared in the Fall 2013 issue of Rotunda, *the member magazine of the American Museum of Natural History.*

Student Worksheet

1. In the Chóco rainforest, find and record information about three different organisms in the data table:

Common/Scientific name of organism	Poison type and location in the body	How does this poison help the organism survive in its environment?

2. Continue exploring the exhibition. When you arrive at the "Mad Hatter" diorama, complete the following questions:

What poison was responsible for harming real-life hat makers?

Why was this chemical used to make hats?

What does this poison do to the human body?

3. Continue exploring until you arrive at the "Emperor Qin" diorama.

What poison caused the untimely death of this first emperor of unified China?

What does this poison do to the human body?

Student Worksheet

4. Continue exploring until you arrive at the "Enchanted Book." Use this book to research and record three plant species in the data table below:

Common/Scientific name of plant	Symptoms caused by human consumption of this plant

5. View the presentation in the poison theater. Record any useful information, including information about arsenic or other poisons and their effects on the human body in the space below:

6. Continue exploring the exhibition until you arrive at the last section, Poison as Medicine.

Walk under the yew tree, scientific name *Taxus baccata*. How is this tree poisonous?

How does poison help this tree survive in its environment?

How is this tree used in medicine?

Student Worksheet

ANSWER KEY

1. In the Chóco rainforest, find and record information about three different organisms in the data table:

Common/Scientific name of organism	Poison type and location in the body	How does this poison help the organism survive in its environment?
(Sample Answer: wandering spider, Phoneutria boliviensis*)*	*(Sample Answer: venom located in fangs.)*	*(Sample Answer: used to hunt for food or defend the spider from predators or other threats)*

2. Continue exploring the exhibition until you arrive at the Mad Hatter diorama.

What poison was responsible for harming real-life hat makers? *(mercuric nitrate)*

Why was this chemical used to make hats?
(This chemical was useful because it removed hair from animal skins and helped turn that hair into felt.)

What does this poison do to the human body?
(exposure causes tremors, weakness, kidney disease, vision loss, speech and hearing impairment, and mental illness)

3. Continue exploring until you arrive at the "Emperor Qin" diorama.

What poison caused the untimely death of this first emperor of unified China? *(mercury)*

What does this poison do to the human body?
(Mercury damages the nervous system causing mental illness, brain damage, and possibly even death.)

Student Worksheet

ANSWER KEY

4. Continue exploring until you arrive at the "Enchanted Book." Use this book to research and record three plant species in the data table below:

Common/Scientific name of plant	Symptoms caused by human consumption of this plant
(Sample Answer: hemlock, Conium maculatum*)*	*(Sample Answer: make a human drowsy, dizzy, slow their heart rate, cause paralysis, trouble breathing, and death)*

5. View the presentation in the poison theater. Record any useful information, including information about arsenic or other poisons and their effects on the human body.

6. Continue exploring the exhibition until you arrive at the last section, Poison as Medicine.

Walk under the yew tree, scientific name *Taxus baccata*. How is this tree poisonous?
(Eating just a small amount, such as a handful of needles from this tree, could kill a human.)

How does poison help this tree survive in its environment?
(Because it is so poisonous, few animals try to eat this tree.)

How is this tree used in medicine?
(This tree is the source for Taxol, an anti-cancer chemical.)

Student Writing Guidelines

Based on the article "The Power of Poison as Medicine," your visit to *The Power of Poison* exhibition, and your discussion, write an essay in which you:

- define the word "poison"
- explain how poisons can harm an organism
- provide at least three examples of poisons, describing their effects on an organism

Support your discussion with evidence from the reading and notes from your visit to *The Power of Poison*.

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

- ☐ I introduced the topic of poison.
- ☐ I clearly defined "poison" and described a range of effects poison can have on different organisms.
- ☐ I only included relevant information.
- ☐ The information I presented is accurate.
- ☐ All of the information I presented addresses the effects poison can have on different organisms.
- ☐ I used science vocabulary correctly.
- ☐ I used information from the reading "The Power of Poison as Medicine" to explain the topic in detail.
- ☐ I used information from the exhibition to explain the topic 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 audience, 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 audience, 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.