American Museum of Natural History

# Educator's Guide

# The Power of POISON

amnh.org/poison/educators

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# MAP OF THE EXHIBITION

***The Power of Poison* exhibition uses models, objects, interactives, live animals, and presenters to explore the biology of poison and its role in nature, human history, and health.**

Use the **guided explorations**, numbered on this map and in the Teaching in the Exhibition section, to guide your visit.

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**1a.** Colombia's Chocó forest

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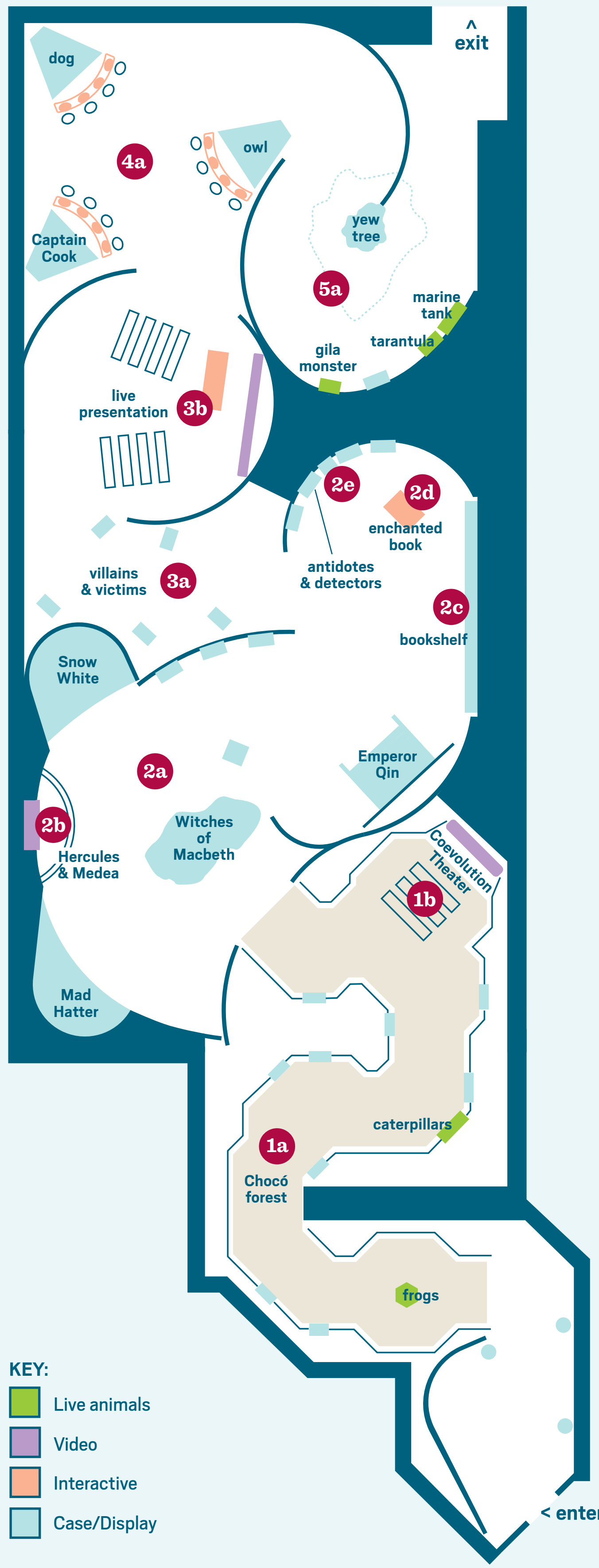
**5a.** Yew tree model and live animals



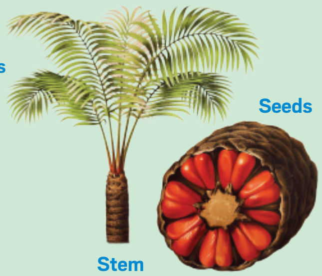
# ESSENTIAL QUESTIONS

**Use the Essential Questions below to connect the exhibition's themes to your curriculum. Identify key points that you'd like your students to learn.**

## What is poison?

**Poisons** are substances that can harm organisms by interfering with biological processes. Organisms use poisons to survive — to capture prey and to defend themselves. In living things, poisons are a product of **adaptation** and **natural selection**. Humans are largely bystanders to this evolutionary process, an arms race that has been waged among plants and animals for hundreds of millions of years. The effect of poison depends on:

- **the target** – chocolate, for example, is easily metabolized by humans but can be fatal to dogs;
- **the dose** – salt is essential for life, for example, but swallowing too much is lethal; and
- **exposure** – some poisons are acutely toxic while others, like lead, build up in the body's tissues and have a cumulative effect.




Ground into flour, the seeds and stems of the cycad plant (*Zamia roezlii*) are an important food for many people. But they contain a dangerous nerve toxin that accumulates in the body and can cause loss of muscle control. Lengthy soaking and repeated rinsing makes the flour safe to eat.

Organisms deliver poison with adaptations that include fangs, spines, and seeds. Venomous animals, like some snakes, manufacture and deliver poison in the form of complex biological mixtures that can weaken, immobilize, or kill. Many **toxins** are used as drugs, and many more are being studied.

## Where are poisons found?

Because they convey an adaptive advantage, poisons have evolved independently on every major branch of the tree of life. An enormous number of species — spread over many groups, including amphibians, fishes, jellies, insects, bacteria, fungi, and plants — are poisonous.

- **animal:** Some animals, like longwing butterflies, get their poisons from their environment or from other organisms. Others make their own **venom**, and most of them share two related traits: special glands for manufacturing the venom and something sharp with which to inject it. Distinctive markings or bright colors warn predators of mortal danger.
- **vegetable:** Over the course of 450 million years, plants have evolved an amazing array of chemical defenses — against insects, other herbivores, and even other plants.
- **mineral:** Some metals can be toxic. Arsenic, for example, seeps into groundwater from the local bedrock. Mercury gets into soil and air through gold-mining and industrial processes, and eventually ends up in the oceans — and in our seafood.

## How do poisons work?

Poisons operate in myriad ways on different biological systems. Poisons are defined by the systems that they affect. For example, **neurotoxins** like strychnine (found in an Asian plant, *Strychnos nux-vomica*) and the heavy metal mercury affect the signaling machinery of nerves; **cytotoxins** like ricin (from castor beans) and arsenic disrupt cell function; and **hemotoxins**, found in leech saliva, the spines of a *Lonomia* caterpillar, and many snake venoms, inhibit blood clotting. Some venoms, like that of most vipers, combine nerve poisons, muscle-destroying poisons (**myotoxins**), and hemotoxins.

## What is the history of poisons in society?

For centuries people have grown or collected plants that could heal or harm. In the dark about how poisons worked, people often attributed their effects to magic. Countless fairy tales and legends from around the world describe mysterious potions that make people seem dead or become immortal. With this history come charmed objects believed to protect the bearer. Myths and folklore offered an explanation for illness or death, and some of the most unlikely tales contain a kernel of truth.

## How do we use poisons?

Sometimes what makes things toxic is also what makes them useful. For example, cone snail venom painlessly paralyzes prey; used medicinally, the same toxins block pain signals and provide powerful relief. Humans have extracted poisons from nature and used them in medicine for thousands of years, and also put them to use as herbicides and mind-altering drugs. Some that are noxious to insects are pleasant to us, like mint, vanilla, chili, and cinnamon. Uncovering how poisons function has been invaluable in learning how the human body works. Beyond the scope of human invention, these complex biomolecules are the result of millions of years of evolution. Applications include an anti-cancer drug from yew trees, a drug from gila monster venom to treat diabetes, and a toxin from bacteria to treat a range of conditions, from infections to muscle spasms. The search for new medicines from natural toxins has barely begun.

# TEACHING IN THE EXHIBITION

## 1 Poison in Nature

**1a. Colombia's Chocó forest:** Organisms use poison to protect themselves or to capture prey. As you and your students walk through this immersive exhibit, use the following prompts to help them observe the many toxic species highlighted here: What is it? Who or what is its target? How does it use poison, and why? *(e.g. A bullet ant* (Paraponera clavata) *uses a retractable, syringe-like stinger in its abdomen to pump powerful neurotoxic venom into its prey, which include much larger animals. Venom from the bite of the aggressive wandering spider* (Phoneutria boliviensis) *can cause pain, cramps, tremors, and even paralysis. The spines of the zebra longwing caterpillar* (Heliconius charitonia) *and the orange-and-black coloring of the flame caterpillar* (Dryas iulia) *warn predators of their toxicity.)*

Toxins on and inside a golden poison frog *(Phyllobates terribilis)* protect it from predators and can cause cardiac arrest. It gets its intense toxicity from something in its diet, probably beetles.

Unlike its larger, big-clawed emperor cousin, this little fat-tailed scorpion (*Androctonus australis*) mainly uses its stinger — and much deadlier venom — for defense.

The bright color and sharp spines of the zebra longwing caterpillar (*Heliconius charitonia*) warn predators of its toxicity. Its poisonous cyanide originates in its host plant, the passionflower.

**1b. Coevolution Theater:** A short video, "A Tale of Toxins vs. Resistance," explores how coevolution drives extreme toxicity in poisons as a defense.

## 2 Poison in Myth & Legend


From the 1700s through the early 1900s, the hat-making industry used a poisonous compound called mercuric nitrate. Long-term exposure causes tremors, extreme irritability, and mood swings — behavior like the Mad Hatter's in *Alice's Adventures in Wonderland*. Born near England's hat-making capital, author Lewis Carroll witnessed this tragic occupational hazard.

**2a. Dioramas of the Witches of Macbeth, Mad Hatter, Snow White, and Emperor Qin:** Once upon a time (or until germs were discovered), people couldn't tell if sickness was caused by disease, poison, or even magic. Stories of dramatic poisonings intrigue because they're mysterious and frightening, and because many contain a kernel of truth. Have students explore the "magical" effects of the poisons described in each diorama. *(e.g. Poisons like the neurotoxins produced by snakes and pufferfish can cause reversible paralysis like Snow White's "sleep.")*

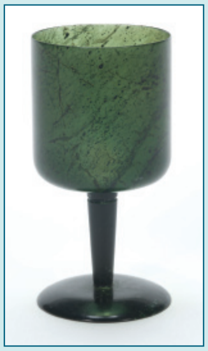
**2b. Greek pottery media projection:** We can trace the use of poisons into antiquity. Students can watch two ancient myths unfold to see how Hercules acquired poison by killing the Hydra, and how Medea used poison to seek revenge.

How does Hercules finally slay the serpent monster Hydra?

**2c. Poisons in Literature bookshelf:** Writers from Shakespeare to Agatha Christie have used poison to propel their plots. Invite students to discuss how poison figures in these stories and others that they've read. *(e.g. Harry Potter uses a universal antidote called a bezoar to save his best friend from poisoning.)*

**2d. Enchanted book interactive:** For centuries, people have grown or collected plants with the power to heal or harm. Students can turn the virtual pages of this "magic book" to learn about belladonna, hemlock, monkshood, and rhododendron. Ask students about their effects on the body, why they're toxic, what they've been used for, and their place in myth and legend. *(e.g. Hemlock contains a toxin that was used to sedate and to treat spasms, but can cause death; the ancient Greek philosopher Socrates was executed by being forced to drink hemlock brew.)*

**hemlock (*Conium macultum*)**



**Jade goblets were prized in Europe because they were thought to purify wine and remove any poisonous elements.**

**2e. Antidote and detectors:** In every culture people have turned, in vain, to "charmed" objects and potions to protect themselves from poisoning. Have students survey the examples displayed here and consider how they were used. *(e.g. In Asia, silver spoons and chopsticks were said to change color to signal the presence of poison. Garnets and emeralds were believed to protect against snake venom and other poisons by many people, including ancient Egyptians. In Roman times frankincense was thought to be an antidote to hemlock.)*

## 3 Detecting Poison

**3a. Villains & Victims gallery:** From Cleopatra to Napoleon, history is filled with famous poisonings, many of which remain unsolved. Have students explore and discuss how these historical figures might have died.

**Could arsenic poisoning have killed Napoleon?**

**3b. Understanding Poisons live presentation:** Throughout most of history, people had little understanding of what was poisonous, and why. Until the mid-1800s, when scientists developed forensic tools to detect poisons in the human body, many deaths remained a mystery.

A presenter will engage students in activities that demonstrate how poisons work in your body, and will be available to answer questions.

## 4 Poison by Accident

**4a. Solve the Case interactives:** Intentional poisonings are rare today, but accidental poisonings do happen. Using iPad interactives, students can investigate evidence, compare clues, and weed out red herrings to figure out what poisoned a dog, an owl, and Captain Cook. *(Spoiler alerts! 1: The dog made the mistake of playing with a cane toad, which defended itself by secreting potent bufotoxins. The dog's bright red gums were the telltale clue. 2: An owl fed on mourning doves that were shot by hunters. Over time, the lead shot remaining in the doves accumulated in the owl. The evidence was its liver, turned green by lead. 3: Captain Cook sampled enough pufferfish for its nerve poison, tetrodotoxin, to make him quite ill. Tingling in the hands and feet was the giveaway.)*

**This human treat is deadly for pets. The ingredient that gives us a pleasant boost — theobromine — causes seizures in dogs.**

## 5 Poison for Good

**5a. Yew tree model, live animals, and surrounding panels:** Toxins extracted from plants and animals, including venoms, are being studied to treat conditions such as high blood pressure, multiple sclerosis, and cancer. Have students examine organisms around the room and explore how their poisons benefit us. *(e.g. Toxoids, a mixture of toxic alkaloids from the yew tree, can cause nausea, vomiting, heart failure, and even death in humans, but drugs made from one particular taxoid limit the spread of fast-multiplying cancer cells. The toxin produced by the* Clostridium botulinum *bacteria can cause muscle paralysis and death by suffocation, but careful application can stop muscle spasms, crossed eyes, jaw clenching, and other disorders — and even reduce wrinkles.)*

**Venom injected by cone snails paralyzes their prey, but these toxins can also block pain signals, making them useful as an anesthetic.**

**Toxins in black mamba venom that block pain signals in the nervous system may lead to new pain medications.**

### Explore More

Visit the **Hall of Biodiversity** and the **Milstein Hall of Ocean Life** on the 1st floor to look for other poisonous organisms, such as spiders and pufferfish.

## COME PREPARED CHECKLIST

- ☐ **Plan your visit.** For information about reservations, transportation, and lunchrooms, visit **amnh.org/plan-your-visit/school-or-camp-group-visit**.
- ☐ **Read the Essential Questions** to see how themes in the exhibition connect to your curriculum. Identify the key points that you'd like your students to learn.
- ☐ **Review the Teaching in the Exhibition section** for an advance look at what your class will encounter.
- ☐ **Download activities and student worksheets** at **amnh.org/poison/educators**. They are designed for use before, during, and after your visit.
- ☐ **Decide how your class will explore** the exhibition:
  - You and your chaperones can facilitate the visit using the Teaching in the Exhibition section.
  - Your students can use the worksheets to explore the exhibition on their own or in small groups.
  - Students, individually or in groups, can use the map to choose their own paths.

## CORRELATION TO STANDARDS

### A Framework for K-12 Science Education

**Science Practices** • Asking questions • Developing and using models • Planning and carrying out investigations • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information

**Crosscutting Concepts** • Patterns • Cause and effect: Mechanism and explanation • Scale, proportion, and quantity • Structure and function • Stability and change

**Core Ideas** • LS1: From Molecules to Organisms: Structures and Processes • LS2: Ecosystems: Interactions, Energy, and Dynamics • LS3: Heredity: Inheritance and Variation of Traits • LS4: Biological Evolution: Unity and Diversity • ESS3: Earth and Human Activity • ETS2: Links Among Engineering, Technology, Science, and Society

## GLOSSARY

**adaptation:** a heritable change that improves the ability of an individual or species to survive in an environment

**aposematism:** having bright colors or markings that warn or repel predators; the opposite of camouflage

**coevolution:** the evolution of two or more species in which each adapts to changes in the other, as between plants and their insect pollinators or predators and their prey

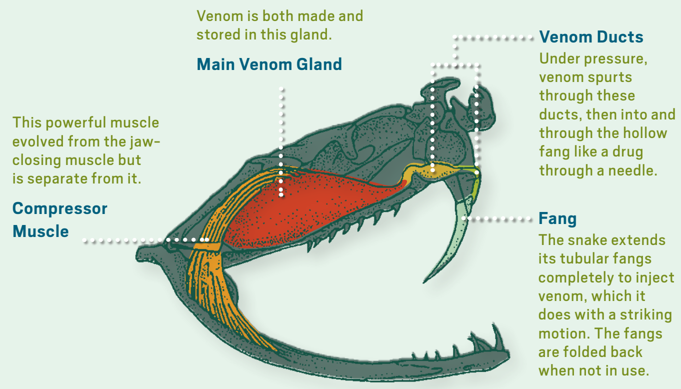
**natural selection:** the process by which organisms better adapted to their environment tend to survive and produce more offspring

**poison:** a substance that interferes with a physiological process in an undesirable way. (If the effect is desired, the substance is called a drug.)

**toxin:** a specific molecular component of a poison or venom that has a specific target, such as:

- **cytotoxins**, which disrupt cell function
- **neurotoxins**, which affect the nervous system
- **hemotoxins**, which target and destroy blood cells
- **myotoxins**, which affect muscles

**venom:** poisonous fluids, often combinations of many toxins, that are injected by a bite or sting




**Viper Skull in Cross-Section**

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