American Museum of Natural History

Educator's Guide

LIFE AT THE LIMITS

STORIES OF AMAZING SPECIES

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amnh.org/lal/educators

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. **Bolded** text are science concepts that are addressed in this exhibition. Words in **blue** are defined in the Glossary.

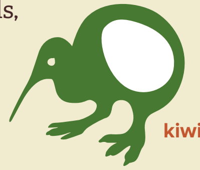
What do all living things need to do?

Basic biological processes often include getting oxygen, finding food, moving around, taking in information, staying safe, and above all, reproducing.

What are some of the unexpected ways in which life survives and thrives?

Living things have responded to the fundamental challenge of surviving and reproducing in extremely inventive ways:

- REPRODUCE: **Every organism on Earth has a way to bring new life into the world and maximize its offspring's chance of survival.** Some animals, like corals, release billions of tiny eggs and sperm at a time. At the other extreme, a female brown kiwi produces a single, enormous egg, up to 25% of her body weight.



kiwi

- BREATHE: **Many animals need a constant supply of oxygen in order to extract energy from nutrients, and they acquire it in vastly different ways.** Most amphibians lose their gills as they mature, but the axolotl never moves onto land and it retains its external feathery gills. Some Antarctic fishes absorb extra oxygen through very porous skin. An elephant seal's organs enable it to hold its breath for 100 minutes.

- MOVE: **Whether to find food, flee, or locate a mate, animals move. How they move, and how far, depends on their environment and the challenges the animals face.** Nautili use **jet propulsion**—and very little energy—to move slowly through seawater. To move fast and far between hosts, fleas can store tremendous amounts of potential energy in their legs and release it to jump up to 200 times their body length.

a flea jumping

- EAT: **All living things need nutrients, which provide energy. Animals get them from plants and other living things, which they find and consume in many ways.** The black swallower, a deep-sea fish, can ingest **prey** ten times its size. Some animals kill prey with powerful jaws or claws, like the mantis shrimp, which can punch with the force of a gun shot. In contrast, parasites live off other organisms and let them do the work. Many **species** evolve special traits for efficient hunting and eating, like the anteater's long, sticky tongue and the aye-aye's extraordinarily long middle finger for collecting grubs.

- KEEP SAFE: **Animals won't get eaten if predators can't find them. Camouflage and mimicry protect species** that range from ants to octopodes, including the harlequin jawfish, which mimics the arm of the mimic octopus and eats its scraps; and the treehopper, an insect that resembles an enormous venomous ant. Because protective armor is such an effective defense, it has evolved again and again in countless plants and animals, from the scales of a snake to the shell of a conch.

The mimic octopus imitates different animals—here, a flatfish moving along the ocean floor.

- SENSE: **In order to carry out all these life processes, every animal needs information about its surroundings. Many have highly developed sense organs.** These include the snout of a sawfish, which detects the electricity that animals produce; and the Atlas moth's extra-long antennae, which comb the air for the scent of females.

Some species, like lobsters and bristlecone pine trees, have evolved very long lifespans. Some others, like the immortal jellyfish, theoretically do not die.

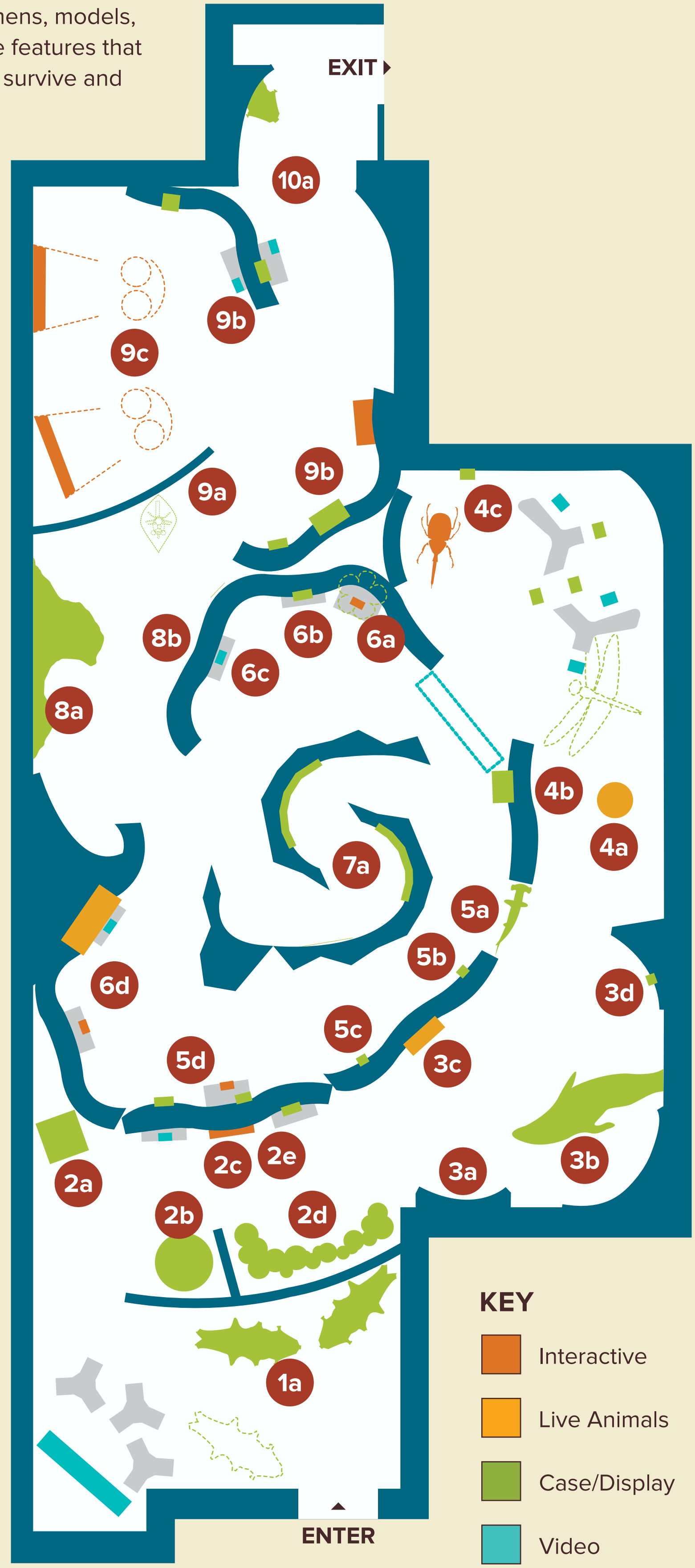
Why do these processes differ so widely among living things?

Life exists in a broad variety of environments, each of which poses different challenges. Species have adapted to these environments in ways that help them survive and reproduce. These adaptations are a result of the process of natural selection operating over vast periods of time. Most organisms can't survive freezing cold, scalding heat, or harsh chemicals. But some—like microbes in superheated hydrothermal vents and wingless midges in Antarctica—thrive under extreme conditions. Few are as tough as tiny, eight-legged tardigrades, which can survive pretty much anything: dehydration, freezing, boiling, and even the vacuum of space. Some species adapt to changes in their habitats, like the African lungfish, which seals itself off in a cocoon when the pool it inhabits dries out. Others migrate.

Species that are not closely related may face similar challenges and evolve similar traits. This is called convergent evolution. For example, many cave dwellers are pale and blind and possess enhanced sensory structures, like the digit-like appendages that some leeches use to feel their way around in absolute darkness or the additional receptors that some cave fish use to sense vibrations. Biologists continue to discover remarkable adaptations, each the result of evolution, to different environments on Earth.

MAP OF THE EXHIBITION

The ***Life at the Limits*** exhibition uses live animals, specimens, models, videos, and interactive displays to explore the remarkable features that organisms across the tree of life have evolved in order to survive and to thrive, even under extreme conditions.



1. INTRODUCTION

1a. Models of tardigrades

2. GETTING STARTED

2a. Bowerbird model
2b. Titan arum plant model
2c. Mating calls audio interactive
2d. Coral reef diorama
2e. "Family Life" area

3. BREATHING IN

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3b. Elephant seal model
3c. Live axolotl
3d. Blood vials

4. MOVING ON

4a. Live nautilus
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4c. Beetle specimen & large climbable model

5. SUPER SENSING

5a. Sawfish specimen & hammerhead shark model
5b. "Seeing" area
5c. "Hearing" area & owl skull
5d. "Smelling" area & smell interactive

6. UNCANNY EATERS

6a. Rafflesia (corpse flower) model & smell interactive
6b. Black swallower model
6c. Giant anteater & woodpecker skulls
6d. Live mantis shrimp, eagle claw touchable model, & cookie-cutter shark model

7. LIVING IN CAVES

7a. Models of cave creatures

8. SURVIVING EXTREMES

8a. Hydrothermal vents diorama
8b. "Hot & Cold" wall

9. TAKING COVER

9a. "Camouflage" wall
9b. Spines case, armor touchables, & hornet nest
9c. Animal adaptations interactive

10. DEFYING DEATH

10a. "Defying Death" area

TEACHING IN THE EXHIBITION

This species of tardigrade is actually about the size of a poppy seed.

1. INTRODUCTION

1a. Models of tardigrades: Members of this group of microscopic creatures can endure astoundingly brutal conditions almost anywhere on Earth, including extreme pressure, radiation, heat, and cold. As you enter the exhibition, point out to students that these models are more than 200 billion times life-size measured by volume, and that tardigrades are incredibly resilient.

2. GETTING STARTED

2a. Bowerbird model: For many animals, the first step in sexual reproduction is attracting a mate. Students can explore how male bowerbirds lure females by decorating elaborate "bowers."

2b. Titan arum plant model: Many flowering plants need the help of insect pollinators in order to reproduce. This large plant emits an aroma to attract flies and beetles that typically dine on decaying animal remains.

2c. Mating calls audio interactive: When some animals are ready to breed, they call out to prospective partners. Students can press buttons to hear some of these sounds.

Many corals are unisex: the same animal releases both eggs and sperm, often bundled together in soft packets that look like bubbles.

2d. Coral reef diorama: Corals have no brains, but they can sense the cycles of the Moon and synchronize release of eggs and sperm into the ocean, where these sex cells unite. Many different coral species spawn at the same time, providing safety in numbers. Students can watch for this release in the diorama.

2e. "Family Life" area: From mammals to insects, animals have different strategies to increase the likelihood of their offspring's survival. Students can compare the examples to see how the number of offspring compares with the level of parental care.

3. BREATHING IN

3a. "Altitude & Depth" wall: Oxygen levels are lower at high altitudes, and animals have different ways of dealing with this. Students can compare how animals extract the oxygen they need, from high-flying geese to Tibetan people adapted to living in the Himalayas.

3b. Elephant seal model: Marine mammals need to be able to hold their breath for a long time. Students can find out how elephant seals routinely do so as they dive nearly a mile deep to hunt fishes and squid.

3c. Live axolotl: Most amphibians lose their gills as they mature, but the axolotl never moves onto land and it retains its external gills. Students can observe this salamander's feathery gills.

3d. Blood vials: Most vertebrates have red blood because iron, which turns red upon contact with oxygen, carries oxygen to their cells. But other metals can do the job, so blood comes in a surprising assortment of colors.

4. MOVING ON

4a. Live nautilus: Many marine animals—including swimming mollusks like octopodes, scallops, and the live nautilus on display here—use jet propulsion to move efficiently. Students can observe the animal to see it move.

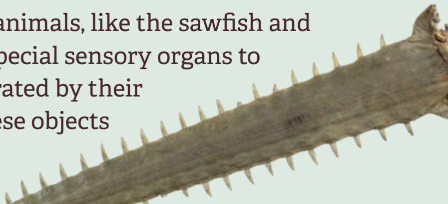
These dragonflies may travel up to 6,000 km (3,700 mi) to breed and lay eggs.

4b. Migration map: Some creatures travel enormous distances to feed and breed. Students can look at the map to compare the migratory routes of terns, whales, and dragonflies.

4c. Beetle specimen & large climbable model: When competing for females, Hercules beetles rush each other like jousting knights and try to lift the opponent into the air. Students can examine a specimen of one of the largest insects in the world, and climb the model.

5. SUPER SENSING

5a. Sawfish specimen & hammerhead shark model: Living things produce weak electrical fields that water conducts especially well. Some marine animals, like the sawfish and the hammerhead shark, use special sensory organs to detect the electric fields generated by their prey. Students can look at these objects to explore this phenomenon, called electroreception.



sawfish saw

5b. "Seeing" area: Eyes have evolved in many organisms across the tree of life. Animals can detect a range of light, from infrared to ultraviolet. Point out that students have their own light receptors, which they can use to investigate the diversity of form and function of eyes.

5c. "Hearing" area & owl skull: Many nocturnal predators rely on sound to detect prey. Students can examine an owl's skull anatomy, which helps it hunt in darkness. They can also explore the range of frequencies audible to different species, including elephants, bottlenose dolphins, humans, and dogs.

5d. "Smelling" area & smell interactive: Animals have a wide variety of systems for collecting and detecting scents. Students can take a whiff of an aroma that certain orchids produce to attract pollinating bees. They can then investigate how different animals—especially insects, and including humans—use smell to help them find food, stay safe, and communicate.

6. UNCANNY EATERS

6a. Rafflesia (corpse flower) model & smell interactive: Instead of making their own food, parasites let other organisms do the work. Students can examine this parasitic plant, which draws all of its nourishment from its host, a vine.

6b. Black swallower model: In the deep ocean, where there's too little sunlight for plants to grow, food can be hard to come by. Students can examine a fish that is able to swallow prey far larger than itself.

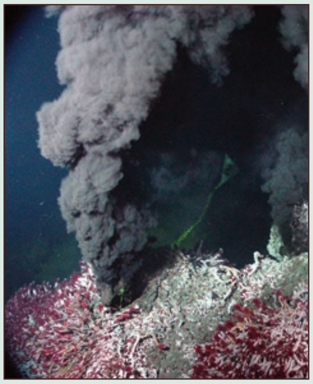
6c. Giant anteater & woodpecker skulls: Tongues are bundles of muscle that can do many jobs. Students can explore how the giant anteater uses its two-foot-long tongue to raid anthills and termite mounds, and see how the back of the pileated woodpecker's tongue might act as a shock absorber.

6d. Live mantis shrimp, eagle claw touchable model, & cookie-cutter shark model: Have students investigate the body parts that help these predators get their prey: a pistol-like punch, a grab with dagger-like limbs, and a razor-sharp bite.

7. LIVING IN CAVES

7a. Models of cave creatures: Most animals in caves have evolved to live in the dark and compensate for the absence of eyesight. For example, spider cave crayfish have extra-long legs and antennae to help them feel their way in the dark. Students can examine these and other adaptations, such as acute senses of smell, hearing, and even organs that help cave creatures detect electrical and pressure changes caused by other animals.

8. SURVIVING EXTREMES



8a. Hydrothermal vents diorama: Scientists have discovered communities thriving around hydrothermal vents on the sea floor, under crushing pressure and in absolute darkness. Students can explore how vent dwellers like clams and giant tube worms rely on a process called chemosynthesis to live on chemical energy.

8b. "Hot & Cold" wall: Organisms can survive at astonishing temperatures. Students can investigate the range shown here, from 121°C (250°F, well above the boiling point of water) for microbes inside hydrothermal vents to –196°C (–320°F) for a leech—in a lab.

9. TAKING COVER

9a. "Camouflage" wall: Animals may hide from predators by blending in with their surroundings or mimicking other species. Can students distinguish the lookalikes?

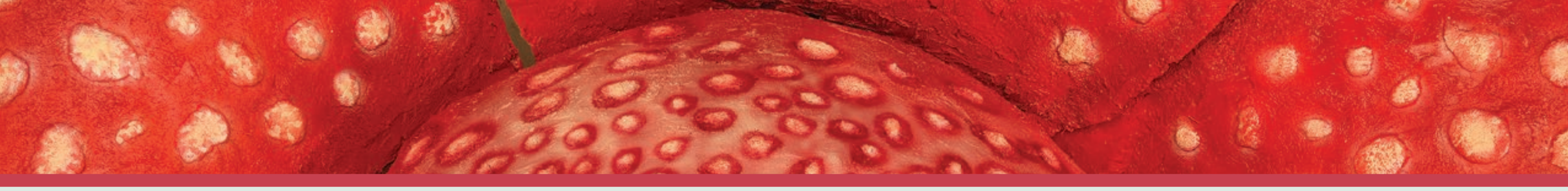
9b. Spines case, armor touchables, & hornet nest: Sharp spikes, protective armor, and secluded shelters all make good defenses. Students can look at examples of these features and behaviors, which have evolved countless times in species as different as porcupines and sea urchins.

spot-fin porcupinefish

9c. Animal adaptations interactive: By gesturing in front of interactive screens, students can make creatures—including the peacock mantis shrimp, star-nosed mole, and okapi—behave in ways that highlight their unique adaptations.

10. DEFYING DEATH

10a. "Defying Death" area: Some organisms have remarkably long lifespans. Students can explore fascinating examples, like the "immortal" jellyfish and the lungfish, which can survive dry seasons that last months to years without food or water.



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.
- ☐ **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/lal/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.
  - Students can use the worksheets and/or maps to explore the exhibition on their own or in small groups.

Next Generation Science Standards

Scientific & Engineering Practices • 1. Asking questions • 6. Constructing explanations • 8. Obtaining, evaluating, and communicating information

Crosscutting Concepts • 1. Patterns • 2. Cause and effect: Mechanism and explanation • 3. Scale, proportion, and quantity • 6. Structure and function • 7. Stability and change

Disciplinary Core Ideas • LS1.A: Structure and Function • LS1.B: Growth and Development of Organisms • LS1.D: Information Processing • LS2.A: Interdependent Relationships in Ecosystems • LS2.B: Cycles of Matter and Energy Transfer in Ecosystems • LS2.C: Ecosystem Dynamics, Functioning, and Resilience • LS2.D: Social Interactions and Group Behavior • LS3.B: Variation of Traits • LS4.B: Natural Selection • LS4.C: Adaptation • ESS2.E: Biogeology

Glossary

adaptation: a physical or behavioral characteristic that helps an organism survive and reproduce in a particular environment

This blind cave fish uses its enlarged fins to hold onto rocks in fast-moving streams—and stay safely in the dark.

camouflage: an adaptation, such as color or shape, that protects an animal by enabling it to blend in with its surroundings

environment: the external surroundings of an organism, including factors like climate, soil, and other living things

jet propulsion: in animals, the thrust produced by passing a jet of water in the direction opposite to the direction of movement

One set of muscles draws water in, and another set shoots the water out. The nautilus doesn't go fast, but moving this way doesn't require much energy.

mimicry: a resemblance of one organism to another, which helps protect the organism from predators

natural selection: the process through which organisms that survive and produce offspring in a given environment pass their traits to the next generation. Natural selection is the primary mechanism of evolution.

predator: an animal that kills and eats other organisms, its **prey**

species: a basic unit of biological classification. A species is typically defined as a group of organisms that share ancestry and characteristics, and which can interbreed and produce fertile offspring.

CREDITS

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PHOTO CREDITS

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