American Museum *of* Natural History

EDUCATOR'S GUIDE

Sharks

INSIDE

MAP OF THE EXHIBITION

The *Sharks* exhibition uses models, fossils, videos, interactive media, and more to bring to life the incredible diversity of sharks, their hundreds of millions of years of evolutionary history, their habitats and hunting styles, and the threats they face from humans.

This educator's guide divides the exhibition into three thematic areas:

Sharks Then and Now

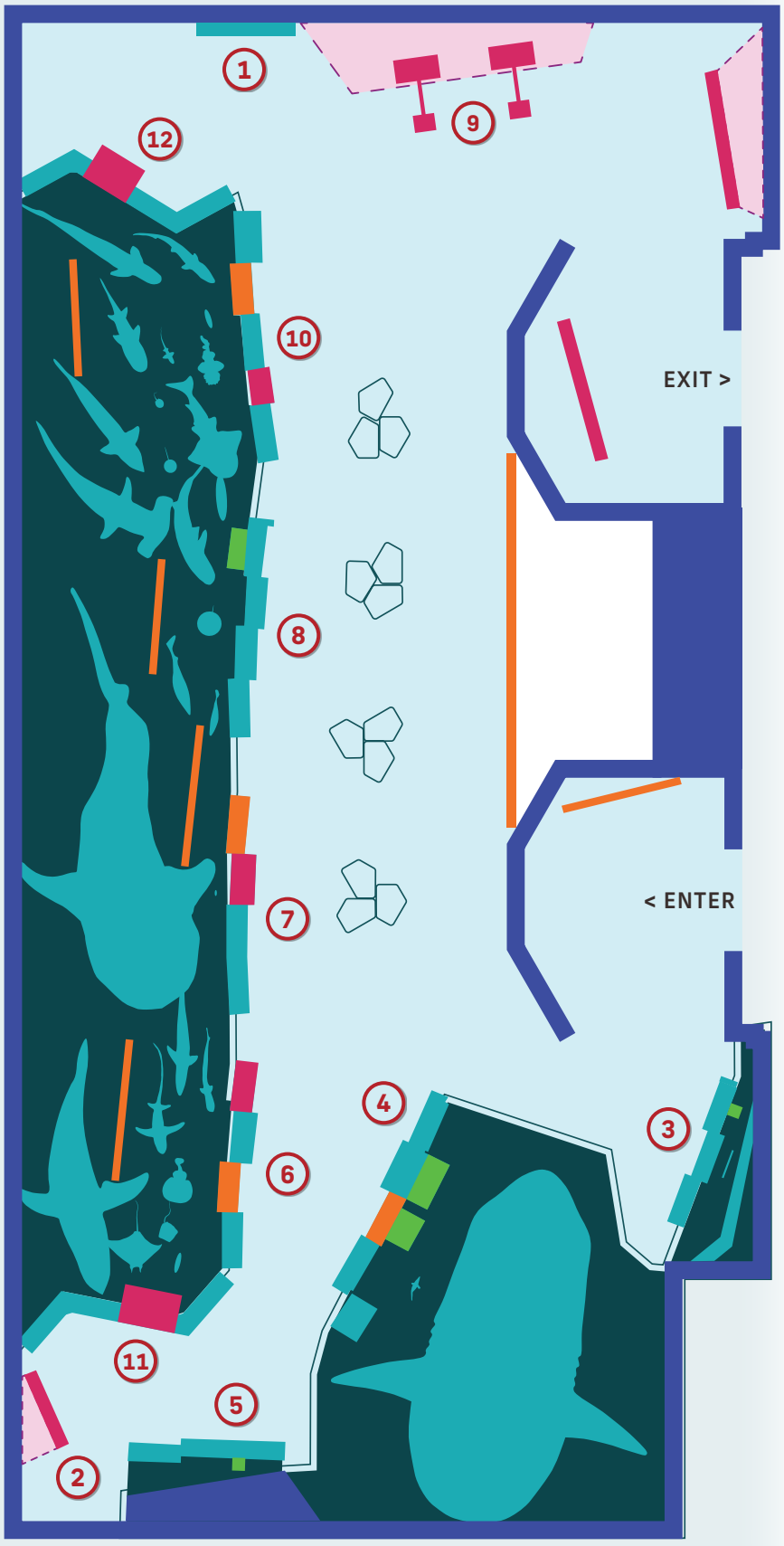
1. How Old Are Sharks?
2. What's So Special About Sharks
3. What Is a Shark?
4. Ancient

Shark Diversity and Adaptations

5. Teeth and Jaws
6. Predator or Prey?
7. Biggest and Smallest
8. Super Sensing
9. Hunt Like a Hammerhead
10. Around the World

Sharks and Us

11. How Dangerous Are Sharks?
12. How Vulnerable Are Sharks?



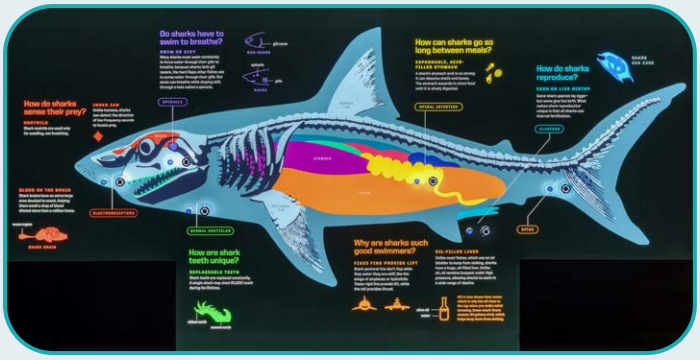
TEACHING IN THE EXHIBITION

Sharks Then and Now

This area dives into the past to explore the long history of these ancient fishes, how they evolved, and what makes them unique. Students can discover traits that have persisted across tens of millions of years until today and can get to know not only sharks but also their relatives.

1. "How Old Are Sharks?" wall graphic: A timeline introduces the idea that sharks (or at least their sharklike ancestors) evolved long before people, dinosaurs, and even trees.

2. "What's So Special About Sharks"? interactive graphic: A shark graphic reveals the distinctive traits of sharks. Students can explore external traits such as electroreceptors and claspers, along with internal traits such as oil-filled livers.



3. "What Is a Shark?" section: On the wall, a graphic depicting the evolutionary tree of sharks shows the major groups of Chondrichthyes, the group of closely related cartilaginous fishes that includes sharks, rays, skates, and chimaeras. Three text panels explain the advantages of a cartilage skeleton covered with a layer of hard, interlocking calcified tiles; a dogfish skeleton embedded in resin illustrates the concept.

4. "Ancient" section: Fossils and models illustrate extinct members of the shark family tree, a diverse and successful lineage. Students can examine several strange and fascinating species—such as the megalodon, the biggest predatory fish of all time—as well as extinct species that look remarkably like living species, demonstrating that many sharks, rays, and chimaeras have persisted in the same basic form for over 100 million years.

This 27-foot long model of megalodon depicts the front portion of the ancient ocean giant, which by some estimates could have grown as large as 60 to 80 feet.

Shark Diversity and Adaptations

This area showcases the great diversity of sharks and related fishes. Students can investigate the models to see how different species have evolved adaptations to take advantage of different food sources, inhabit different ranges, and respond to different threats.

5. "Teeth and Jaws" section: Students can compare 11 casts of jaws and explore an interactive text panel to examine feeding adaptations that are suitable for all manner of prey—from wide, flattened teeth specialized for crushing shellfish and crustaceans to needle-like teeth specialized for gripping fish and slippery squid. There is also a photo op with a life-size megalodon jaw cutout.

6. "Predator or Prey" section: Models of 11 shark species showcase apex predators that hunt fishes and marine mammals, as well as smaller sharks that feed on small sea creatures such as shrimps and crabs. In interactive panels and a matching game, students can also explore the variety of hunting behaviors and the adaptations sharks and their relatives use to defend themselves.

The deep-sea frilled shark may use its bright white, hooked teeth, as shown in this model, as lures to ambush prey.

7. "Biggest and Smallest" section: A large whale shark model is juxtaposed with the models of several tiny shark species. Students can find out why filter feeding is an efficient way to collect large quantities of food and how some smaller, deep-sea species make their own light through bioluminescence. They can also play a pattern-matching game to get a glimpse of how scientists recognize whale sharks by their spots.

The biggest fish in the world is a whale shark, which can reach 65 feet! The exhibition's model is 33 feet long.

8. "Super Sensing" section: Sharks and rays use a variety of senses suited to their specific habitats and feeding styles. Students can explore the senses that these fishes do not share with humans, such as: a specialized canal in the inner ear that helps them determine the direction of low frequency sounds; thousands of pressure sensors, together known as the lateral line system, which enables them to feel and map their environment; and electroreception, which allows them to detect electromagnetic fields.

9. "Hunt Like a Hammerhead" interactive media: At these two one-player stations, students rely on vibrations that mimic electroreception to track, approach, and attack life-size prey.

10. "Around the World" section: This area explores two main themes: migration and reproduction. Students can play a matching game to learn about the variety of shark and ray habitats, from polar seas to freshwater rivers to the deep sea. Text and video panels reveal why some sharks and rays stay in one place their whole lives while others migrate annually. The panels also examine sharks' diverse reproductive strategies, from bearing live young to producing egg cases.

Sharks and Us

For all their evolutionary success, sharks may now be facing a greater threat than any in their hundreds of millions of years of history. This area investigates their relationship with the most dangerous animal ever to walk the planet: humans.

11. "How Dangerous Are Sharks?" section: This area dispels the myth that sharks are a significant danger to humans. Panels explore how sharks benefit humans, ways to avoid being bitten by sharks, and why some people find them so frightening. Students can play with an interactive display to compare how risky sharks are compared to other animals, such as mosquitos and hippos.

12. "How Vulnerable Are Sharks?" section: This area examines who is more dangerous to the other—sharks or people—and why. It also explores why a great many shark species are threatened with extinction; details ways that humans threaten sharks, such as hunting them to make them into fish sticks, supplements, and cosmetics; and presents case studies of how humans can protect sharks.

Divers participate in the Great Fiji Shark Count, which informs the creation of marine protected areas.

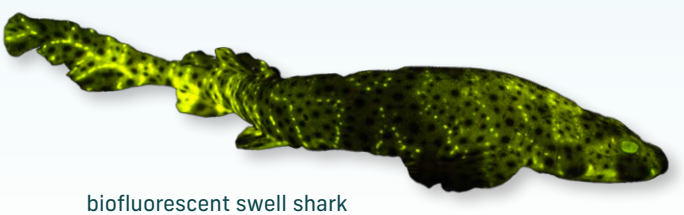
ESSENTIAL QUESTIONS

What are sharks?

Sharks are members of an ancient group of fishes belonging to the **chondrichthyans**, fishes that have **cartilage** skeletons. The first chondrichthyans arose about 450 million years ago—long before humans, dinosaurs, and even trees. They are descended from bony fishes, rather than the other way around; as their ancestors evolved, they gradually lost the bony elements from their skeletons. There are three major modern lineages of chondrichthyans: sharks (Selachii, with about 540 species); **rays** and **skates** (Batoidea, with over 600 species); and **chimaeras** (Holocephali), with only about 50 species still alive today. The basic body plan of sharks that survives to this day—a torpedo-shaped body with large, rigid **pectoral fins** and a powerful tail—first emerged over 350 million years ago in an **extinct** chondrichthyan. Sharks' cartilaginous skeletons are covered by hard, interlocking tiles, called **tesserae**, made of the same calcium-based mineral as your tooth enamel. The tesserae lend strength to the light and flexible cartilage skeleton.

How do humans and sharks interact?

We are much more dangerous to sharks then they are to us. On average, sharks cause about 10 human fatalities per year. Compare that to the 100 million sharks taken per year by fisheries. About half of these sharks are killed as **bycatch**—caught in nets and lines intended for other species. Humans threaten sharks in many other ways as well, such as by killing them for their fins to make into soup, by sport fishing, and by polluting and destroying their habitats. **Anthropogenic climate change** is raising ocean temperatures, altering seawater chemistry and ocean currents, and ravaging sharks' **food webs**. About 400 species of sharks and other chondrichthyans (more than 30 percent) are threatened with **extinction**. **Conservation** efforts include devices to prevent wildlife from being caught in fishing nets; tagging studies to track and monitor sharks; protective legislation, such as establishing fishing quotas and marine sanctuaries; educational campaigns to help consumers to buy sustainable seafood; campaigns against shark-fin soup; and involving local communities in shark conservation.



biofluorescent swell shark

How are sharks adapted to life in water?

Sharks are extremely diverse and widespread, found in just about every marine habitat; there's even a genus, *Glyphis*, that lives its entire life in freshwater rivers. Their adaptations enable this diversity.

STRONG SWIMMERS: Along with their distinctive skeletons, sharks have stiff, fixed fins that provide liftlike airplane wings and powerful tails that provide forward thrust. Their buoyant, oil-filled livers allow them to swim at a great range of depths without sinking. Some species, such as blue, great white, and mako sharks, go on extremely long migrations; some individuals cross the Atlantic several times in their lifetimes. Other species, such as deep-sea and Greenland sharks, have daily vertical migrations—they move up and down the water column following the small fish and crustaceans they feed on.

FEEDING: Sharks have replaceable teeth, with new rows growing in as the old ones wear out. Some sharks shed up to 30,000 teeth over their lifetimes. These teeth can be spiky for stabbing, serrated for sawing, or flat for grinding; each species has teeth adapted to its feeding style. A handful of sharks, such as the great white, are powerful predators that hunt fishes and marine mammals—though almost never, despite their reputation, people. Most sharks feed on small marine animals like shrimps, crabs, plankton, and small fishes. And the biggest species, such as whale sharks, are filter feeders.

SENSES: Sharks have some of the same senses we do, plus a few we lack. Studies of chondrichthyan vision suggest that while rays and some chimaeras can distinguish colors, sharks have monochromatic vision. Shark species that live in the deep sea tend to trade color vision for big eyes to capture all available light. Sharks can hear the direction of low-frequency sounds, such as the thrashing of injured prey. They have an extra-large brain area devoted to smell, allowing them to detect a drop of blood in a volume of water a million times greater than that of the blood. Like most fish species, they have thousands of pressure sensors—the **lateral line system**—which they use to map their environment by sensing how water is flowing around them. But unlike most other fishes, they also have a sense called **electroreception**, with which they can detect the tiny electromagnetic fields that living organisms produce. Electric rays can use this system for electrogenesis, producing strong electric discharges to stun or kill pray.

REPRODUCTION: Sharks and other chondrichthyans fertilize eggs internally rather than by releasing eggs and sperm into the ocean. Males use a pair of organs called claspers to insert sperm into females. Some species are **oviparous**, laying eggs. Some are **ovoviviparous**—their eggs hatch inside the female's body, where the pups mature and are born ready to swim. And some species are **viviparous**, or live bearers, nurturing the embryo inside the female's body with a placenta, like humans and other mammals.

COME PREPARED CHECKLIST

- ◯ **PLAN YOUR VISIT.** For information about field trip reservations, visit **theStoryofTexas.com/education/field-trips**.
- ◯ **READ THE ESSENTIAL QUESTIONS** in this guide to see how themes in the exhibition connect to your curriculum. Identify the key points that you'd like students to learn.
- ◯ **REVIEW THE TEACHING IN THE EXHIBITION** sections for an advance look at what your class will encounter.
- ◯ **DECIDE HOW YOUR CLASS WILL EXPLORE THE EXHIBITION:** You and your chaperones can facilitate the visit using the Teaching in the Exhibition sections. Students can use the map to explore the exhibition on their own or in small groups.

CORRELATIONS TO STANDARDS

A Framework for K-12 Science Education

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 • LS3.B: Variation of traits • LS4.A: Evidence of common ancestry and diversity • LS4.C: Adaptation • LS4.D: Biodiversity and humans

Crosscutting Concepts • 1. Patterns • 2. Cause and effect: mechanism and explanation • 4. Systems and system models • 6. Structure and function

Scientific & Engineering Practices • 2. Developing and using models • 8. Obtaining, evaluating, and communicating information

CREDITS

The Museum gratefully acknowledges Warner Bros. Discovery for its generous support of *Sharks*. A selection of footage in *Sharks* has been provided by Discovery's *Shark Week*.

Discovery SHARK WEEK

American Museum *of* Natural History

GLOSSARY

cartilage: a firm, flexible, strong, tough, fibrous tissue that functions as a connective tissue and shock absorber and as a precursor to bone in many vertebrates (including humans) and that forms the skeletons of chondrichthyans

chondrichthyans: a class of fishes that have cartilage skeletons, comprising sharks, rays and skates, and **chimaeras**—the Holocephali, a mostly extinct group with only 52 species alive today, most of which dwell in the deep sea

anthropogenic climate change: changes in the weather (including extremes) in a particular region averaged over a number of years resulting from human activity, especially the release of carbon dioxide from burning fossil fuels

conservation: protecting and managing natural resources, habitats, organisms, and ecosystems for present and future generations

electroreception: a sensory system that allows some animals to detect electromagnetic fields

extinct: having no living members; **extinction**, the death of all living members of a group

food web: the complex network that describes which organisms eat and are eaten by which other organisms within an ecosystem

lateral line system: a sensory system that enables some animals to detect subtle movement and pressure gradients in the water that surrounds them, allowing them to map their environment

oviparous: producing eggs that mature and hatch outside the mother's body

ovoviviparous: producing eggs that mature and hatch inside the parent's body, resulting in a live birth without a placenta

pectoral fins: the two fins located on the sides of a fish behind its head, used for controlling its direction and orientation as it swims; they are analogous to the forelimbs of a tetrapod

rays and skates: members of four orders of Batoidea, a group of chondrichthyans closely related to sharks; with wide, flat bodies, whiplike tails, and heavy teeth for crushing shellfish, many rays and skates are well adapted to living on the seafloor

tesserae: hard, interlocking calcified tiles that cover a shark's cartilage skeleton

viviparous: producing young that develop as embryos within the mother's body by means of a placenta ; humans and other mammals are viviparous

IMAGE CREDITS

Cover: group of sharks, © Jakob Owens/Unsplash; students, © Pete Oxford; hammerhead shark; © iStockphoto; fossil, D. Finnin/© AMNH. **Essential Questions:** biofluorescent swell shark, courtesy of D. Gruber/J. Sparks. **Teaching in the Exhibition:** sharks anatomy, M. Shanley/© AMNH; all other exhibition photos, D. Finnin/© AMNH; divers in Great Fiji Shark Count, James Lea/Save Our Seas Foundation.