SHARKS KIDS

LET'S INVESTIGATE SHARK ANATOMY AND PHYSIOLOGY

LESSON PLAN & TEACHING GUIDE
VOCABULARY
SUGGESTED ACTIVITIES

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Lesson: Let's Investigate Shark Anatomy and Physiology

Grades: 9 - 12

Objective: Students will be able to compare and contrast mammals, teleosts and cartilaginous fishes. Students will be able to identify statements that are facts versus those that are attitudes and explore personal attitudes toward and knowledge of sharks.

Teaching Methods: Cooperative learning, Discussions, Multimedia instruction

Next Generation Science Standards: HS-LS1, HS-LS2, HS-LS4

Ocean Literacy Essential Principles and Fundamental Concepts: OLP 1, OLP 2

Activity Time: 45-90 MINS

Preparation: Whether in person or virtual, save all visual resources (including PowerPoint) to scroll through during lesson. For outdoor groups, you may choose to print and laminate. Small group discussions can be modified by using virtual breakout rooms or having students do this as a homework assignment prior to this lesson. Post list of terms for students to define and take notes on during the lesson.

Directions

* (Figures refer to slides on the PowerPoint) *

1. Ask students what they know and have heard about sharks?

Ask the students to come up with words and facts they associate with sharks. Record answers by having students write their answers down on paper individually or on the board, in a chat box (if virtual) or say aloud and assign one student to be a recorder. Explain to students that they should express anything that comes to mind about the topic. Encourage students not to censor what they share. If students are struggling to make connections, suggest that they consider what they have seen in movies, on television, or read. Inform students that you will return to the list and discuss later.

2. Compare and contrast a fish and a mammal.

Ask: Is a shark a mammal? Have them consider what classifies a mammal as such. Elicit from students that a mammal's young are nourished by milk from the mammary glands of the mother and has hair at some stage in their life. Some students may bring up that mammals are endothermic (warm-blooded) and/or breathe air; explain that these are not unique to mammals because they are also characteristics of birds.

Direct students to *Figure* 1. Ask students if they can identify any of the parts of the animal. If students are struggling, have them consider themselves in relation to their body parts. Throw out the following types of fins (anal, caudal, dorsal, pectoral and pelvic). Then, direct students to *Figure* 2 to point out missing and/or incorrect features.

Have the students imagine a dolphin. Then, ask: Is this whale shark a whale or a shark? Explain to the students that whales, dolphins, sharks and bony fish may have such fins. Not all sharks have an anal fin, but when present it provides stability. Generally, the upper lobe of the caudal fin is larger than the lower lobe. Dorsal fin, whether they have one or two help to stabilize the shark. The paired pectoral and pelvic fins work to compensate for any lift or downward forces created by the caudal fin.

Ask: Have you ever heard of a shark making clicks or sounds? Elicit from the students that they do no such thing as a form of communication.

Redirect students back to *Figure* 1. Ask: Does this whale shark look like it moves side to side or up and down? Elicit from students that fish move their caudal fin side to side, whereas a mammal's tail fin is called a fluke and moves up and down to propel the animal forward. Explain to the students that the whale shark is the largest shark in the sea averaging 12m (39ft.), while the pygmy shark is presently the smallest sharks averaging 15cm (5.9 in.) long.

Optional addition: Direct students to *Figure* 3. Explain that the epaulette shark is one of few sharks that has an increased range of motion in its pelvic and pectoral fins allowing it to walk over the ocean floor or through tide pools. Explain that the Thresher shark can use their caudal fin to slap and stun their prey before eating them.

Direct students to *Figure* 4. Ask: Are these blow holes? Explain that some species of elasmobranchs have small openings called spiracles behind the eyes at the top of the head to bring in oxygen rich water. Remind students that sea turtles come up from air, again negating that air-breathing is a unique characteristic of mammals.

Optional addition: Spiracles originate from rudimentary first gill slits and are reduced or absent in active, fast-swimming sharks. Humans may have remnants of this as well, if they have a whole or dimple located at the top of their ear lobe. Have students check to see if any of them can spot their inner fish.

Conclude that a whale shark is not a marine mammal because they do not breathe air nor are they warm-blooded. We have yet to investigate if their young are nourished by milk from the mammary glands of the mother or if they have hair at some stage in their life.

3. Compare and contrast sharks and bony fish.

Ask students to consider if sharks do not breathe air, how do they get oxygen from the water. Ask: How do fish breathe? Elicit from students that fish breathe through gills. Draw their attention to the gill slits on the ventral (under) side of its body. Explain that water enters the mouth or spiracles and is expelled through the gill slits. Take a moment to point out that nowhere do we see nipples, which would be the anatomical feature indicating that a shark wound nurse their young.

Direct students to *Figure* 5. Explain that this is a demonstration of buccal pumping, a process in which sharks can respire by pumping water over their gills by opening and closing their mouths without actively swimming. Many sharks do have to swim constantly, which forces water to flow through the mouth and across the gills and continuously circulate oxygen in their blood, which is known as ram ventilation.

Direct students to *Figure* 6. Remind them that we have established both sharks and fish breathe via gills. Explain that the gill filaments, which are supported by gill rakers, absorb oxygen from the incoming water. Elicit from students the differences in the species. Explain that sharks have 5-7 gills slits, while bony fish have an operculum.

Ask: Is a shark a fish? Have them consider what makes a fish a fish. Elicit from students that fish are covered in scales, breathe via gills, and have rigid bones like humans.

Ask: Has anyone ever touched a shark? Elicit from students that sharks feel like sandpaper. Direct students to *Figure* 7. Explain that sharks feel very smooth in one direction (head to tail), but like a cat's tongue or sandpaper when you rub it the other way (tail to head). Sharks do not have flat scales like other fish, they have placoid scales called dermal denticles, which are tiny tooth shaped scales, formed from a dense network of collagen (protein fibers). Explain that at no point in their life do they have hair, which supports the fact that they are not mammals.

Instruct students to wiggle their noses and ears. Ask: What are our noses and ears made of? Elicit from students that it is not bone but rather cartilage, which allows for flexibility. Direct students to *Figure* 8. Explain that sharks are cartilaginous fish and their skeleton is unlike ours. Cartilage is lighter (less dense) than bone, so it helps sharks maintain neutral buoyancy (keeps them from sinking to the bottom). It also allows some sharks to be extremely flexible and able to touch their own tail.

Ask: Are sharks vertebrates? Elicit from students that vertebrates possess a backbone or spinal column, so they are regardless of what their bones are made of. Some older and larger shark skeletons can be partially calcified, so it is harder like our bones, but is still not true bone. Most shark skeletons are composed of only ten elements, compared to a teleost skull that has over 60 bones in its skull alone. Commonly these structures include the skull, gill arches, jaws, vertebral column, and fins.

4. Engage in a class discussion on a shark's senses.

Ask: How many senses do we have? What are they? What are the associated body parts for each? Elicit from students that (1) for sight we have eyes, (2) to hear we have ears, (3) for smell it is the nose, (4) taste the tongue, and (5) touch is all over our skin.

In small groups, have students discuss shark senses by assigning each group some probing questions. For vision – Do they have good eyesight? Can they see color? Do they have eyelids? For hearing – Did you see ears in the picture we looked at? For smell – Can a shark smell under water? Can they breathe through their nose? For taste – What do sharks eat? Do you think they can taste? Do they have a tongue? What happens when a shark loses a tooth? For touch - Since they lack hands, how do they feel? Can they feel?

Facilitate a class discussion, direct students to *Figure* 9, and conclude that shark can see like us. Include that shark eyes vary in size and shape depending on the habitat and depth they spend most of their time in. Sharks have eyelids, but they do not close all the way. Some sharks have a third eyelid called a nictitating membrane, which protects their eyes when they are going after prey. Sharks without nictitating membranes can roll their eyes back in order to protect them. Direct students to *Figure* 10 and explain that sharks have a basic vertebrate eye, but it is laterally compressed. Cone cells are present, indicating that sharks may have some sort of color vision. In clear water, a shark's vision is effective at a distance up to about 15 m (50 ft.) Uncommon to other fish, a shark's pupil can dilate and contract.

Optional addition: Direct students to *Figure* 11. Explain that some sharks can absorb and re-emit light in a different colour seen here in this swell shark. This ability is known as biofluorescence, which is not the same as bioluminescence because the sharks do not appear to glow by light they produce themselves.

Continue the class discussion, direct students to *Figure* 12, and conclude that sharks can smell. Include that they have 2 nares (nostrils) on the underside of their snout or in front of the mouth. Each nare has 2 openings: 1 for water to enter and 1 for water to exit. Sharks do not use their noses to breathe. They are only used for smelling. Some sharks have "whiskers" or barbels near the nostril area. The nurse shark barbels presumably enhance the tactile or chemoreceptors. Direct students to *Figure* 13. Sharks have an incredible sense of smell. Imagine being able to smell a chocolate chip cookie in an area the size of a football field. Some sharks can detect a single drop of fish blood within a million drops of seawater or from a quarter of a mile away. A ¼ mi is almost 4 football fields (360 ft) in length.

Continue the class discussion, direct students to *Figure* 14, and conclude that they have taste buds in their mouth and nostrils but no tongue. Include that if a shark eats something upsetting, some species can force their stomach out through their mouth into the water to empty it. Direct students to *Figure* 15. Humans have one row of teeth on the top and one row on the bottom (52 teeth total over our lives, 20 baby teeth that we lose, and 32 adult teeth). Sharks have several longitudinal rows of teeth that are constantly falling out as they have a series of replacement teeth waiting to move forward somewhat like a conveyor belt. Most sharks have about 5 rows of teeth with usually a series of 20 replacement teeth, while a whale shark has more than 300. Different sharks have different shaped teeth depending on what they eat.

Continue the class discussion, direct students to *Figure* 16, and conclude that sharks have ears, but they are located entirely on the inside of the body. Include that sound vibrations travel faster and farther through water, generally a shark can hear something before it comes into sight. A shark's ear is similar to ours and can detect vibrations and gravity. Sharks are very sensitive to irregular pulses of low-frequency and most can identify the precise direction from which a sound has originated.

Continue the class discussion, direct students to *Figure* 17, and conclude that sharks can feel. Explain that in sharks it is known as mechanosensing, and involves a lateral line, which is not the same as in teleost fishes, and series of interconnected canals that run from the back of the shark's head to its tail. Like the ear, the lateral line functions mainly in detecting low-frequency vibrations and directional water flow. Similarly, the shark does not have to see an animal to know it is there, it can feel it by detecting movement or disturbance in the water. Each canal is made up of tiny pores, which allow water to penetrate the skin. Tiny hairs line the canal and allow the shark to detect movement and pressure changes in the water. If you are in a swimming pool and your friend does a cannon ball you feel the wave, right? Imagine if you were at the opposite end of the pool and your friend wiggled his or her fingers very gently and you were able to feel that.

Complete the class discussion by reminding the students that that was five senses, but explain sharks have a 6^{th} sense. Visit https://www.youtube.com/watch?v=4VLhYxnF2Uo&feature=youtu.be and point out the nictitating membrane. Ask: Why do you think the sharks are attracted to the camera? If students are struggling, encourage them to think of what powers such a device. Invite students to imagine what allows an animal to locate things without GPS. Elicit from students the commonality between the two are electric energy. Explain that sharks have a sixth sense called electrosensing. They can detect the tiniest electric fields given off by other animals as well as inanimate objects and the earth's magnetic field. Direct students to *Figure* 18. Explain sharks have an ampullae of Lorenzini composed of special jelly-filled sensory organs, which are an extension of the lateral line system branching out around a shark's head and mouth. It allows sharks to detect things at close range (50cm).

End the discussion by directing the students to *Figure* 19 to compare the approximate distance range for each sense.

5. Assign students to reflect on what they have learned.

Remind students that, at the beginning of the lesson, they were asked to come up with words and facts they associated with sharks. Have students revisit this list, organize them into myths and facts, and write a brief statement to support why they have placed them in such a category.

Informal Assessment

Assess students based on their participation in the small group and class discussions. Check students' understanding by asking them to orally restate the definitions.

Extension Assignments

Direct students to *Figure* 20. Have students investigate a specific species, focusing on their unique anatomy and physiology. Ask students to present their findings to the class.

Optional Activities

Shark Teeth Matching, Shark Parts Labeling

Vocabulary

Ampullae of Lorenzini: Tiny pores filled with a jelly like substance that can detect electrical fields traveling through the water. There are more of them on the head of the shark (around the snout) than anywhere else.

Anal fin: a single fin located on the underside of most sharks, behind the anus.

Barbels: Whisker-like sensory projections that extend from the nostrils in some sharks.

Buccal pumping: A method of respiration involving the movement of the mouth in a rhythmic manner to take in water.

Cartilage: A strong, flexible fibrous tissue.

Caudal fin: The fin on the end of the tail, generally not present in rays.

Chemoreceptor: Sensors that detect changes in CO_2, O_2, and pH.

Cold Blooded (exothermic): Animals like reptiles, amphibians, and fish that become hotter and colder, depending on the temperature around them. For most shark species, their body temperature will be the same as the water it is swimming in.

Dermal Denticles: Tiny tooth shaped scales, formed from a dense network of collagen (protein fibers), that cover a shark's body (also called placoid scales). They reduce resistance as the shark moves through the water (hydrodynamic), allowing it to swim faster while using less energy.

Dorsal fin: The famous, triangular fin most associated with sharks, located on the shark's back. Some sharks have just one and others have two, a larger anterior one and a smaller posterior one.

Elasmobranch: A term used for sharks, rays, and skates.

Gills: A respiratory organ, which replaces lungs.

Gill filament: The red, fleshy part of the gills, which take oxygen into the blood.

Gill raker: The stiff, cartilaginous processes, which strain the water.

Lateral Line: A row of sensory cells along the side of a shark that allow it to detect vibrations in the water.

Nictitating Membrane: A thin membrane similar to our eyelids that sharks have and can use to protect their eyes when attacking prey.

Operculum: A series of bones, found in bony fish, which protects the gills.

Pectoral fin: A pair of fins just behind the gills.

Pelvic fins: A pair of fins on the underside of the shark between the pectoral and anal fin.

Ram ventilation: A method of respiration where the animal keeps the mouth open while swimming, to allow water to flow through the mouth and across the gills.

Spiracle: A gill slit found in some sharks behind the eyes providing oxygen directly to the eyes and brain.

Terminal mouth: Mouth that opens at front end of head with upper and lower jaws equal.

Teleost: A name used for classifying ray-finned fishes.

Vertebrate: A name used for classifying animals with a backbone or spinal column.

Warm blooded (endothermic): Animals like mammals, birds, and some sharks that become can regulate or alter their internal temperature. Some species like the Great White, Salmon and Mako sharks can warm parts of their body to be able to swim faster.