jump | STEAM

AT HOME

DO TRY THESE AT HOME!

VIRTUAL SHARK LAB MANUAL

THINK LIKE A SCIENTIST!

Have you ever wondered whether wall color affects moods, why your dog prefers one food over another or whether bread molds faster in a paper or plastic bag? What's the best way to answer these questions?

Scientists turn wondering into a formal process called the **scientific method** to get logical or empirical answers to their questions. They conduct **experiments** that are **repeatable** until answers can be confirmed with the same predictable results each and every time.

Did you know that YOU were born a scientist?!

Babies are great at observing, trying and learning until they get predictable results.

SIX STEPS OF THE SCIENTIFIC METHOD

1 **OBSERVE:** *Notice something that makes you wonder.*

2 **QUESTION:** *Open your mind to ask, "What if...?"*

3 **HYPOTHESIS:** *Make an educated guess to answer your question.*

4 **EXPERIMENT:** *Make a plan and test your hypothesis.*

5 **COLLECT, ANALYZE AND REPORT DATA**

6 **MODIFY AND REPEAT**

HAVE THE RIGHT TOOLS!

The most important scientific tools are not expensive or fancy. And they are something you already possess! We're talking about your natural curiosity, your sense of exploration and your love for the unknown. With these tools, you can turn your world into your very own science lab every day.

- Jump STEAM at Home experiments are designed to spark your curiosity in Science Technology, Engineering, Arts and Math with an emphasis in health care.
- At the end of your experiment, **DO keep exploring** a topic.
- Think about it! Try to apply what you've learned to other things.
- Look it up! Search bold words online for connections.

GET PREPARED!

BASIC SCIENCE SAFETY

Science is fun, but it is also serious business! Messing around or not being prepared can cause you or someone else to get hurt while experimenting. You should ALWAYS use the safety checklist and data sheet before beginning an experiment.

- ❑ Gloves
- ❑ Eye protection
- ❑ Apron/lab coat
- ❑ Nearby sink
- ❑ Sharps and specimen safe disposal
- ❑ Adult within sight AND sound

jump | STEAM

KIT MATERIALS

- Dissection manual
- Baby dogfish shark
- Personal Protective Equipment: gloves, goggles and apron
- Dissection tray
- Dissection tools: tweezers, ruler, scissors, probe and pins
- Table cover/disposal bag

JUMP STEAM AT HOME LESSON:
BABY SHARK AUTOPSY

OBJECTIVE: Be able to identify the anatomical structures of the dogfish shark and how they compare to the anatomy of humans.

- Review safety
- Identify materials and equipment
- Begin lesson and dissection!
- Close with discussion and clean up

MEET YOUR PATIENT

This lesson will introduce you to general anatomical structures and dissection skills by comparing the anatomy of the spiny dogfish shark to the make-up of humans. You will learn why each has organs specialized to work differently, allowing them to survive in their own environments.

WHAT IS AN AUTOPSY?

- Technically, an "autopsy" is the examination of a human after they have died. "Forensic autopsies" are done to determine if the death was an accident, intentional (a crime) or natural event.
- Today, YOU will be performing a "necropsy," an examination of the anatomy of an animal. Necropsies are also done to determine why an animal died.

THINK ABOUT IT!

- What kind of doctor do you think usually studies the death of other animals?
- Why would it be important to learn why animals die?

DOGFISH SHARK

FYI:

- Sharks are one of most "primitive" creatures on the planet.
- Spiny dogfish (Squalus acanthias) sharks are **vertebrates** in a **class** called Elasmobranchiomorphii aka Chondrichthyes.
- They are also called cartilaginous fish because their skeletons are made of cartilage. But they were one of the first creatures to develop biting jaws.
- There are about 1,000 species of Chondrichthyes. Approximately 400 are sharks.
- Sharks are usually ectothermic.
- Although they spend their entire life in the water, they breathe oxygen and share many features similar to land animals including most sensations, digestive processes, paired appendages and a blood circulatory system.

Taxonomy uses features of a creature to classify their relationship to other animals.

THINK ABOUT IT **Look up "human taxonomy."**

What might be different about shark anatomy from yours? Make a list!

https://www.sharksider.com/easy-guide-understanding-shark-taxonomy/

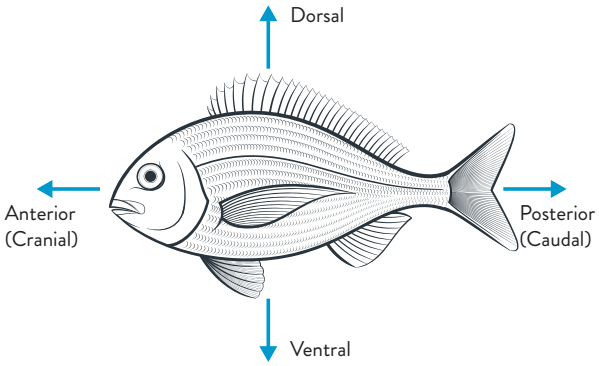
EXTERNAL EXAMINATION

COMPARATIVE ANATOMY

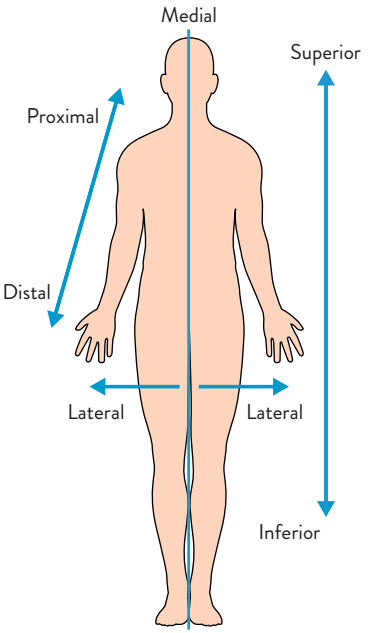
- Comparative anatomy lets you cut and observe one type of animal to understand another that you cannot cut open.
- **What other animals might be the MOST similar to humans?**

LET'S LABEL ANATOMICAL DIRECTIONS!

Fish Anatomy



Human Anatomy



OTHER IMPORTANT TERMS

Proximal =
Distal =

Superficial =
Deep =

<u>Planes (cuts)</u>
Sagittal =
Transverse =
Frontal =

OPEN. EXAMINE. LABEL.

How long is it?
Yours: _____cm _____in
Group Average: _____cm _____in

What's the wing span?
Yours: _____cm _____in
Group Average: _____cm _____in

WORD BANK

- Pectoral fin
- Pelvic fin
- Dorsal fin
- Caudal fin
- Lateral line
- Gills
- Spiracle
- Eye
- Nostril (nare)
- Cloaca
- Rostrum
- Mouth

INTEGUMENTARY SYSTEM

SHARK "SKIN"

- Shark skin is made up of a matrix of tiny, tooth-like structures called **dermal denticles** or **placoid scales**. These structures are shaped like curved, grooved teeth and make the skin so tough that it can injure its prey!

DENTICLES

- Shark skin is covered by tiny flat V-shaped scales, called dermal denticles that are more like teeth than fish scales. These denticles decrease drag and turbulence, allowing the shark to swim faster and more quietly.

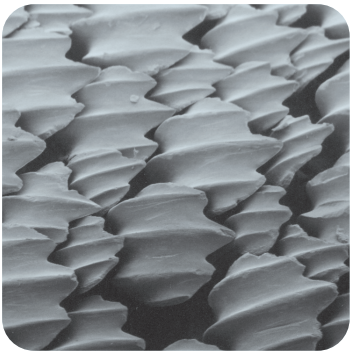


Photo courtesy of Pascal Deynat/Odontobase / CC BY-SA

THINK ABOUT IT **What benefits would thick, armor-like skin give the shark in its environment?**

SKIN COLOR

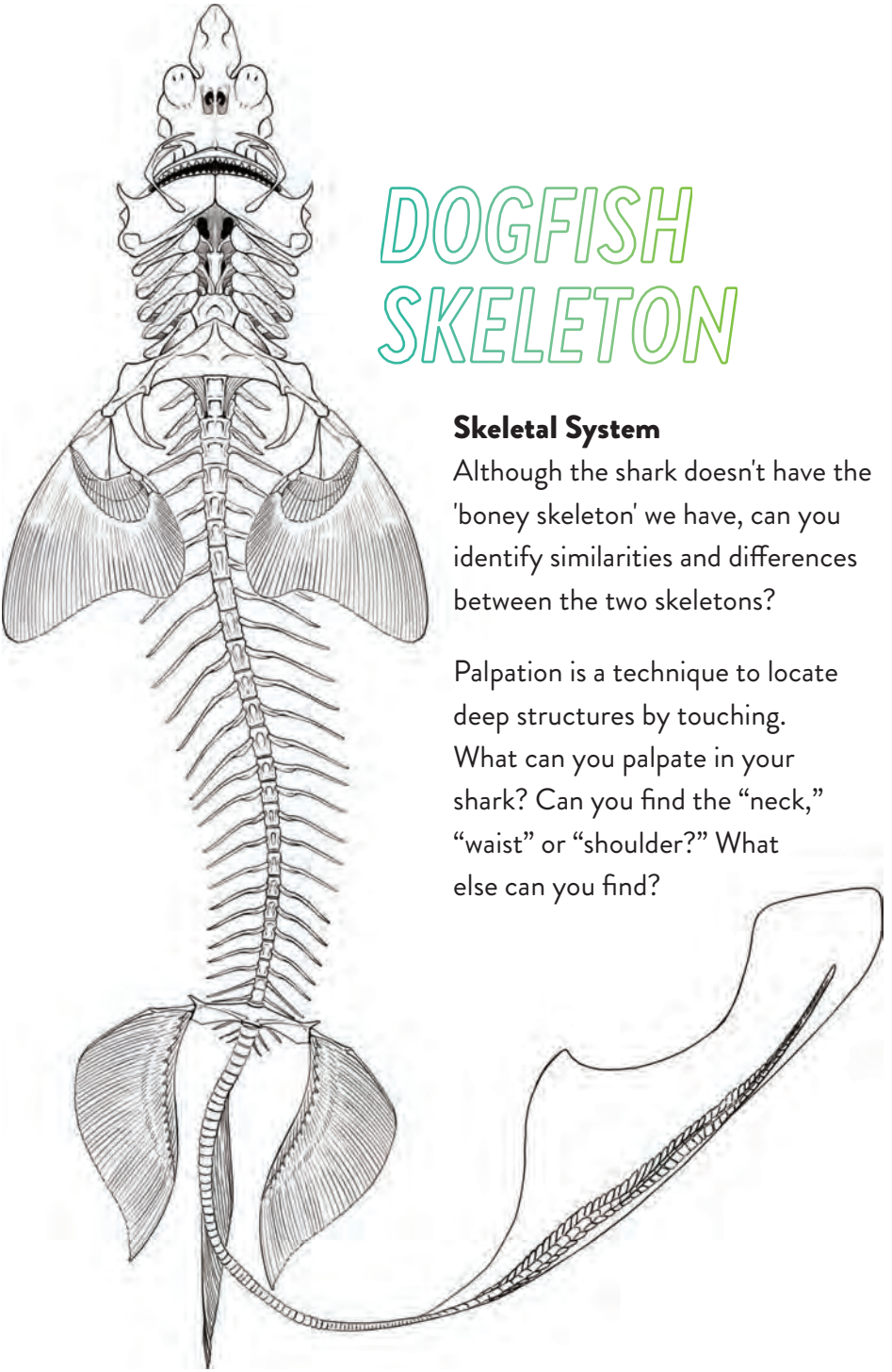
- Sharks are known for their characteristic color; there is even a line of paint colors modeled after it!
- What color would you say the shark is? Is it the same all over its body?
- Why do you think the color differs based on the location of the shark?
- Look at the **color** of the **dorsal** and **ventral** sides of the shark. **What** do you notice? **Why** do you think it is colored this way?
- Learn More: **https://www.sharksinfo.com/skin.html**

LOCOMOTION

- The muscular and skeletal systems provide support to the body and allow for movement. The bones of the skeleton **protect** the shark's internal organs and **support** the weight of the body.
- Humans are limited to terrestrial locomotion on two limbs or swimming with all four limbs. Other animals explore both the aquatic and aerial spaces more extensively. For example, birds are excellent swimmers and fliers. However, some birds are not good at moving in both air and water. For example, penguins do not have the ability to fly and move very slowly on land, but are excellent swimmers in the water.
- To swim, most fish have to wriggle their entire body from side to side. But a shark can get most of the power it needs from the rear caudal fin. Some large sharks can swim at speeds of up to 40 miles per hour.

THINK ABOUT IT **As you explore your shark, what features make it an expert in water that would be a disadvantage on land?**

1. Locate the **head, trunk and tail** regions on your shark.
2. Locate and name the shark's **seven fins** and discuss their functions.
3. Locate the **spines** that are directly in front of where the dorsal fins were. These spines carry a poison secreted by glands at their base.

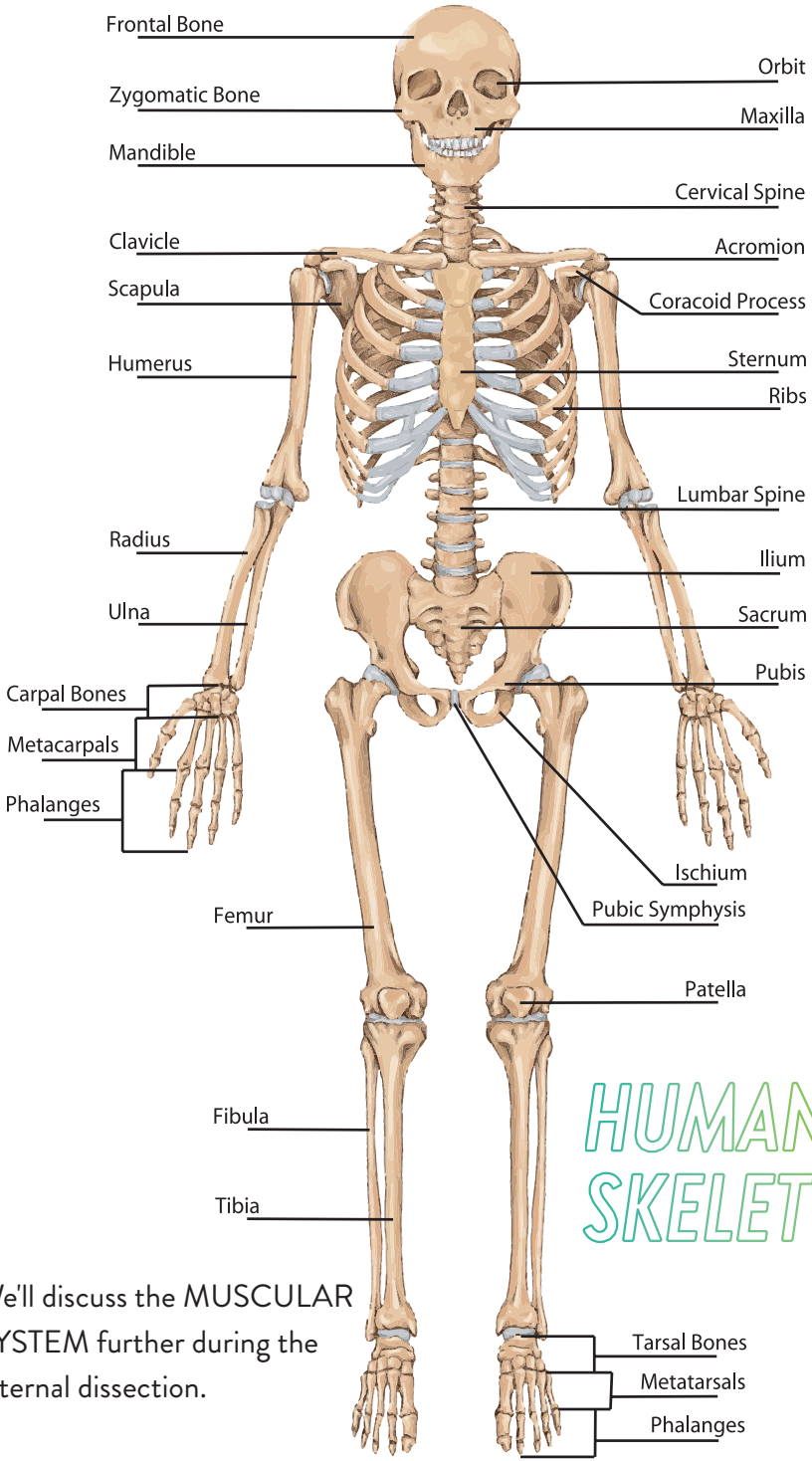


DOGFISH SKELETON

Skeletal System

Although the shark doesn't have the 'boney skeleton' we have, can you identify similarities and differences between the two skeletons?

Palpation is a technique to locate deep structures by touching. What can you palpate in your shark? Can you find the “neck,” “waist” or “shoulder?” What else can you find?



HUMAN SKELETON

We'll discuss the MUSCULAR SYSTEM further during the internal dissection.

NERVOUS SYSTEM, PART 1

Most animals have well developed nervous systems that allow them to navigate their world, respond to their environments and process that information. The nervous system is made up of the central nervous system (brain, spinal cord and nerves) and the peripheral nervous system (sensory neurons, cranial and spinal nerves and their branches). At the end of these branches are sensory neurons that bring information into the nervous system.

SHARKS HAVE THE SAME SENSATIONS AS YOU...

SMELL: One of the shark's most important sensations is smell. Almost 2/3 of the shark's brain is dedicated to smell. Why would smell be so important deep in the sea?

- Locate the **rostrum**, the pointed snout at the **anterior** end of your shark.
- The external nostrils (**nares**) are located on the **ventral side** of the rostrum **anterior** to the jaws. Water passes into and out of the **olfactory sac,** permitting the shark to detect the odors of the water.
- What do you think sharks have in common with bloodhounds?

SIGHT: Light doesn't travel well in the deep. Sharks have special features to help them see, including a **tapetum lucidum**—a layer of tissue lying immediately behind the retina.

- The **eyes** stand out in sharks and are very similar to your eyes. A transparent **cornea** covers and protects the eye. A darkly pigmented **iris** can be seen below the cornea with the **pupil** at its center. Upper and lower **eyelids** protect the eye. Just **inside the lower lid** is a **membrane** that extends over the surface of the eye to cover the cornea (**nictitating membrane**).
- Why does a shark's eye location seem odd for a predator?
- What other animals would likely have tapidum lucidum?

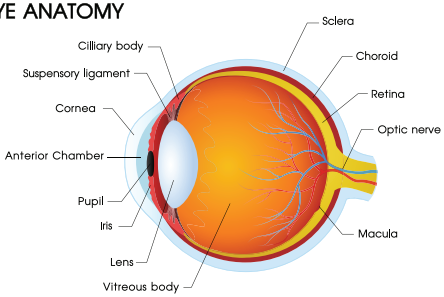
TOUCH

- Sharks have a high concentration of touch receptors in their rostral end and their teeth. This can be a problem because sharks want to feel things with their teeth much like you want to feel with your fingers.
- Why can feeling with their teeth be a problem?

TASTE

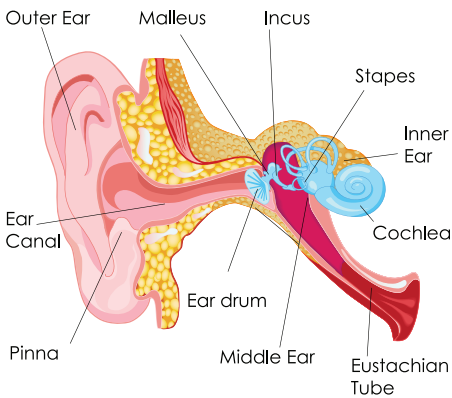
- You would think taste would be important for one of the world's most infamous carnivores, but it's actually the weakest of their sensations. A shark's senses are developed to find food, but not to enjoy it.
- Why might this explain the high survival rate of humans in shark attacks?
- The taste organs of a shark are not as highly adapted as their other senses because taste doesn't help them find food. They'll often 'test bite' potential food to see if it's palatable. If it's not they'll spit it out.

EYE ANATOMY



HEARING

- A shark's ear is entirely internal. Otherwise it is practically the same as us. The endolymphatic pores on the top of a shark's head allow sea water to run through endolymphatic ducts and are the only external evidence of its ears.
- Sharks are very sensitive to low frequency sounds. Bass vibrations travel further and better underwater, so sharks can hear well in the deep, dark sea.
- The ear is also involved in balance and equilibrium. Dual hearing and balancing functionality, combined with the lateral line system gives the shark great directional hearing. These systems working together are called the acoustico-lateralis system.



...BUT WAIT, THERE'S MORE!

PRESSURE

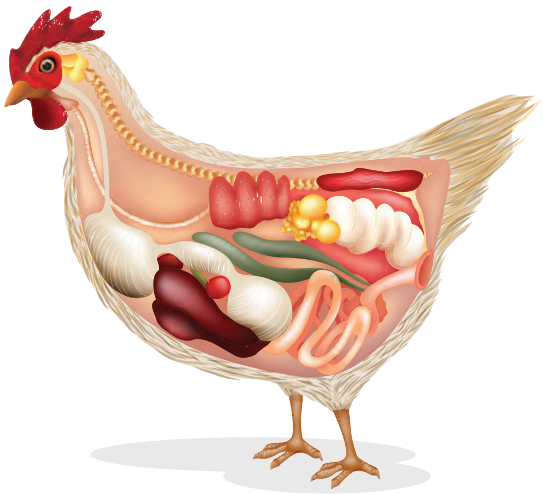
- Sharks have rows of small pores that run from tip to tail. As objects move in water and change the flow, these pores detect those water pressure changes. A shark can also detect how far it is away from objects based on the water pressure changes of its own movement bouncing back to the pores.
- Locate the Lateral Line.
- What other animal creates "waves" that bounce off objects and return to help them recognize location?
- Have you ever felt the pressure of something that isn't directly touching you?

ELECTRORECEPTION

- Similar to birds, sharks migrate far distances based on the earth's geomagnetic fields. They can even detect tiny electric fields in muscles given off by their prey during an attack.
- The **patches of pores** on a shark's head in the areas of the eyes, snout and nostrils are the openings of the **Ampullae of Lorenzini**.
- Why would Ampullae of Lorenzini be important in a fight?
- Rub your hands together quickly until they are warm. Close your eyes and pretend you're holding a ball. Squeeze the ball. Can you feel the energy of your hands getting closer together?

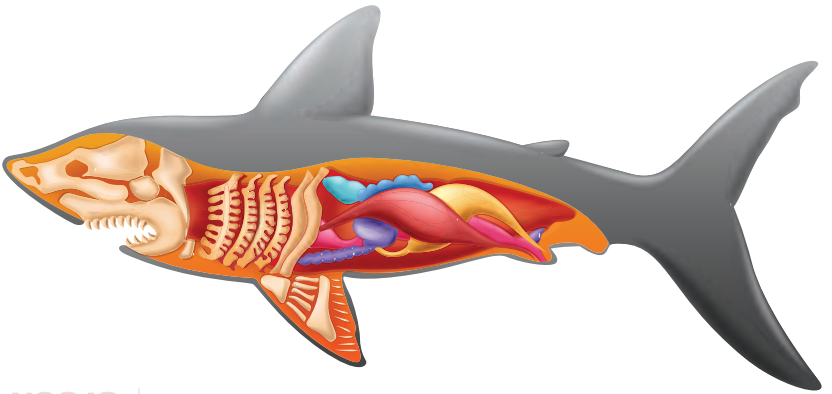
REPRODUCTION

- **Sharks are unique when it comes to reproduction** and exhibit a great diversity in reproductive modes. There are both an oviparous (egg-laying) species and viviparous (live-bearing) species. Because of this, **the shark shares a similar structure with other egg laying creatures like** birds, reptiles, amphibians, most fish and monotremes.
- A **cloaca** is a common cavity at the end of the digestive tract for the release of both excretory and genital products in vertebrates and certain invertebrates.



RESPIRATION

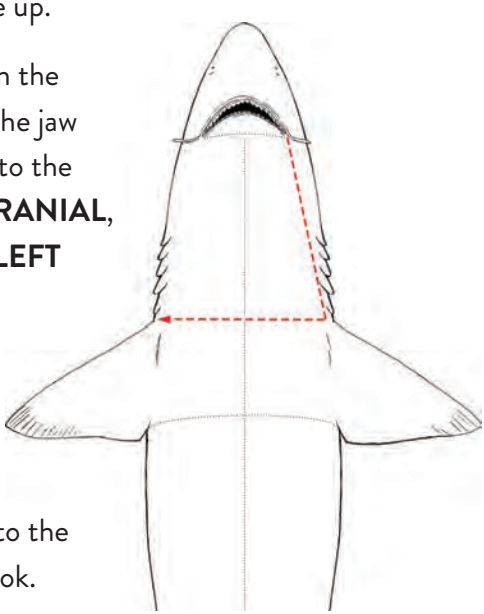
- Like other fish, **sharks "breathe"** through their gills which are respiratory organs similar to our lungs. As water passes over the gill membranes, tiny blood vessels extract oxygen from the water. Most sharks need to keep swimming to allow the water to circulate over the gills just so they can breathe.
- Locate your shark's **gill slits** as well as two large openings that are posterior and dorsal to the eyes called **spiracles**. Water taken in by the mouth and spiracles (incurrent water passageways leading into the mouth for respiration) is passed over the internal gills and forced out by way of the gill slits.
- Most fish only have one gill opening. How many does your shark have?
- While most sharks need to keep swimming to stay alive, others have developed strong cheek muscles and spiracles to pump water over their gills—allowing them to breathe while resting on the ocean bottom.

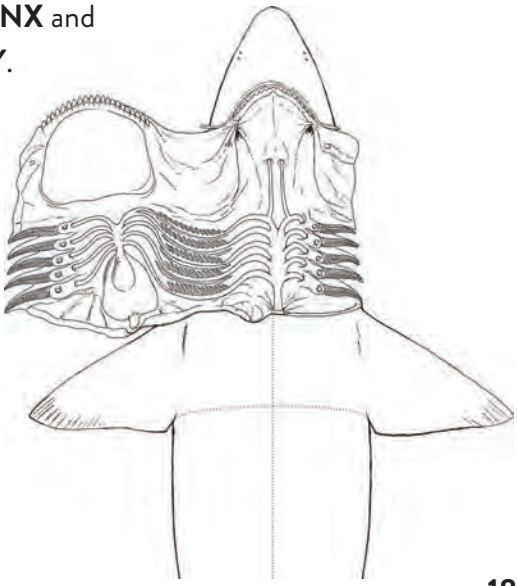


INTERNAL EXAMINATION

Read and listen carefully for instructions.

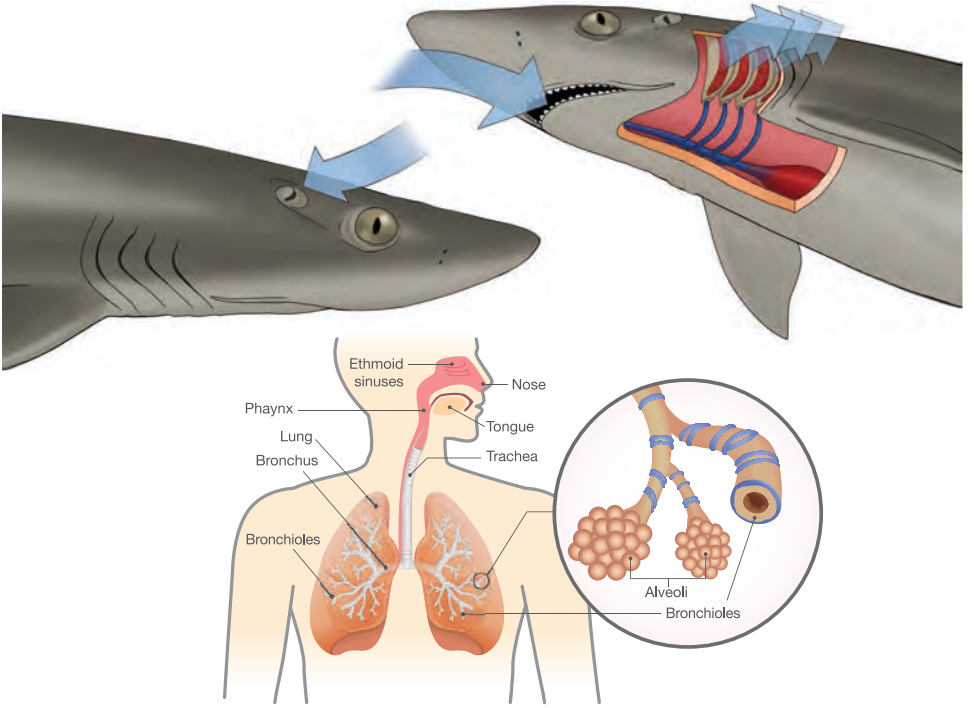
1. Place your shark ventral side up.
2. Using your scissors, cut from the **LEFT LATERAL** corner of the jaw **CAUDALLY** and **MEDIAL** to the gills stopping at the most **CRANIAL**, **PROXIMAL** corner of the **LEFT** pectoral fin.
3. Make a **TRANSVERSE** cut to the same location on the opposite Pectoral fin.
4. Reflect the **VENTRAL** jaw to the right, **LATERALLY** like a book.
5. This exposes the **PHARYNX** and **PERICARDIAL CAVITY**.





CIRCULATION

- Can you find the lungs?
- Gas exchange into the blood happens in air sacs called alveoli in human lungs and the lamellae in the gill filaments of sharks.



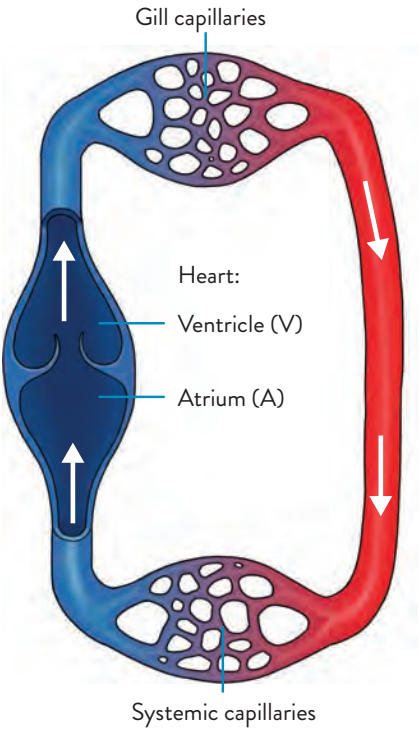
The gills are provided with a rich blood supply. Arteries run directly from the nearby heart to the gills bringing deoxygenated blood into the gills. Oxygen diffuses from the ventilating water current flowing over the gills into the blood.

CIRCULATORY SYSTEM

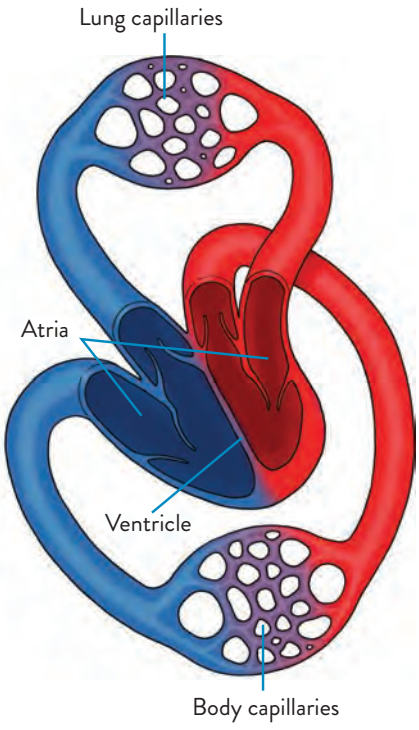
- Like humans, sharks need blood to pick up oxygen and nutrients to deliver to all parts of the body. Of all species of fish, a shark's blood is the most similar to humans. Sharks and humans have **"closed" circulatory systems** using less blood and delivering it faster which means better nutrient delivery to far parts of the body.
- Would a small or large animal need a closed system?
- In general, blood flows away from the heart through arteries and returns to the heart through the veins.
- Sharks have a blood collecting area leading into the heart called a **Sinus Venosus** and funnel shaped outlet called the **Conus Arterisus**.
- Sharks have a two-chambered **"s-shaped heart"** with an atrium (also called the auricle) and a ventricle. The blood is pumped by the **heart** through the afferent branchial arteries (ventral aorta) to capillaries in the gills, where the blood is oxygenated.
- Hearts with chambers support unidirectional flow, meaning the blood always goes around the "track" one way, but fast!
- What does the size of the heart tell you about a shark's activity level?
- Can you see the blood vessels coming out of the heart?
- Can you see the small blood vessels on the surface of the heart? If these get clogged, we say someone is having a what?

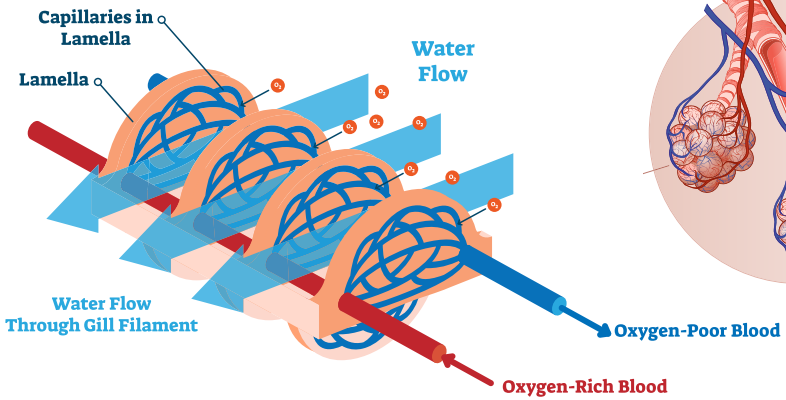
COMPARING CIRCULATORY SYSTEMS

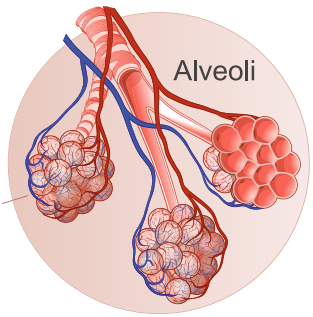
SHARK



HUMAN



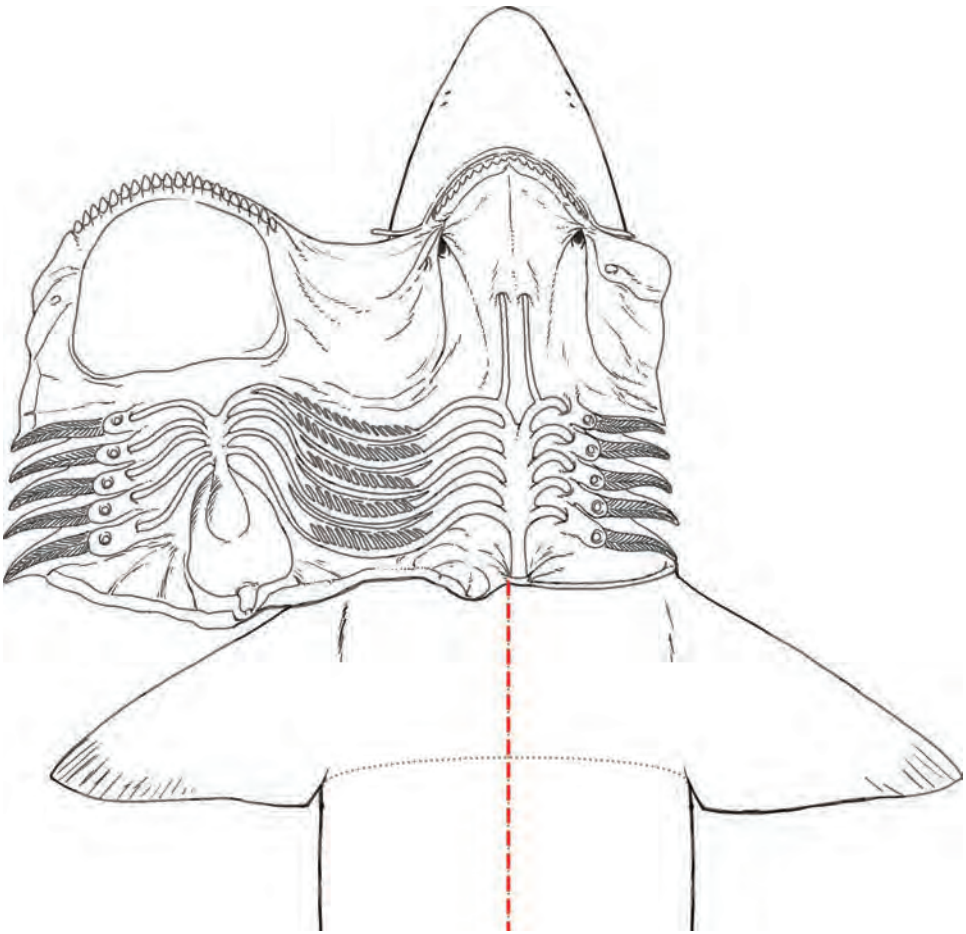




BLOOD FLOW

Can you follow the blood flow by labeling each structure on the diagram below?

A. Sinus venosus
B. Heart atrium
C. Heart ventricle
D. Conus arterious
E. Ventral aorta
F. Afferent branchial arteries
G. Right gills
H. Efferent branchial arteries
I. Dorsal aorta

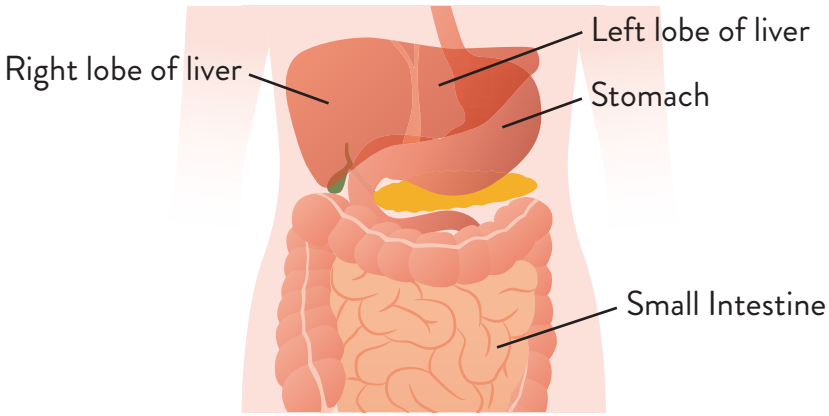


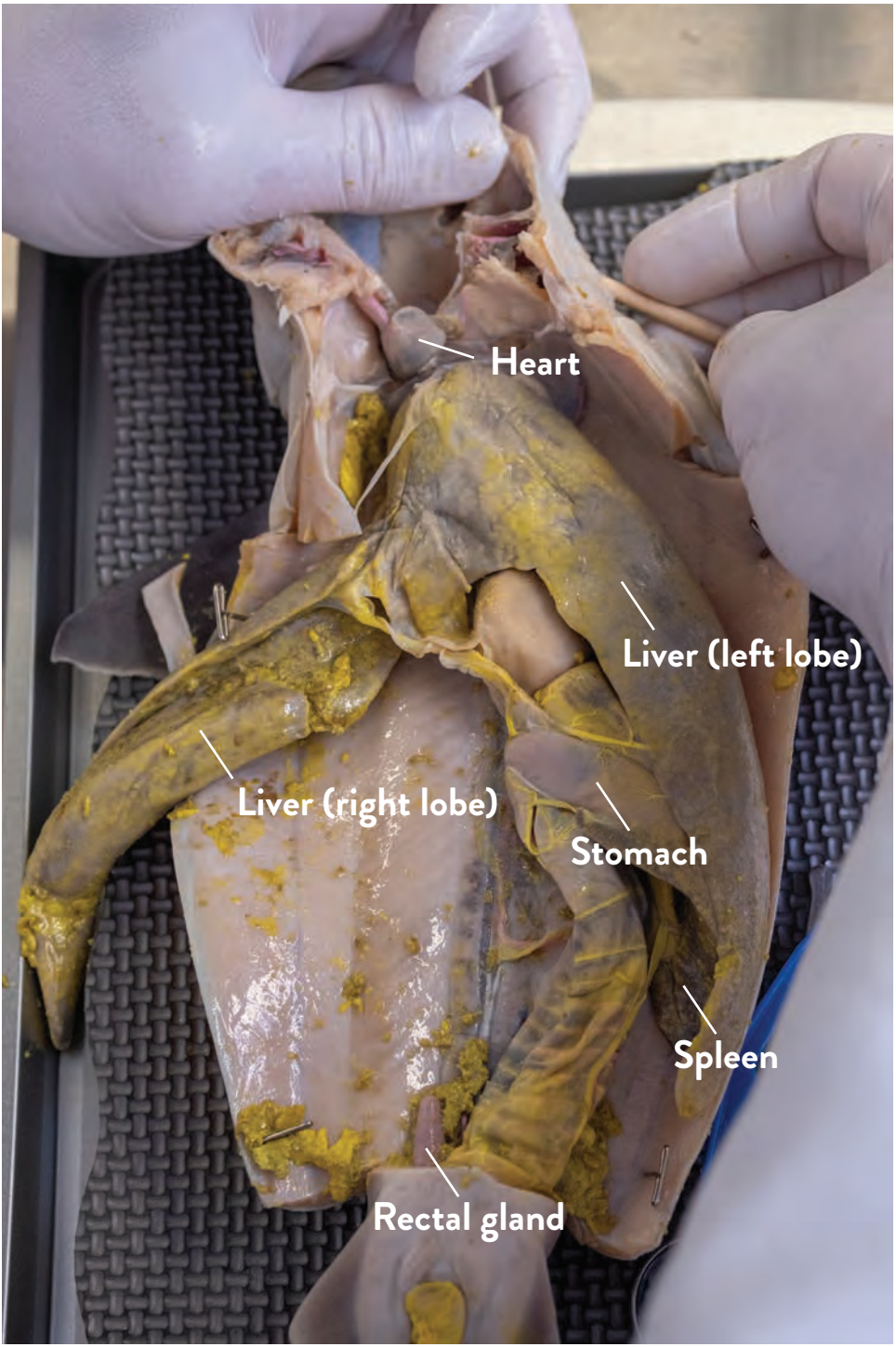
DIGESTIVE SYSTEM

- Sharks are carnivores, meaning they live to eat meat. The digestive system of a shark has two openings: the mouth and the anus, making the alimentary canal like a one-way tube allowing food to pass through and get broken down by chemical and mechanical processes along the way. Generally, carnivores like sharks have shorter intestines compared to herbivores. Sharks have spiral valves, which increase the surface area of the intestine, saving time on the digestive process.
- Locate the shark's **mouth** and look inside.

- Feel their teeth, including their orientation, number, etc. Using your forceps, pry the mouth open to observe the teeth. Since sharks swallow food as a whole or as large pieces, very little physical digestion happens in the mouth.
- How might multiple rows of teeth help this? How many rows of teeth can you see?

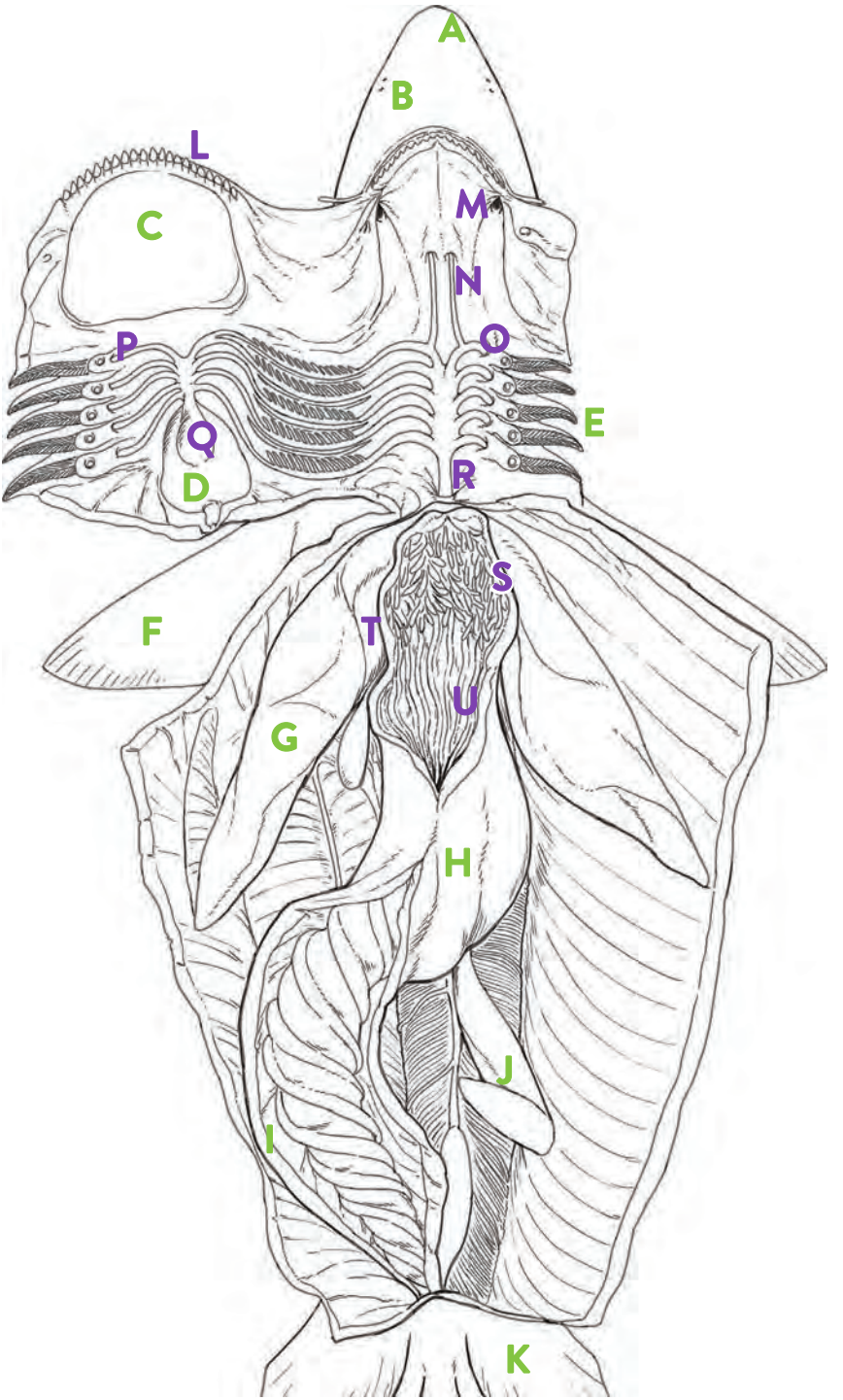
- Do you notice anything strange about the movement of the rows?
- Touch the tongue. Using the blunt side of your probe, wiggle it into the shark's mouth until you see it moving along a tube in the chest. Do you know what this tube is?
- The liver is its **largest** organ lying just within the body cavity. Move the liver to the side so that you can see the stomach and other organs more clearly.
- Locate your shark's stomach and cut it open. Did you find anything?
- Measure the stomach.
- How would you describe the wall of the stomach?
- Why do you think the stomach is this length and oriented so differently from that of a human's?




Heart
Liver (left lobe)
Liver (right lobe)
Stomach
Spleen
Rectal gland

DIGESTIVE TRACT

- Continue past the stomach into the intestines. You might need to move the liver again to do this.
- Pull the intestine forward so that you can view the colon, which is the narrowed continuation of the intestine. It is located at the posterior end of the body cavity. The intestine is relatively short because meat is easier to digest than plants.
- Cut the intestine open.
- There is a "spiral valve" in the intestine, which is "screw-like and symmetrical shaped."
- What do you think adding more intestinal surface with a spiral valve does for digestion?
- The rectal gland is a slender, blind-ended, finger-like structure that leads into the colon by means of a duct. A rectal gland is a special feature in sharks that regulates the shark's salt balance by excreting sodium chloride behind the spiral fold.
- Relocate the shark's **liver**. Its two main lobes, the right and left, extend from the pectoral girdle posterior to most of the length of the cavity. A third, much shorter lobe is located medially and contains the green **gall bladder** along its right edge.
- Follow the bile duct. Where does it go?
- Remove the liver, pancreas, and spleen to reveal the urogenital structures: gonads (testes or ovaries) and kidneys.


A
B
L
C
M
N
P
O
E
Q
D
R
S
F
T
U
G
H
J
I
K

LABEL

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

H. _____

I. _____

J. _____

K. _____

L. _____

M. _____

N. _____

O. _____

P. _____

Q. _____

R. _____

S. _____

T. _____

U. _____

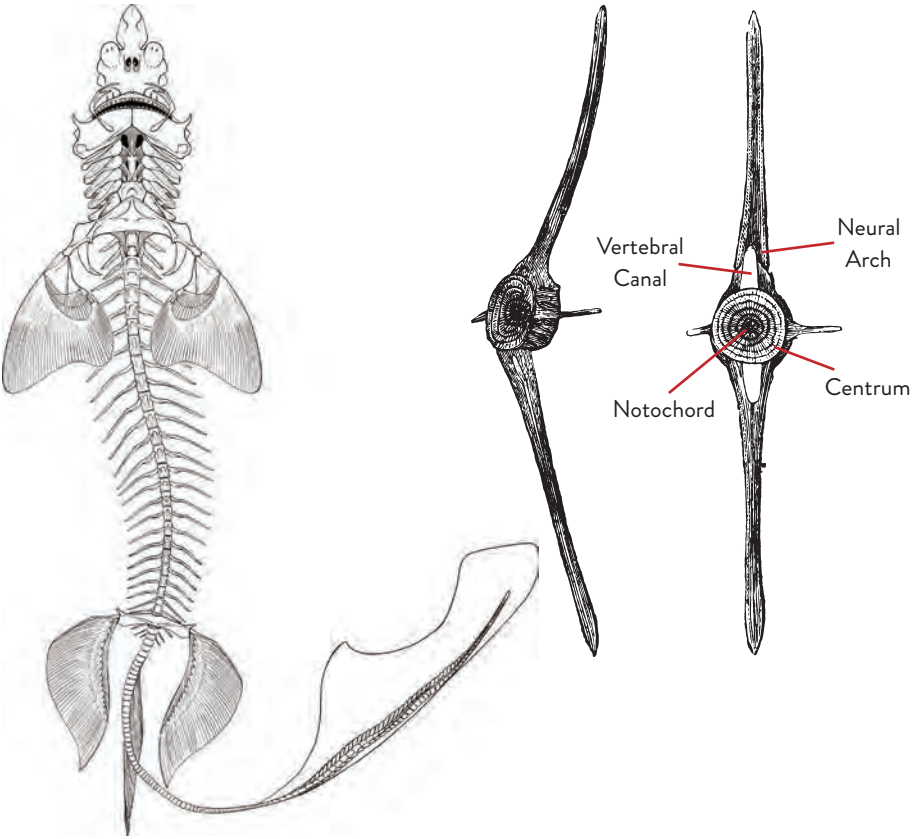
V. _____

W. _____

NERVOUS SYSTEM, PART 2

The spinal cord sends sensory signals to the brain to understand the world outside. It also sends signals from the brain to muscles to respond to the environment. Observe the cut tail on your shark.

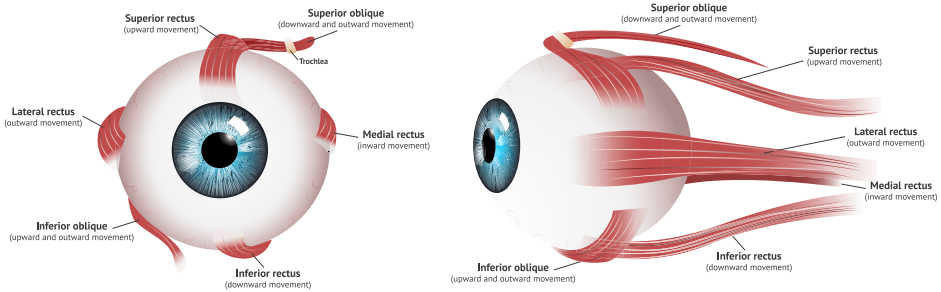
In the center of the tail you can see a caudal vertebra with the spinal cord, centrum and the hemal canal. The lower caudal vein has some red latex that partially covers it as a result of cutting the tail.



INVESTIGATING THE EYEBALL

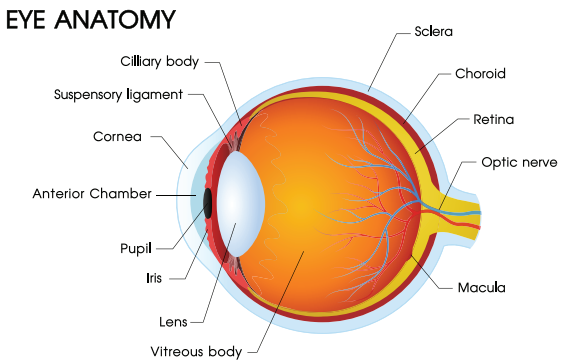
The eye is probably one of the most precise muscular systems in the body. Small movements make an enormous change in what you see. Each eye has to work perfectly in sync with the other otherwise you will see two different images. Can you figure out how each muscle moves the eye?

Muscles of the Human Eye



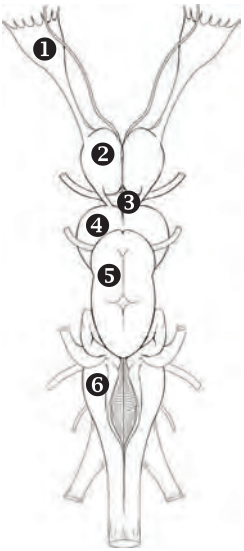
Follow the path of an image from the front of the eye to the back.

1. Cornea
2. Pupil
3. Lens
4. Vitreous body
5. Retina
6. Tapetum lucidum
7. Optic nerve
8. Brain



NERVOUS SYSTEM, PART 2

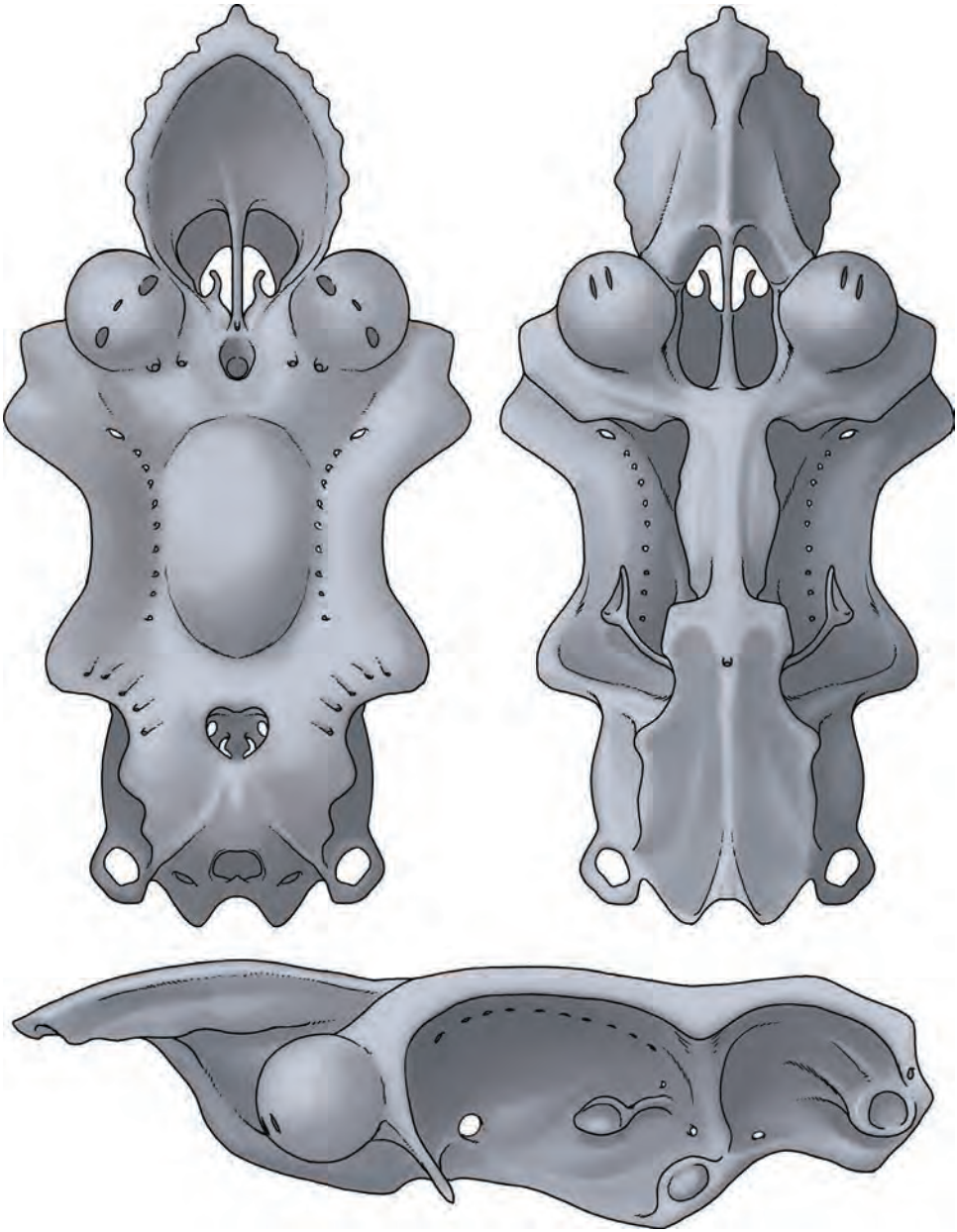
- Although the shark's skull is not made of bone, it is still quite hard and cutting open the skull may require a scalpel. Some scissors may be able to cut the skull, but be careful when holding the head down so that your fingers are always behind the blade.
- A shark's brain to body mass ratio is higher than most other fish and is comparable to many other vertebrates, including some mammals.
- The cerebellum is in charge of body movement; the hindbrain processes most sensory information and moves the head; the tectum integrates sensory information; the olfactory lobes are for the sense of smell; the diencephalon regulates hormones and some behaviors; the forebrain coordinates sensory information.



THE SHARK BRAIN

1.
2.
3.
4.
5.
6.

CHONDRACRANIUM



ANALYSIS & CONCLUSION QUESTIONS:

1. List three traits the human and shark share.

2. List three traits/characteristics that were different between the human and the shark.

3. What type of scales does the shark have?

4. What is the purpose of the claspers and cloaca?

5. How does a shark maintain buoyancy?

6. What is the purpose of the caudal fin?

7. How many gill slits did your shark have?

8. What purpose do the pectoral and pelvic fins serve in the shark?

9. What is the function of the Ampullae of Lorenzini?

10. What features made the digestive system different from yours?

COMPARING SYSTEMS

Integumentary system

Same _____

Different _____

Musculoskeletal system

Same _____

Different _____

Nervous system

Same _____

Different _____

Reproductive system

Same _____

Different _____

Respiratory system

Same _____

Different _____

Cardiovascular system

Same _____

Different _____

Digestive system

Same _____

Different _____

NECROPSY REPORT

Dissection results: What did you learn?

MEDICAL EXAMINER REPORT

Victim Name: _____ Medical Examiner(s): _____

Case #: _____ Date of Birth: _____ Date of Death: _____ Age: _____

Race/Species: _____ Sex: _____ Date/Time of Exam:_____

Reason for Autopsy: _____

Victim identification

- Group _____
- Species _____
- Unique features _____

CLEAN UP

Wrap up your shark and throw it away in the garbage bag provided with your kit. Wash off and dry all dissecting equipment and return items to storage. Dispose of your gloves and gown.

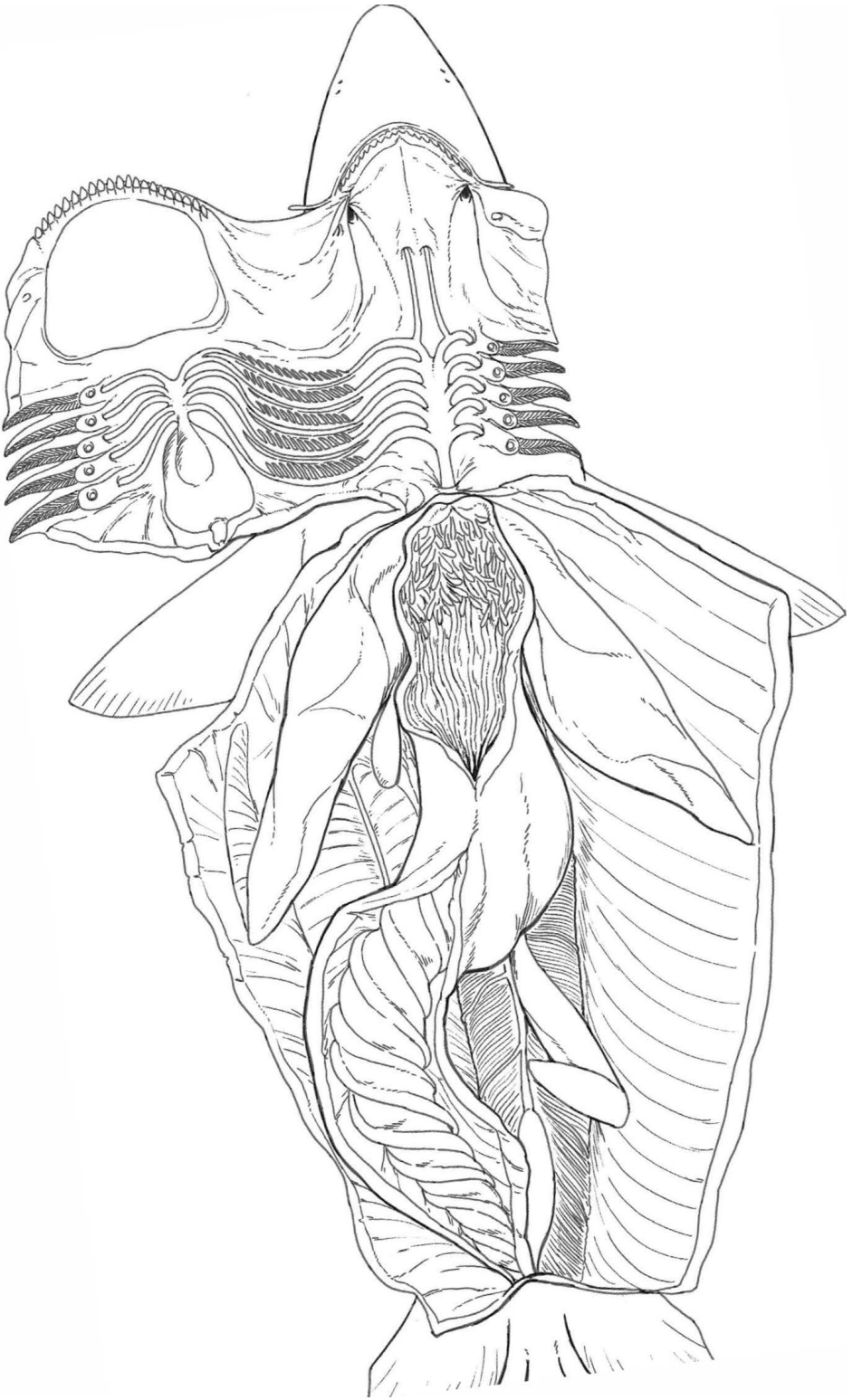
WASH YOUR HANDS WITH SOAP!

EXTERNAL CHARACTERISTICS

- Weight _____
- Length _____
- Circumference _____
- Color _____
- Unique features _____

INTERNAL EXAMINATION

ORGAN	WEIGHT (g)	LENGTH (cm)
Heart		
Lungs		
Liver		
Pancreas		
Spleen		
Kidneys		
ORGAN	**WEIGHT (g)**	**LENGTH (cm)**
Small intestine		
Large intestine		
Stomach		
Gall bladder		



LOOKING FOR MORE JUMP STEAM OPPORTUNITIES FOR HOME?

About Me App

Rube-E App

Go to **jumpsimulation.org/PNC** to learn more about STEAM education and order a copy of the Jump Simulation PNC "About Me" Activity Book and app.

The "About Me" Activity Book and app are interactive tools that give kids the opportunity to learn about the body by coloring 3D models that pop off the page, defend against invading germs in a short video game and watch fun videos! The Rube-E Educational app allows young people to better understand their bodies as they build a 3D Rube Goldberg machine using augmented reality elements.

ABOUT JUMP STEAM

Jump Simulation created its STEAM program to spark the curiosity of our youth in health care careers. Designed to give middle and high school students hands-on opportunities, Jump STEAM offers experiences in everything from learning what it takes to be a doctor to understanding how engineers are working with clinicians to transform health care. Learn more and sign your kids up at **jumpsimulation.org/STEAM**

OSF HEALTHCARE

jump | SIMULATION

THE UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE
PEORIA CHICAGO ROCKFORD URBANA

Made possible through the generous support of PNC