Name _____

Date _____

Dogfish Shark Dissection

Introduction

During this activity you will observe and dissect a shark to develop a better understanding of vertebrate anatomy. The dogfish shark is an excellent model organism for comparative vertebrate anatomy due to its size and availability. Studying dogfish anatomy also helps provide some insight into vertebrate evolution and classification. As you proceed through this investigation, you will be asked to consider how the form of a particular structure fits its function. Correlating structure and function is an underlying theme in all anatomical studies.

Background

Squalus acanthias is one of the most common types of migratory sharks, the spiny dogfish. Dogfish travel in large schools, often composed of individuals of the same size and sex. Dogfish may live up to 30 years. They reach sexual maturity at about 6–12 years. Dogfish eat a variety of small fish and marine animals such as squid, shrimp, crabs, and octopus. They are eaten by larger fish (especially other sharks) and by marine mammals such as seals and killer whales. While the name "spiny dogfish" seems ominous, this shark poses little threat to humans. A poisonous spine located on the dorsal fin is used for protection against predators. The dogfish shark is often seen as a nuisance to fisherman as these animals shred through fishing nets to reach their food. Another interesting feature of the dogfish is its lengthy gestation period, up to 2 years!

Name _____

Date _____

Pre-Lab Observation Sheet

Part 1. Directional Terms and Body Planes

Review the following directional terms and body planes. Write a definition for each term. Then, label the directional terms and planes on the dogfish illustration. Items marked with an asterisk (*) are not in the illustration.

Direction	Definition
Lateral –	
Medial –	
Proximal* –	
Distal* –	
Dorsal –	
Ventral –	
Anterior (cranial) –	
Posterior (caudal) –	
Superficial* –	
Deep* –	

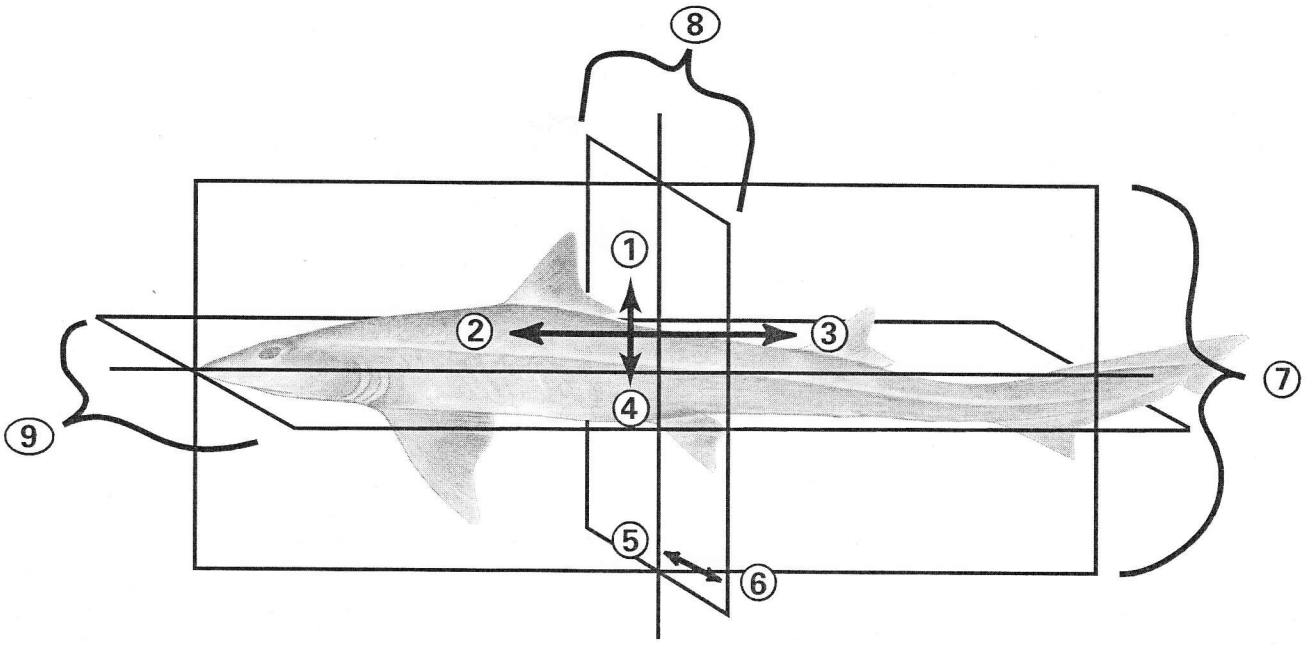
Plane	Definition
Sagittal plane* –	
Midsagittal plane –	
Transverse plane –	
Frontal plane –	

Name _____

Date _____

Pre-Lab Observation Sheet (cont.)

Orientation of Body Planes and Directions



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____ plane
8. _____ plane
9. _____ plane

Name _____

Date _____

Pre-Lab Observation Sheet (cont.)

Part 2. Characteristics of the Dogfish Shark

1. What have you learned about the dogfish shark in terms of physical characteristics, range, habitat, behavior, reproduction, and food habits.

2. Why is the dogfish a good choice for study and dissection?

3. What are three questions you have concerning the dogfish shark that can be answered only through dissection?

Name _____

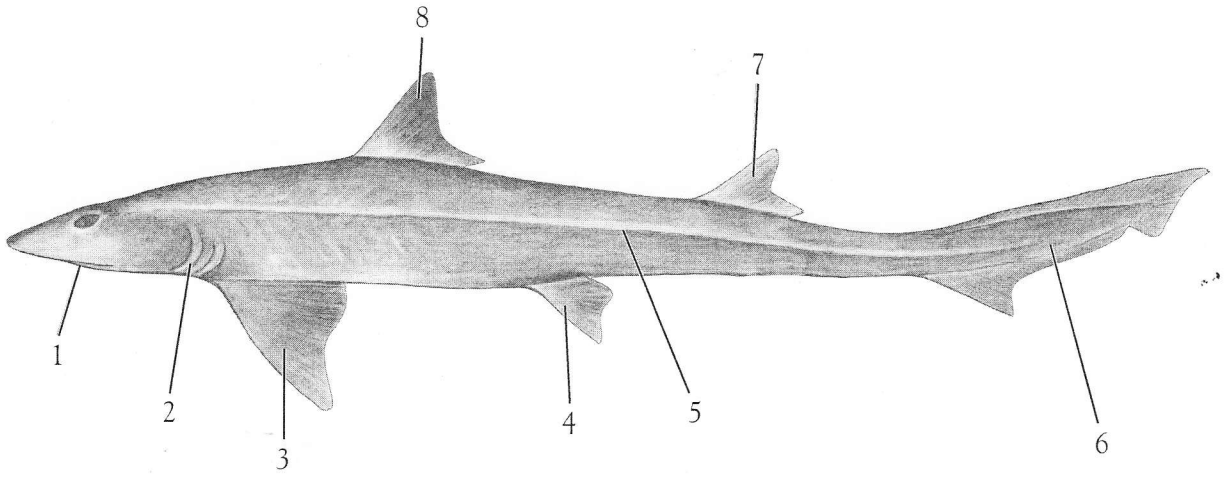
Date _____

Procedure

This dissection procedure is divided into several parts, each part addressing a different body system. Before you begin this dissection, read the entire procedure carefully. As you follow the step-by step instructions, any observations and answers should be recorded on the Dogfish Disection Observation Sheet provided by your instructor. Use the diagrams to reconcile what you have learned from the procedure. And remember—form fits function.

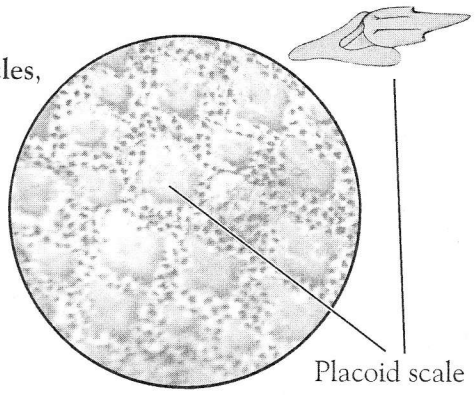
Part I. External Anatomy

1. The spiny dogfish shark is an agile swimmer with a long, streamlined body. It possesses a **caudal fin**, two single **dorsal fins**, one pair of **pelvic fins**, and one pair of **pectoral fins**. Refer to the figure below to locate each type of fin on your specimen. Pay particular attention to the large poison-secreting spine that precedes each dorsal fin and the asymmetrical shape of the caudal fin. Based on the shape and location of each fin, what type of function, or movement, do you think it might provide the shark? Record your ideas on the Observation Sheet.



1. Mouth
2. Gill slits
3. Pectoral fin
4. Pelvic fin
5. Lateral line
6. Caudal fin
7. Posterior dorsal fin
8. Anterior dorsal fin

2. The skin is covered by tiny **placoid scales**, or **dermal denticles**, with sharp spines that project posteriorly. You can run your hand over the shark's body from tail to head to feel this rough texture. Run your hand in the opposite direction and it feels smooth. Amazingly, these scales are considered modifications of teeth and consist of enamel and dentin. What benefit might the configuration of these scales have to a shark's swimming ability? Record your answer on the Observation Sheet.



4× magnification

3. Locate the narrow horizontal stripe along each side of the body of your shark. This interesting characteristic common to all fish is called the **lateral line system**. Using your hand lens, observe the small pores found along this line. They are openings that lead to sensitive nerve receptors below the skin. What purpose might this lateral line system have to a fish, especially in murky waters? Record your thoughts on the Observation Sheet.

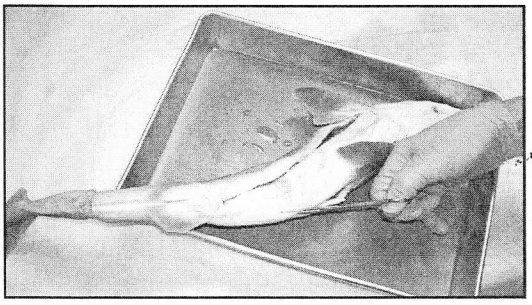
4. Examine the head of your specimen. The pointed snout is called the **rostrum**. On the underside of the rostrum, the **nares,** or nostrils, allow water in to moisten the olfactory sensory cells and permit the shark to detect odors in the environment. The **eyes** are very similar to human eyes, with an iris, pupil, cornea, and conjunctiva. Just behind the eyes, locate two tiny pores. These openings lead deep within the braincase to the inner ear, the organ of equilibrium. How does the tapered rostrum benefit the shark? Record your ideas on the Observation Sheet.

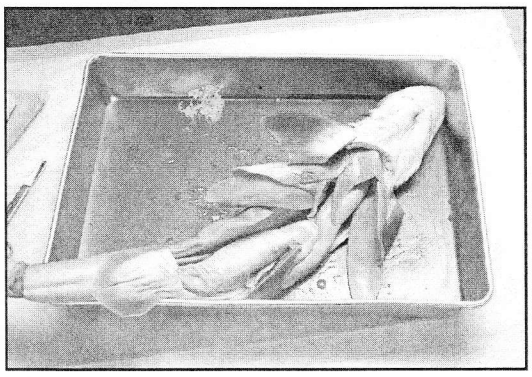
5. Next locate the large openings called the **spiracles**, which serve as passageways for water into the mouth. This makes it possible for water to be brought in to the **gills** for respiration when the mouth is closed. How would this benefit a bottom-dwelling shark or ray? Record your ideas on the Observation Sheet.

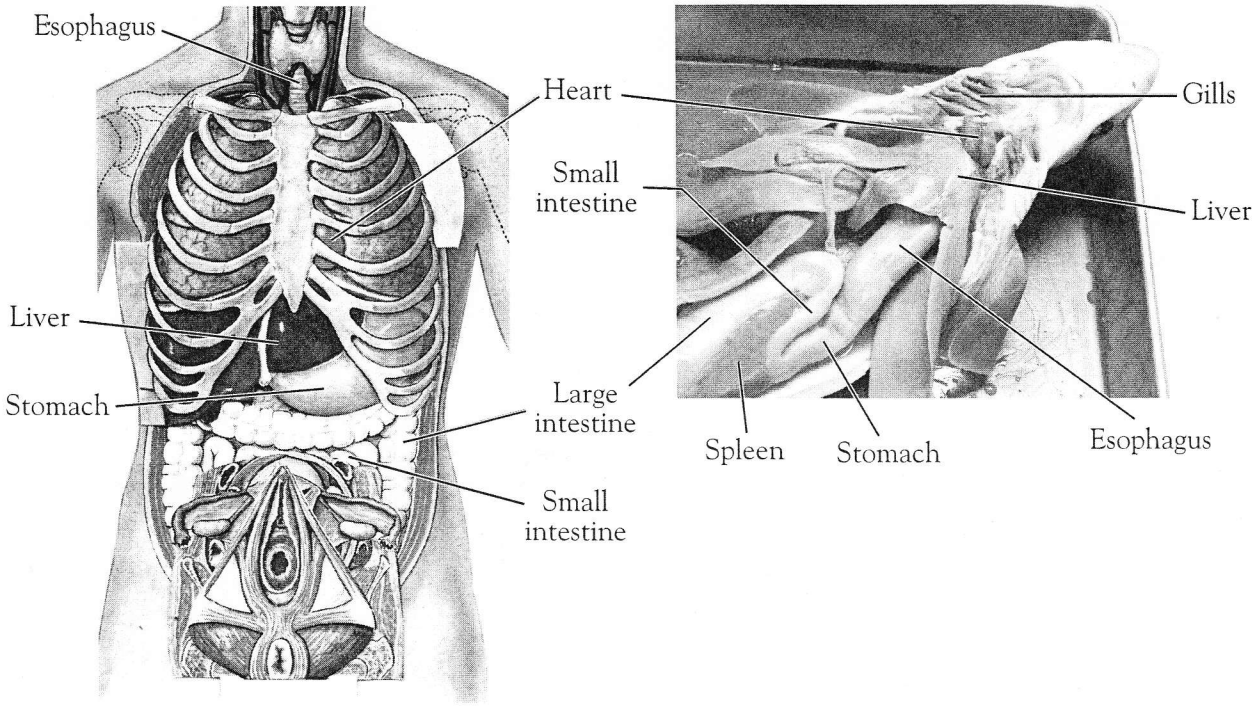
6. Determine the sex of your specimen. Use the diagrams below to compare male and female sharks. The male specimen has a noticeable finger-like structure called a **clasper** on the medial side of each pelvic fin. During copulation, the clasper is inserted into the female for transfer of sperm. Record the sex of your specimen on the Observation Sheet.

Part II. Internal Anatomy

7. Place the dogfish on the dissecting tray with the ventral side facing up. Using a scalpel, make an incision just anterior to the pelvic fins. Because the skin is tough, you may need to use scissors to cut through the body wall from the pelvic fins anteriorly to the right pectoral fin. Make an incision at the base of the left pectoral fin and cut carefully through the body wall back to the **pelvic girdle**. Then, make a transverse incision across the **pelvic girdle** (from the right pectoral fin to the left pectoral fin). Continue the incision posteriorly to the pelvic fins. This incision should resemble a triangle. Remove the ventral body wall. You have now exposed the **coelom**, the large central body cavity found in all vertebrates. In the shark, it is divided into two parts: the large posterior portion called the **pleuroperitoneal cavity**, and the small anterior portion called the **pericardial cavity**, which contains the heart. How would an *air-breathing* vertebrate (such as a human) be different from the dogfish in terms of its body cavities? Refer to the following diagram, if needed, and record your ideas on the Observation Sheet.





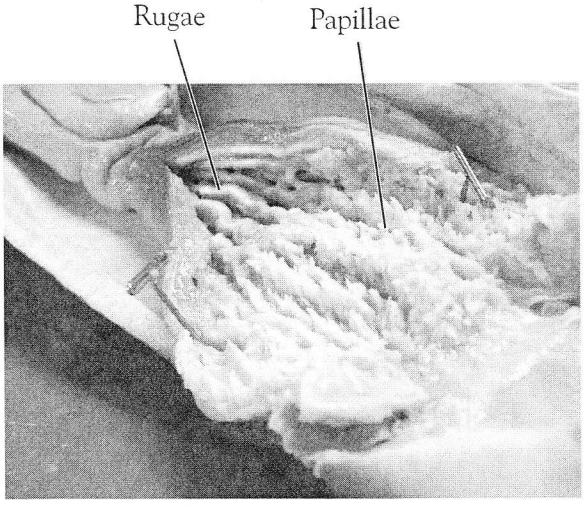


8. The most conspicuous organ in the pleuroperitoneal cavity is the **liver**. Note the elongated right and left lobes and the median lobe. In addition to producing bile and detoxifying wastes, the liver also stores energy in large amounts of oil, which can provide limited buoyancy in the absence of a swim bladder. How does the oil provide this ability? Record your answer on the Observation Sheet.

The **DIGESTIVE SYSTEM** is responsible for chemically and mechanically breaking down food into smaller compounds that can be released into the bloodstream and then transported to body cells. Let's investigate the specialized organs of this system.

9. Using the diagrams provided, locate the major organs of the digestive system, including the **esophagus**, **stomach**, **small intestine**, and **colon**. You will have to move the long liver lobes gently to the side to see the esophagus and stomach. As you locate and observe these organs, provide a detailed description (relative size, shape, color) of each on your Observation Sheet.

10. Examine the esophagus and J-shaped stomach more closely. Because it is sometimes difficult to distinguish these two organs externally, observe their internal structure. Make an incision through the ventral wall of the esophagus and extend down to the stomach. Open both organs, noting the stomach contents, if any, on your observation sheet. You may need to wash out contents to view the lining. The lining of the esophagus is covered with small, finger-like projections called **papillae**, while the stomach lining has deep folds called **rugae**. Based on your observations, which organ is more suited for mechanical digestion of food? Explain your ideas on the Observation Sheet.

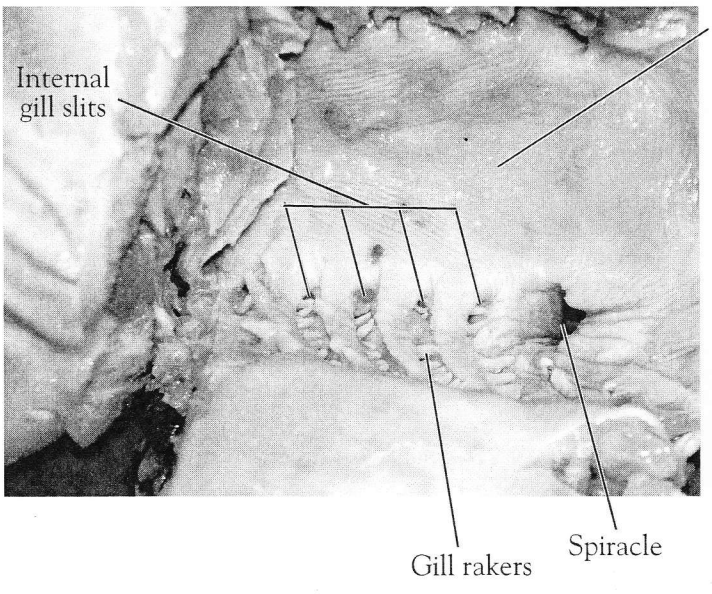


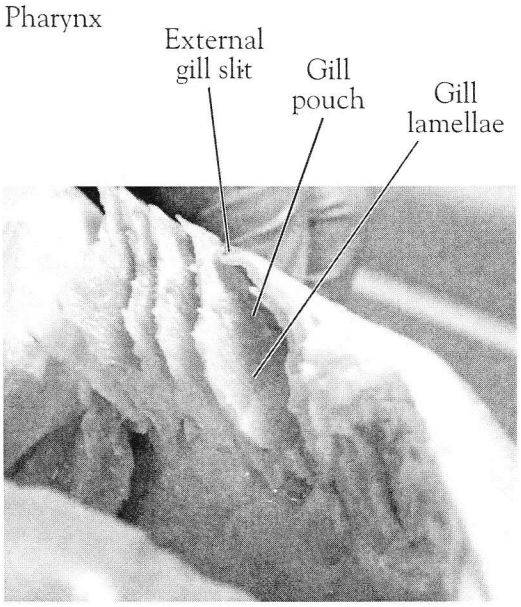
11. The contents of the stomach empty into the U-shaped **duodenum**, the first of three sections of the **small intestine**. At this point, digestive fluids are secreted into the small intestine from two important accessory organs, the **gallbladder** and the **pancreas**. Locate the gallbladder along the right edge of middle lobe of the liver. It is responsible for concentrating and storing bile that is produced by the liver. **Bile** provides for the emulsification of fats. The lightly colored pancreas can be found at the curve of the duodenum. This two-lobed glandular organ releases **pancreatic juice**, a cocktail of digestive chemicals, into the duodenum. From the duodenum, foodstuff travels to the noticeably larger **valvular intestine**, whose outer surface is marked by rings. Cut open this structure by making a shallow incision along one side. You will see something unique. In sharks, the **spiral valve** serves to increase surface area in a very short intestine. How is this increase in surface area accomplished in higher vertebrates, such as mammals? Record your answer on the Observation Sheet.

12. The **colon** is a narrowed continuation of the valvular intestine. It terminates at the **anus**, which opens into the **cloaca**. Leading into the colon, a slender, finger-like structure called the **rectal gland** excretes salt as a means of regulating excessive concentrations in the blood. Why would a shark need to regulate its salt concentrations? Record your ideas on your Observation Sheet.

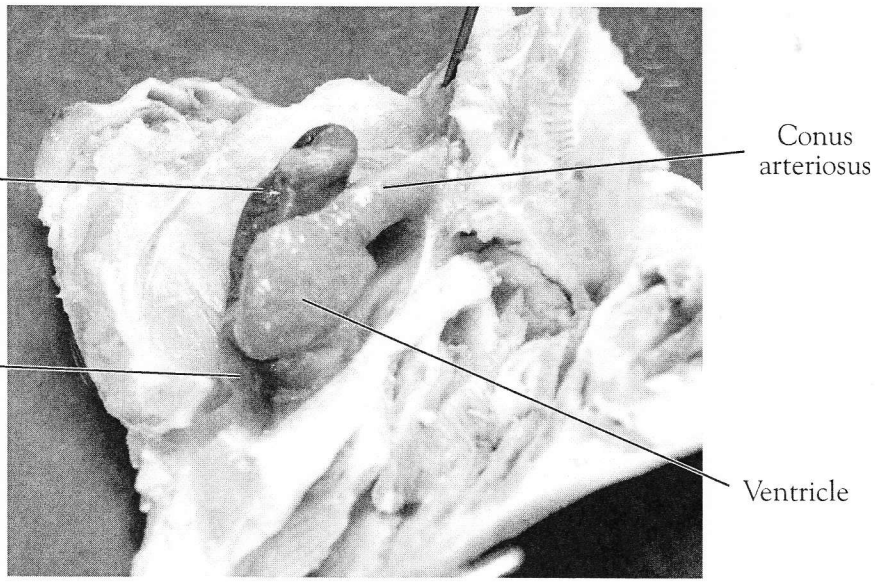
The **RESPIRATORY SYSTEM** functions in gas exchange, in which outgoing carbon dioxide waste is replaced with fresh oxygen to the bloodstream. The **CIRCULATORY SYSTEM** is responsible for the transport of respiratory gases, nutrients, hormones, defense cells, and wastes throughout the body. Dissection of the primitive shark provides an excellent opportunity to compare to more advanced vertebrates.

13. In fish, respiration occurs by the diffusion of oxygen and carbon dioxide between the water and specialized structures called **gills**. To examine these structures, insert the scissors into the right corner of your shark's mouth. Cut posteriorly through the jaws and across the external gill slits as far as the pectoral girdle. Finally, cut across the ventral muscles to open this flap along your dissection tray and secure with pins. You have exposed the **pharynx**, the muscular chamber that extends from the oral cavity to the esophagus. Along the lateral walls, locate the five pairs of **internal gill slits**. They lead to the gill pouches, which in turn lead to the **external gill slits**. The gill slits are protected by special finger-like structures called **gill rakers** that act as strainers to block food particles. Now examine the cut surfaces of the gills. These highly folded filamentous **gill lamellae** are the primary respiratory portion of the gills. Using your hand lens, carefully observe these lamellae to notice that each is covered by tiny, closely packed **secondary lamellae**. How is the structure of these gills suited to their function in respiration? Record your answer on the Observation Sheet.





14. Now examine the pericardial cavity and heart. The dogfish heart has four chambers arranged in a tube-like configuration: **sinus venosus**, **atrium**, **ventricle**, and the **conus arteriosus**. Using the diagrams provided, locate these four chambers in your specimen and trace the path of deoxygenated blood through the heart beginning with the sinus arteriosus. Unlike the heart of mammals and birds, the heart of the shark transports only deoxygenated blood. Where do you think the blood is oxygenated in the shark? Record your thoughts on the Observation Sheet.

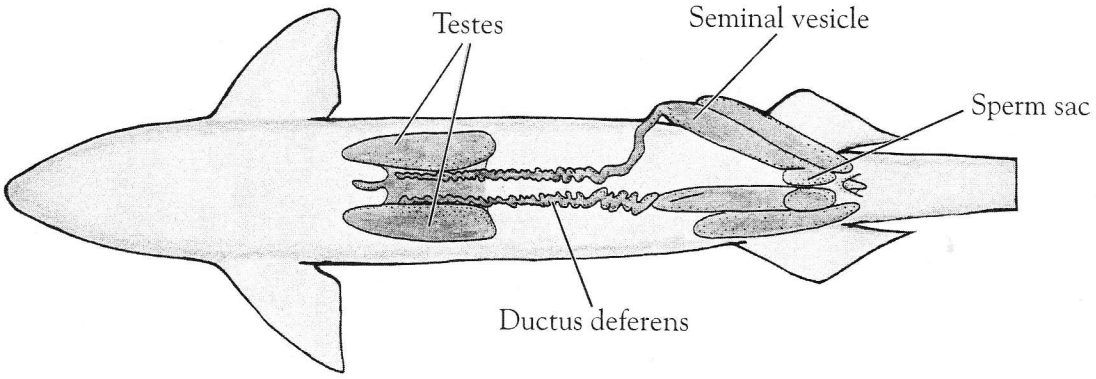


The **UROGENITAL SYSTEM** includes both reproductive and excretory organs and structures. These systems are often studied together because they share common ducts. The main purpose of the excretory organs (kidneys) is to filter nitrogenous wastes from the blood, producing urine. The reproductive organs, of course, are responsible for the production of the egg and sperm and the necessary means for the union of these two special cells.

15. Returning to the pleuroperitoneal cavity, remove the liver at its anterior end. If you have not removed it already, remove the digestive tract from the anterior end of the esophagus to the posterior end of the colon. This will reveal the slender paired kidneys in your specimen located along the dorsal wall lateral to the midline. While the kidneys are the primary organs of excretion, you will learn that they also have a reproductive role in the male shark. Considering the sex of your specimen, what specific structures do you expect to observe? Record your ideas on the Observation Sheet.

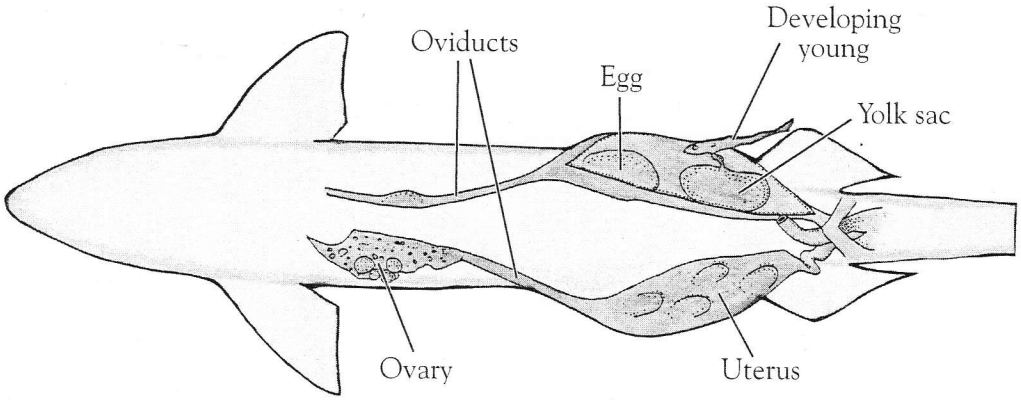
If your specimen is male, continue with step 16. If your specimen is female, skip to step 18. You will be expected to be familiar with structures of each sex, so it is important to work with another group that has a shark of the opposite sex.

16. Locate the paired **testes** adjacent to the cranial end of the kidneys. Minute ductules carry sperm produced in the testes to the anterior portion of the kidney called the **epididymis**. The sperm then travel through the **ductus deferens**, which widens into the **seminal vesicle**. In an immature specimen this tube will appear straight in comparison to the coiled tube of a mature male. The sperm-containing fluid is received by the paired **sperm sacs** (located just dorsal to the cloaca) and then passes through the cloaca to exit the body. (The cloaca is also the exit for rectal waste and urine.) Study the diagrams below that compare the shark anatomy to that of a higher vertebrate. Explain the primitive nature of the shark's urogenital system. Record your ideas on the Observation Sheet.



17. How is sperm transferred from the male to female during copulation? The previously identified **claspers** (located on the medial aspect of the pelvic fins) each have a dorsal **groove** that carries the fluid from the cloaca to the female. Also associated with the clasper is a thin-walled **siphon** that is connected to the dorsal groove just under the skin. You can make a transverse cut into the ventral surface of a pelvic fin to locate this structure. The siphons secrete a lubricating fluid for the claspers. On your Observation Sheet, trace the path of sperm from its production in the testes to its release into the female.

18. In the female, locate the large, paired **ovaries** adjacent to the anterior end of the kidneys. If your specimen is immature, these egg-producing organs will appear quite small and smooth. Use the diagram below to locate the paired **oviducts** and **uterus** in your specimen. The eggs are released from the ovary into the oviducts through a small pore called the **ostium**. (It is difficult to see in most specimens.) The egg is fertilized here, then passes through the **shell gland**, which secretes a thin membrane around the fertilized egg. From there, the egg continues down the oviduct to the uterus, where gestation occurs. As the young grow, they are attached to the nourishing yolk sac by means of a stalk. This method of development in the dogfish shark is known as *ovoviviparous*. Chickens are *oviparous*, and humans are *viviparous*. Explain the differences on your Observation Sheet.



Name _____

Date _____

Dogfish Dissection Observation Sheet

1	**fins** Based on the shape and location, what type of function or movement does each fin provide the dogfish shark?
caudal fin:	
dorsal fins:	
pelvic fins:	
pectoral fins:	
2	**placoid scales** What benefit might the configuration of the placoid scales have to a shark's swimming ability?
3	**lateral line system** What purpose might the lateral line system have to a fish, especially in murky waters?
4	**rostrum** How does the tapered rostrum benefit the shark?
5	**spiracles** How would being able to bring water in to the gills when the mouth is closed benefit a bottom-dwelling shark or ray?
6	**gender (male or female)** What gender is your specimen? ❑ Male ❑ Female

7	**body cavity** Compare the body cavity of the dogfish shark to a human. How are they different?
8	**liver oil** How does the oil from the liver provide limited buoyancy in the absence of a swim bladder?
9	**major organs of the digestive tract** Write a detailed description (relative size, shape, color) of each of the following organs:
esophagus: stomach: small intestine: colon:	
10	**esophagus and stomach linings** What are the contents of the stomach (if anything)? Compare the lining of the esophagus and the lining of the stomach. Which organ is more suited for mechanical digestion of food?
11	**spiral valve** Compare the small intestine of the dogfish shark and the small intestine of a mammal. How is the inside surface area maximized in each animal?
12	**rectal gland** Why would a shark need to regulate its internal salt concentration?

13	**gills** How is the structure of the gills suited to their function in respiration?
14	**oxygenation** Unlike the heart of mammals and birds, the heart of the shark transports only deoxygenated blood. Where do you think the blood is oxygenated in the shark?
15	**reproductive structures** Considering the sex of your specimen, what specific structures do you expect to observe?
16	**male urogenital system** Compare the shark anatomy to that of a higher vertebrate. Explain the primitive nature of the male shark's urogenital system.
17	**path of sperm** Draw a diagram or simple sketch of the path of sperm from production in the testes to its release into the female.
18	**ovoviviparous, oviparous, viviparous** Explain the differences of each method of offspring development listed below:
ovoviviparous: oviparous: viviparous:	

Name _____

Date _____

Questions

1. Discuss the hydrodynamics of the dogfish shark.

2. What are the two classes of fish? In which class is the shark?

3. Draw the digestive tract of the shark from mouth to anus. Label the structures.

4. What is the advantage of the spiral valve in the shark's intestine? How does this differ from the extremely long intestine of the human?

5. How do the gills function in respiration?

6. What advantages does a cartilaginous skeleton have over a bony skeleton?

Name _____

Date _____

Glossary

Ampullae. Sense organs that form a network of jelly-filled canals.

Anterior chamber. The fluid-filled space inside the eye between the iris and the cornea.

Anus. The opening through which solid waste is eliminated from the body.

Atrium. Either of the two upper chambers of the heart. The left atrium receives oxygenated blood into the heart via the pulmonary veins, and the right atrium receives blood from the superior and inferior vena cava.

Bile. A greenish-yellow fluid secreted from the liver that is released into the duodenum of the small intestine. Bile aids in the process of digestion.

Caudal fin. The tail fin, or main propelling fin of a fish.

Ciliary body. Thin, vascular, middle layer of the eye, located between the sclera and the retina.

Claspers. Paired male copulatory organs located on the rear base of the pelvic fins.

Cloaca. The posterior opening that serves as the opening for the intestinal, urinary, and genital tracts.

Coelom. A secondary body cavity that surrounds the digestive system.

Colon. Large intestine; functions in formation of feces from undigested remains of food through the reabsorption of water and action of intestinal bacteria.

Conjunctiva. The thin, transparent tissue that covers the outer surface of the eye.

Conus arteriosus. The cavity of the heart which begins at the supraventricular crest and ends in the pulmonary trunk.

Cornea. Transparent covering that allows light to enter the eye; in a preserved specimen, the eye is cloudy.

Dermal denticles (placoid scales). Tiny scales with sharp spines that cover the skin of the shark.

Dorsal fin. Fin located on the back of a fish.

Ductus deferens. Tube that carries sperm from the testis (via epididymis) to the urethra.

Duodenum. The first part of the small intestine, connecting the stomach to the jejunum. This is the location of further breakdown of food after breakdown in the stomach.

Epididymis. Connects the testis to the vas deferens. Also serves as a storage area for sperm produced by the testis but not yet ejaculated.

Esophagus. Muscular tube through which food passes from the pharynx to the stomach.

Gallbladder. Small sac attached to the liver; stores bile produced by the liver.

Gill arches. The bony or cartilaginous support to which gill filaments and gill rakers are attached.

Gill lamellae. An arrangement of thin plates that increase surface area for gas exchange.

Gill pouches. Area between the internal and external gill slits.

Gill rakers. Bony or cartilaginous projections that point forward and inward from the gill arches.

Gill slits. Gills with individual openings rather than an outer cover.

Gill. A highly vascular respiratory organ through which oxygen is obtained from water.

Iris. Diaphragm that regulates the size of the pupil.

Kidneys. Bean-shaped excretory organs responsible for filtering excess water and waste products from the blood.

Lateral line. Sense organ used to detect movement and vibration in the surrounding water.

Lens. Biconvex, transparent structure that focuses the light coming in through the cornea and pupil of the eye.

Liver. Accessory digestive organ with many functions, including fat digestion and storage, bile production, glucose metabolism, and detoxification; the largest visceral organ.

Nares. Nostrils. Incurrent openings for the respiratory system.

Ostium. Small pores in which eggs are fertilized and pass from the ovaries to the oviduct.

Ovaries. Female gonads. Release eggs into the fallopian tubes.

Oviducts. Fallopian tubes; passageway for egg cells from the ovaries to the uterus.

Pancreas. Accessory gland with both an endocrine portion, producing insulin and glucagon, and an exocrine portion, producing digestive enzymes.

Papillae. Small, finger-like projections covering the esophagus.

Pectoral fins. Paired fins located on each side, usually just behind the operculum.

Pectoral girdle. Portion of the appendicular skeleton supporting the forelimbs.

Pelvic fins. The most posterior paired fins of a fish, used for stability.

Pelvic girdle. Portion of the appendicular skeleton supporting the hind limbs.

Pericardium. Sac of specialized peritoneum that encloses the heart; surrounded by pericardial fluid that cushions and protects the heart.

Peritoneum. Thin membrane that lines the abdominal cavity.

Pharynx. The muscular chamber that extends from the oral cavity to the esophagus.

Placoid scales (dermal denticles). Tiny scales with sharp spines that cover the skin of the shark.

Pleuroperitoneal cavity. Larger posterior portion of the coelom.

Pupil. The opening through which light enters the eye.

Rectal gland. Salt-secreting organ that regulates salt concentrations in the shark's blood.

Retina. Light-sensitive portion of the eye, composed of receptor cells called cones and rods.

Rostrum. Structure of the anterior, ventral region of the cerebrum, extending ventrally from the genu to the septum pellucidum.

Rugae. Several longitudinal folds in the wall of the stomach that allow for expansion.

Sclera. Outer covering of the eyeball; a tough, opaque sheet of connective tissue that protects the inner structures of the eyeball and helps maintain rigidity.

Seminal vesicle. Gland located dorsal to the urinary bladder in males. This gland releases fluid that combines with sperm to make semen.

Shell gland. Gland which secretes a thin membrane around the fertilized egg.

Sinus venosus. Large chamber of the heart that receives deoxygenated blood from the body and has a valve that opens to the atrium.

Siphon. Thin-walled sac that secretes lubricating fluid for the claspers.

Sperm sacs. Sperm-collecting sacs located just above the cloaca.

Spiracle. Small opening found behind each eye; used to pump water through the gills while the animal is at rest.

Spiral valve. The lower portion of the intestine.

Spleen. An accessory organ to the circulatory system that produces lymphocytes and destroys old and defective red blood cells.

Stomach. Organ responsible for the breakdown of food into absorbable particles. Located in the digestive tract between the esophagus and the small intestine.

Testes. Organs responsible for production of sperm in males.

Urinary papilla. The external projection of the male urinary bladder.

Urogenital papilla. A small conical tube located just ahead of the anal fin.

Urogenital sinus. Cavity that surrounds both the urethral and vaginal openings.

Uterus. Female reproductive organ that holds developing fetuses.

Valvular intestine. The second, and much larger portion of the small intestine.

Ventricle. One of two lower chambers of the heart; the left ventricle forces blood into the aorta, and the right ventricle forces blood into the pulmonary arteries.

Vitreous chamber. A cavity of the eye posterior to the crystalline lens and anterior to the retina.