

Dogfish Dissection Instructions

EXTERNAL STRUCTURES

The shark's body has a gray dark dorsal side and a much lighter, almost white, ventral side. This is called counter-shading and is made possible with the distribution of pigment cells called melanophores.

Locate the lateral line system, which is a narrow, horizontal stripe extending laterally along the sides of the body. Nerve receptors called **neuromasts** run along a lateral line canal and carry impulses to the central nervous system. These receptors, found only in fish and some aquatic amphibians, sense vibrations in the water.

There are patches of pores on the head in the areas of the eyes, snout, and nostrils. These are the openings of the **ampullae of Lorenzini**, sense organs which are sensitive to changes in temperature, water pressure, electrical fields, and salinity.

Dorsal fins – Dogfish possess two dorsal fins, each having an anterior spine. When captured, these sharks will arch their backs and attempt to pierce their captor with these long sharp spines. Besides the puncture wounds these can inflict, the spines also carry a poison secreted by glands at their base. The spines are clipped by the company that prepares the sharks.

Caudal Fin (Tail Fin) - The primary forward thrust for all fish is achieved by the movement of the caudal fin. This fin is divided into two lobes; a larger dorsal lobe, and a smaller ventral lobe. This type of tail is known as a heterocercal tail and creates a forward, downward thrust. Other fish have a tail fin in which the lobes are symmetrical and fan-shaped (homocercal). This type of tail is built for moving straight forward and speed.

Pectoral Fins - The paired pectoral fins located posterior and ventral to the gill slits act to deflect water downward and provide the lift needed to keep the shark moving in a horizontal direction.

Pelvic Fins - Paired ventral fins located on either side of the cloacal opening. These fins are used for balance and are different for male and female sharks. Males have **claspers**, which are stout, grooved copulatory structures. Fertilization is internal and occurs when seminal fluid is transferred from a male's clasper after being inserted into the cloacal opening of the female. Female sharks do not have claspers.

Cloacal opening – The opening located on the ventral surface between the pelvic fins, where all the products of the digestive, excretory and reproductive systems exit to the outside. In higher vertebrates (such as mammals), separate areas and openings exist for these systems.

Rostrum - The pointed snout at the anterior end. This streamlined, tapered tip at the anterior end helps overcome water resistance in swimming.

Buccal cavity - Another name for the mouth. The mouth/jaws of most sharks are found on the underside of the snout.

Nares (nostrils) - These openings, located on the underside of the rostrum are used to draw water into the shark for smell. Water is taken in through the small openings, passes over and moistens the sensory cells of the olfactory sac, permitting the shark to detect smells. Water is then expelled through the larger openings. The sharks' ability to smell is legendary in the animal kingdom.

Spiracles –The large openings posterior and dorsal to the eyes. The spiracles serve as an incurrent water passage leading to the gills. Water can be brought in for respiration even when the shark's mouth is closed or when feeding. The **spiracle valve** opens and closes the spiracle.

Gills and gill slits – Most sharks have five external gill slits. Water taken in by the mouth is passed over the internal gills where oxygen and carbon dioxide is exchanged. Water is then forced out through the gill slits.

Sharks have a basic vertebrate eye, but it is laterally compressed and is a prominent feature in sharks. A transparent **cornea** acts as a window that controls and focuses the entry of light into the eye. A darkly pigmented **iris** with a **pupil** in the center regulates the amount of light entering the eye. The **lens** is used to focus images. Each eye has a **retina** containing rods (light intensity sensors) and cones (color sensors). Sharks possess excellent vision in low light conditions. The structure in the eye responsible for this is called the **tapetum lucidum**. This is a layer composed of mirrored crystals which lay behind the retina that can be adjusted to reflect light back onto the retina amplifying the strength of the image. Upper and lower eyelids protect the eye. Just inside the lower lid you can see the **nictitating membrane**. It extends over the surface of the eye to cover and protect the cornea. Some sharks have a nictitating membrane while others do not. The **vitreous chamber** is a gelatinous, transparent semi-solid structure that makes up the main cavity of the eye. It gives shape to the eyeball and prevents it from collapsing.

MUSCULAR ANATOMY

Cut away a two-inch piece of skin off the thickest part of the tail (you are cutting through the skin only). Working with a dull probe or the handles of your scissors carefully peel off the skin exposing the underlying muscles.

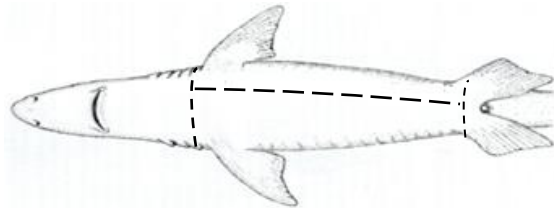
Examine the skin using a magnifying glass or microscope. The scales you see are modifications of teeth called **placoid scales**. Because their structure and mode of development are similar to the teeth of higher vertebrates, they are also called **dermal denticles**.

The muscles revealed by skinning the side of the shark are arranged in W-shaped bundles called **myomeres**. The myomeres are separated from one another by connective tissue. Contractions of the myomeres produce the side to side motion of the caudal fin that propels the shark forward.

PLEUROPERITONEAL CAVITY (main body cavity)

Place your shark ventral side up on the dissection tray. Using scissors make a mid-ventral incision just anterior to the cloacal opening. Cut through the skin and muscle in an anterior direction slightly to the right of the mid-ventral line. Continue your cut all the way to the anterior of the pectoral fins. Cut the skin and muscles laterally toward the right and to the left pectoral fins. Similarly, cut laterally to the right and to the left just posterior to the pelvic fins. Fold back and secure the flaps of body wall to expose the large body cavity known as the pleuroperitoneal cavity.

A smooth, shiny membrane called **peritoneum** can be seen lining the inside of the body wall. As you move some of the organs to the side, you will see that they are suspended by a double membrane known as **mesentery**. Different sections of mesentery have various names indicating the types of organ suspended.



Liver - The largest organ lying within the shark is the liver. The liver has two large left and right main lobes and a third, smaller middle lobe. Locate the elongated, green sac-like **gall bladder** on right edge of the median lobe. The common bile duct extends from the anterior portion of the gall bladder to the duodenum. One of the digestive enzymes made by the liver is bile. Bile helps break down fat. The bile made in the liver is stored in the gall bladder and transferred to the duodenum through the common **bile duct**. A shark's liver is also rich in oil, which is its main source of energy. The oil's specific gravity is also responsible for giving the shark additional buoyancy.

Esophagus - Move the liver to the shark's right side. The esophagus is the thick muscular food tube extending from the top of the cavity connecting the oral cavity and pharynx with the stomach.

Stomach - The esophagus leads into the "J"-shaped stomach. A muscular valve located in the anterior portion of the stomach, known as the **cardiac sphincter** controls the passage of food and water from the esophagus into the stomach. Mechanical and chemical digestion take place in the stomach. Inside the stomach are longitudinal folds called **rugae**, which help in the churning and mixing food with digestive juices. A muscular valve located in the posterior portion of the stomach, called the **pyloric sphincter**, regulates the passage of partially digested food out of the stomach and into the small intestine.

Duodenum - The first portion of the small intestine is a short, U-shaped tube called the duodenum. It receives partially digested food from the stomach, continues chemical digestion of food and is the beginning of nutrient absorption in the small intestine.

Pancreas - Locate the glandular, whitish pancreas in the curve between the stomach and the duodenum. It has two lobes and it secretes digestive enzymes into the duodenum by way of the **pancreatic duct**.

Spleen - Near the posterior end of the stomach is the dark, triangular-shaped spleen. Although it is part of the lymphatic system (making white blood cells for the immune system), it is closely associated with the digestive organs in all vertebrates.

Valvular intestine - This second, and much larger, portion of the small intestine follows the duodenum. Its outer surface is marked by rings. The **spiral valve** is the screw-like, symmetrical shape within the valvular intestine. It adds surface area for digestion and absorption to an otherwise relatively short intestine.

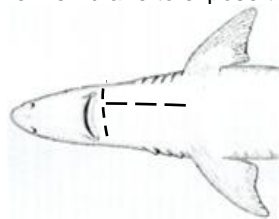
Colon - The shark's digestive tract ends with the narrowed colon, located at the posterior end of the shark. It functions in the reabsorption of water and the compaction of digestive waste.

Rectal gland - Locate the slender, narrow, finger-like structure, leading into the colon. This is the rectal gland and it is used to regulate the shark's water to salt balance (osmoregulation).

The last portion of the digestive canal is the **cloaca**. It is a catch-all basin for the products of the digestive, excretory and reproductive systems. The word cloaca means "sewer".

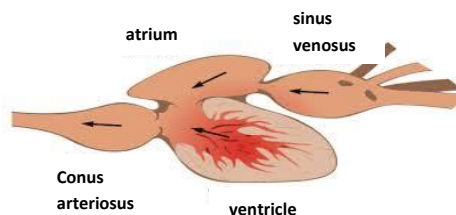
RESPIRATORY AND CIRCULATORY ANATOMY

Place the shark ventral surface upward and continue your original cut anteriorly to the mouth. Cut through the pectoral girdle and the surrounding muscles. Make a transverse cut just below the mouth and fold back the flaps. Mesentery will be found covering the triangular pericardial cavity. Remove the membrane to expose the heart and some of its major blood vessels.



The shark **heart** is composed of four distinct, continuous tube-like structures. The **sinus venosus** is the most posterior of the four structures and can be found by lifting the main portion of the heart. It is a broad, thin walled, flattened, almost horizontal, sac-like structure extending the width of the pericardial cavity. Deoxygenated blood from the entire body returns here first. The **atrium** is anterior and dorsal to the sinus venosus. It is also thin-walled with two lateral bulging lobes. It receives blood from the sinus venosus. The **ventricle** is the main pumping chamber of the heart. It is an oval shaped, thick-walled, muscular sac, lying ventral to the atrium. The **conus arteriosus** is a thick, muscular, tubular structure which originates from the anterior surface of the ventricle. It extends anteriorly to the upper end of the pericardial cavity.

Note: Unlike the heart of higher vertebrates, the heart of the shark transports deoxygenated blood only. The process of oxygenation takes place at the gills, from where blood passes to the entire body without first returning to the heart.



BUCCAL CAVITY AND PHARYNX

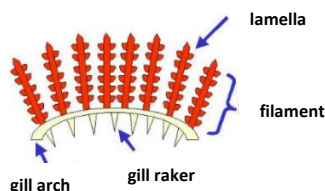
The buccal cavity contains the tongue and teeth. It is enclosed by the jaws and the cartilage of the throat.

The triangular sharp teeth are arranged in several rows beginning at the outer edges of the upper and lower jaws. They are similar to the dermal denticles found on the skin of the shark in their structure and development. Behind the visible rows of teeth are other rows of teeth folded downward ready to replace any teeth that are lost.

The technical term for the tongue of a shark is called a **basihyal**. It is a thick immovable piece of cartilage found on the floor of the mouth. The tongue of the shark is different from the true tongue of higher vertebrates in that in most sharks it serves no purpose.

The **pharynx** is the posterior area of the throat between the gills. The pharynx narrows to form the esophagus.

The **gills** are the respiratory organs of the shark. Water enters into the pharynx from the spiracles before it can reach the internal gills. The internal gill slits lead into cavities called gill pouches, which lead to the outside by external gill slits. The gill slits are supported by cartilaginous gill arches and guarded by small cartilaginous papillae-like **gill rakers** which act as strainers to prevent food particles from leaving the pharynx through the gill slits. Oxygen and carbon dioxide exchange occurs in the many folds of the **gill lamella** found on each gill filament.



THE UROGENITAL SYSTEM

The excretory and reproductive systems have distinct and unique functions. The first function is the removal of nitrogenous wastes and the maintenance of water balance, while the second function is for reproduction. Due to their similar developmental origins and the sharing of common structures, they are usually considered as a single system, called the urogenital system. Push aside or remove almost the entire liver, alimentary (digestive) canal, pancreas, and spleen to reveal the urogenital structures.

The **kidneys** are flattened, ribbon-like, darkly colored structures lying dorsally on either side of the midline, along the entire length of the body cavity. The kidneys of the male are essentially the same as those of the female. The posterior portion is involved in the manufacture and transport of urine. The main difference lies in the anterior portion of the kidney, which in females is degenerate and functionless, but in males is an active part of the reproductive system.

Make sure you look at both a male and female shark

MALE SHARK

Paired **testes** lie near the anterior end of the body cavity, dorsal to the liver, adjacent to the anterior ends of the kidneys. They are supported by a mesentery called the **mesorchium**. The sperm pass from the testes to the kidneys within narrow tubules called efferent ductules.

After passing through the anterior end of the kidney the sperm enter the **ductus deferens** and pass posteriorly toward the cloaca. In mature male specimens the ductus deferens may be seen on the ventral surface of the kidneys as a pair of highly coiled tubules. These tubules transport spermatozoa and seminal fluid. The posterior portion of the ductus deferens widens and straightens to form the paired **seminal vesicles** where sperm continue development.

The paired **sperm sacs** at the posterior ends of the seminal vesicles receive and store seminal secretions. They join to form the urogenital sinuses which exit through the fleshy conical urogenital papilla which extends from the cloaca.

FEMALE SHARK

The **ovaries** are two cream-colored elongated organs in the anterior part of the body cavity dorsal to the liver on either side of the mid-dorsal line. The shape of the ovaries will vary depending upon the maturity of the specimen. In immature females they will be undifferentiated and glandular in appearance. In mature specimens you may find two to three large eggs, about three centimeters in diameter, in each ovary. When these break the surface of the ovary, upon ovulation, they enter the body cavity and move into the oviducts.

The **oviducts** are elongated tube-like structures that run the length of the body cavity, along the sides of the kidneys. In mature specimens they are more prominent. The distal half of the oviduct is enlarged to form the uterus. Fertilization in the dogfish shark is internal, usually taking place within the shell gland of the oviduct. The fertilized eggs receive a light shell-like covering as they pass through a shell gland before reaching the uterus.

The posterior half of the oviduct becomes enlarged and is known as the **uterus**. Fertilized eggs develop into embryos in the uterus. As they grow the pups are attached to the egg, now known as the yolk sac, by means of a stalk. During its period of gestation, which is nearly two years, the yolk is slowly absorbed by the shark "pup." Numerous uterine villi, finger-like projections from the uterine wall, make contact with the surface of the developing embryo and its yolk sac. It is believed that these provide the embryo with water; all other nutrients are supplied by the yolk. Upon completing their period of gestation the young "pups" are ready to be born via the cloaca. The two uteruses open into the posterodorsal portion of the cloaca just ventral to the urinary papilla. This type of development, where the young are born as miniature adults but have received hardly any nutrition directly from the mother's uterus, is known as ovoviviparous.

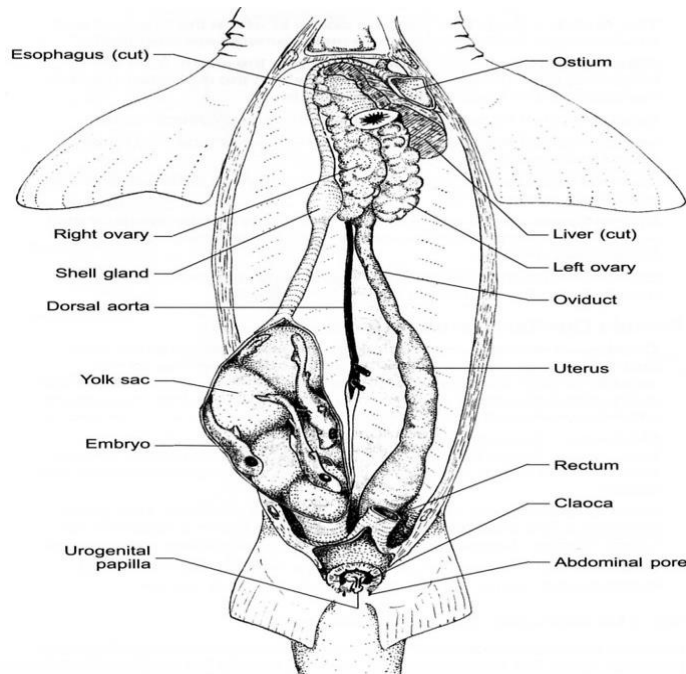


Figure 13. Female reproductive system (kidneys not shown).

THE NERVOUS SYSTEM

The nervous system functions in communication between the various parts of an organism and its external environment. It consists of the central nervous system; the brain and spinal cord, and the peripheral nervous system; the sense organs, cranial and spinal nerves, and their branches.

Remove the skin from the dorsal surface of the head and shave off thin horizontal chips of cartilaginous cranium with your scalpel until the brain and cranial nerves are exposed.

Beginning at the anterior end of the brain, examine and identify the following structures:

Olfactory Sacs – Two large bulbous nerve sensors that detect chemical “smells” in the surrounding water.

Olfactory Lobes – Area of the brain that receives nerve signals from the olfactory sacs and processes smell.

Cerebrum – The two hemispheres between the olfactory lobes and are associated with sight and smell.

Diencephalon – The region just caudal from the cerebrum. This “inner brain” includes the thalamus and the hypothalamus which are the major relay centers for all functions.

Optic Lobe – Large prominent lobes of the mid-brain that receive nerve signals from the eyes.

Cerebellum – Just caudal to the optic lobes it controls muscular coordination and position.

Medulla Oblongata – Also known as the base of the brain or where the beginning of the spinal cord occurs. This controls many of the spinal reflexes (involuntary actions) such as digestion and respiration.

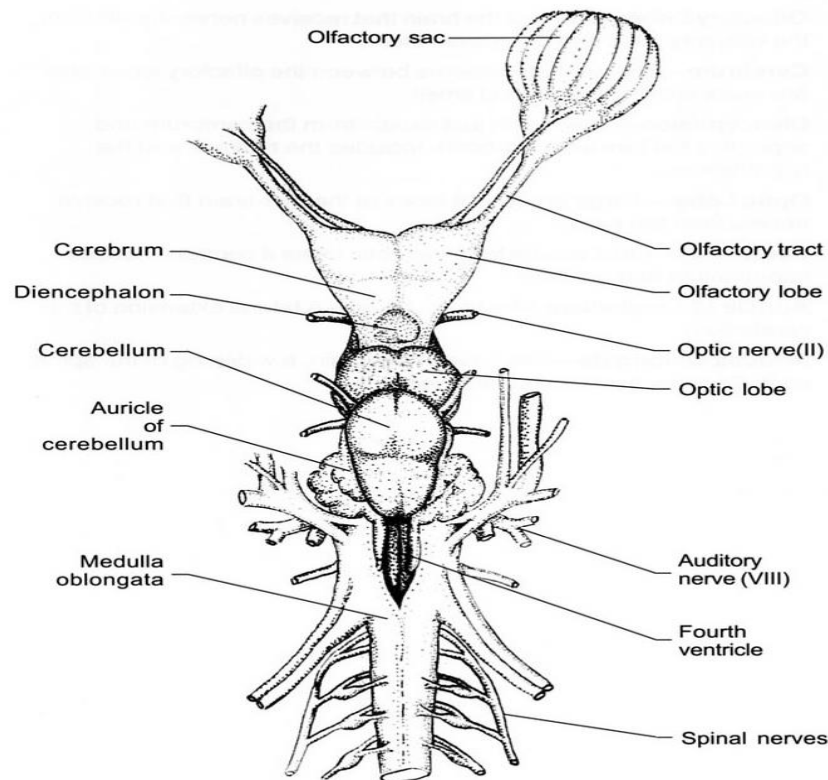
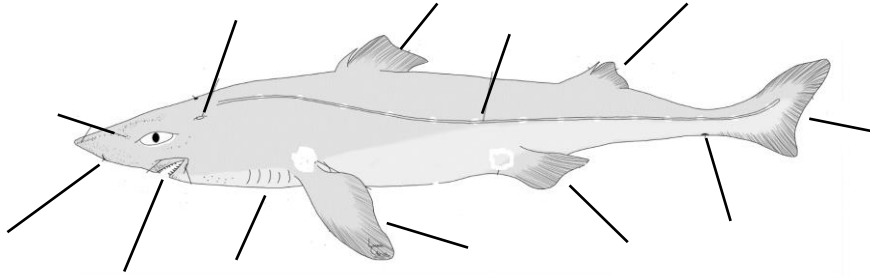


Figure 14. Dorsal view of the shark brain.

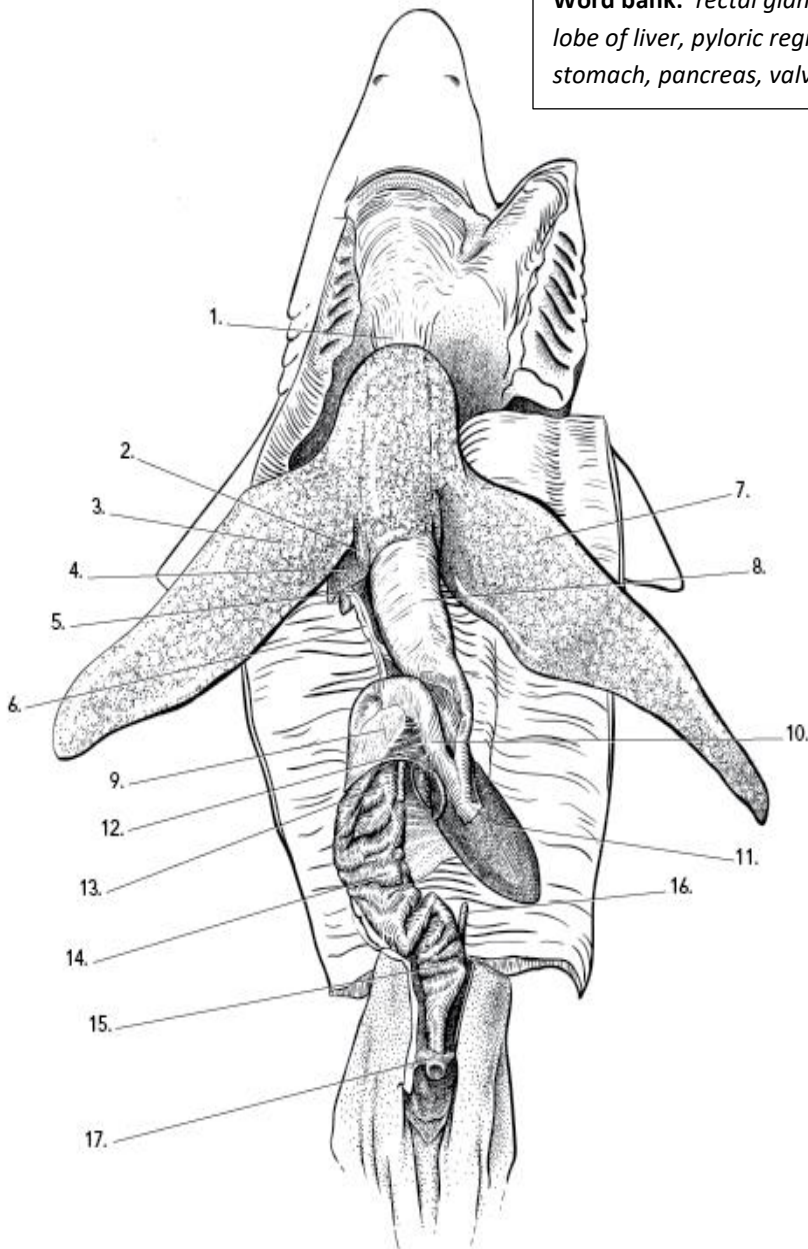
Shark dissection labeling and questions

Label the following on the diagram below: *gill slits, nare/nostril, lateral line, anterior dorsal fin, spiracle, caudal fin, posterior dorsal fin, pectoral fin, pelvic fin, buccal cavity, cloacal opening, ampullae of Lorenzini*



Label the digestive diagram below using the word bank provided. Some of the structures have been labeled for you.

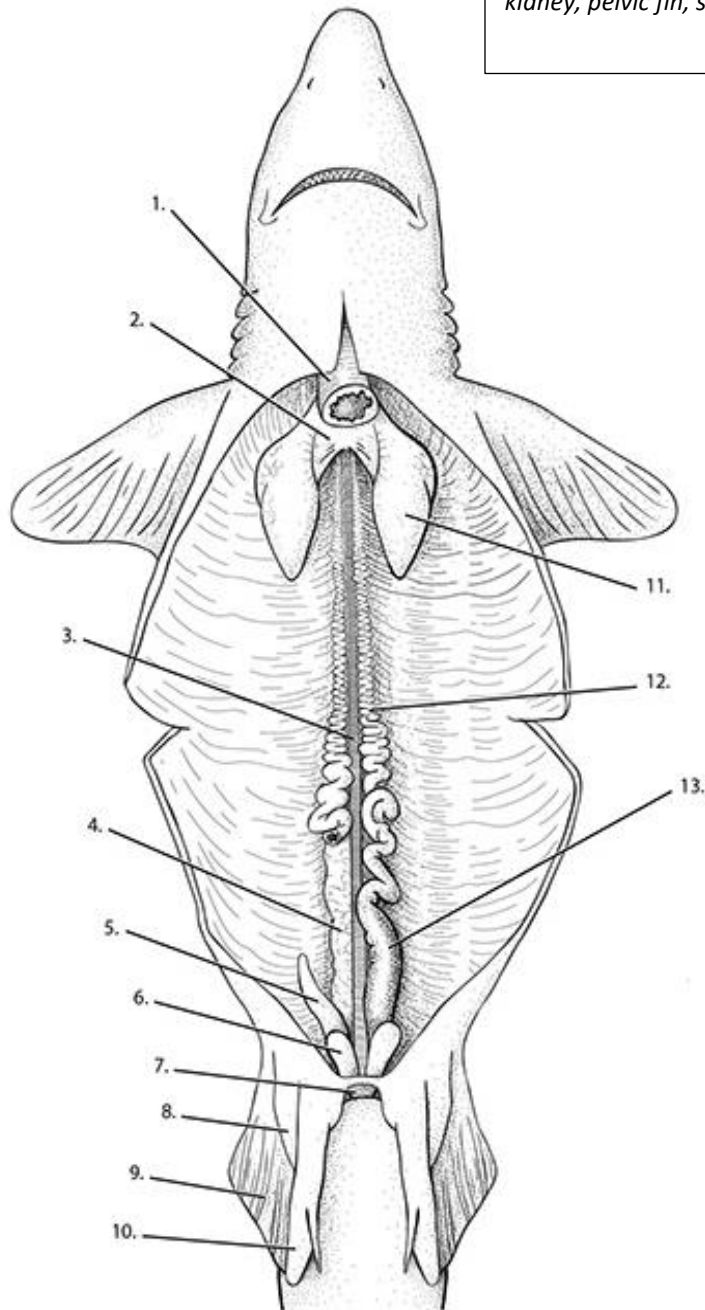
Word bank: *rectal gland, spleen, median lobe of liver, right lobe of liver, left lobe of liver, pyloric region of stomach, colon, gall bladder, cardiac region of stomach, pancreas, valvular intestine, esophagus, cloaca, duodenum*



- 1.
- 2.
- 3.
- 4.
5. ligament
6. ligament
- 7.
- 8.
- 9.
- 10.
- 11.
12. mesentery
- 13.
- 14.
- 15.
- 16.
- 17.

Label the male urogenital diagram below using the word bank provided. Two structures have been labeled for you.

Word bank: testes, esophagus (cut), clasper, mesorchium, ductus deferens, kidney, pelvic fin, seminal vesicle, cloaca, sperm sac, rectal gland



- 1.
- 2.
3. dorsal aorta
- 4.
- 5.
- 6.
- 7.
8. siphon
- 9.
- 10.
- 11.
- 12.
- 13.

Use the dissection instructions, notes and previous assignments to answer the following questions.

1. What does chondrichthyes mean?
2. How are melanophores an adaptation for sharks?

3. Describe a heterocercal tail?
 - a. What type of movement does it create?

4. Describe a homocercal tail.
 - a. What type of movement does it create?

5. What the purpose of the pectoral fins?

6. How is the shape of a shark's body adapted for swimming?

7. What external structures can be used to determine the gender of a dogfish?

8. How many gill slits do dogfish have?

9. Why are the scales of dogfish also called dermal denticles?

10. Give the name for the main body cavity of the shark.

11. What is the name of the membrane lining the main body cavity?

12. What is mesentery?

13. Describe the flow of blood in a shark's heart from posterior to anterior (start at the sinus venosus).

14. Is the blood moving through the heart of a shark oxygenated or deoxygenated?

15. The urogenital system is a combination of what two systems?

16. What does it mean when an animal is ovoviviparous?

17. What do the large olfactory sacs and olfactory lobe tell you about the smelling ability of sharks?