Biology 3B
Cardiovascular, Respiratory and Digestive systems of vertebrates: shark/fish, mudpuppy and rat.

Objectives

- To locate and identify the organs for the cardiovascular, respiratory and digestive systems of various vertebrates (dogfish or perch, mudpuppy and rat)
- To understand the functions of the organs in aforementioned systems.
- To be able to trace homologies between the different species
- To understand blood flow though 2-4 chambered hearts.
- To recognize changes from fetal circulation to adult circulation.

BODY CAVITIES

Vertebrates have a coelomic body cavity. This coelomic space is divided anteriorly into a **pericardial (heart) cavity** and a posterior **pleuroperitoneal** cavity by the **transverse septum**, a tough, white membrane. This is the situation in the dogfish and *Necturus*. In mammals, the **thoracic cavity** is subdivided into a central **pericardial cavity** and paired lateral **pleural cavities** around the lungs. The esophagus runs through this cavity, but we will be looking primarily at the posterior cavity, the **abdominal cavity** in this lab. These cavities are separated by a muscular **diaphragm** in mammals.

The posterior pleuroperitoneal, visceral or abdominal cavity, houses the liver, digestive tract, and gonads. This body cavity has muscular walls (mesoderm). The visceral cavity is lined on the inside with a transparent parietal (somatic) peritoneum. It is attached to the muscles of the body wall but it also overlies the urogenital system, which is retroperitoneal. The parietal peritoneum from each side meet dorsally and ventrally to form a double walled mesentery. This splits to line the digestive tract and other organs as the splanchnic (visceral) peritoneum. The peritoneum is serous (wet). The fluid serves as a lubricant to allow frictionless movement of the organs.

The primary mesenteries are dorsal and ventral, although the dorsal mesentery is often interrupted and moved to one side or the other with the organs and the ventral mesentery is reduced to the membranes of the liver and bladder. Mesenteries running from organ to organ are usually called ligaments.

Dogfish or Perch Respiratory System

In the shark (perch), the circulatory and respiratory systems is one as the heart pumps unoxygenated blood to the gills for oxygenation and from their oxygenated blood is distributed to the body. Gas exchange also takes place in the skin, but primarily in the gills. Look at the diagrams and follow in your shark the passage of water in the **mouth** and **spiracles** (which have a one way valve) and through the **five gill slits** (NOTE: There are no spiracles or gill slits present in the perch). The gill slits close and the pharyngeal chamber expands to suck in water. When the **pharynx** is filled, the mouth closes and the gill chambers expand and fill with water. Then the gill slits open and the chambers constrict to flush out the water. If you look down the gill slits, on each side you will see one half of the gill, a **demibranch**. The internal septum, blood vessels, nerves, muscles and two demibranchs make up each **holobranch**. At their base are **gill rakers**, which project into the mouth and protect the gills from mechanical injury. The demibranchs have **primary lamellae**, which can be easily seen, and **secondary lamellae**, which can be seen if you remove a

portion of the gill and examine it closely. The oxygen rich water flows in a countercurrent pattern to the blood and allows efficient oxygen and carbon dioxide exchange to take place.

Dogfish Heart and Aortic Arches

To expose the blood vessels, first skin the roof of the mouth where the **efferent (e=from) branchial arteries** are located. They are pink and usually well injected. Make a shallow cut just inside the teeth and peel the skin off by flaying it. You will have to go well down the pharynx to the place where the arteries meet. If the dogfish is not injected well, dissect a perch to locate the **efferent branchial arteries**. To do so, you must cut reflect the operculum back as you cut anteriorly. Make sure that you do not cut the **ventral aorta**.

The floor of the mouth, under the attached tongue, has the **afferent (a=to) branchial arteries** and posteriorly the heart. There will not be any blue latex, so the vessels are not injected and are delicate. They are colorless or brown with blood. Remove only the skin with a scalpel. Expose the heart by removing its protective cartilage and identify the **sinus venosus**, **auricle** and single **ventricle**. Trace the ventricle anteriorly into the **conus arteriosus**, and into the short **ventral aorta**. Pry off the cartilage on the afferent vessels with forceps and tease it loose with dissecting needles but do not use the scalpel any more in this area. The vessels are almost stuck to the cartilage. Expose all **5 afferent branchial** arteries as far as the right gills. Follow one into the gill as far as you can. Expose the efferent arteries on each side of this afferent one and find how the major efferent duct loops up to the proceeding gill. In the region of the gills, skin a pair of gill arches and trace one loop of the efferent branchial arteries around a gill slit.

Using your diagrams, trace the pathway of the blood through the afferent branchial arteries, the gills and the efferent branchial arteries.

Necturus Respiratory System

Much of the respiration in amphibians is through the skin. Up to 75% of the oxygen and 90% of the carbon dioxide is exchanged this way in aquatic forms. In addition, *Necturus* has three pairs of gills and one pair of lungs. External gills develop before the two gill slits open and can be waved about by branchial muscles. Lungs developed from swim bladders, which sometimes function as lungs in fish that gulp air. Look for the **glottis**, a longitudinal slit in the pharynx floor, which is the opening to the lungs. The **larynx** is a pair of cartilages surrounding the glottis and will not be noticed. The **trachea** is short. The **lungs** are long, slender and saclike. They run along the dorsal sides of the pleuroperitoneal cavity and are attached to the body wall by the pulmonary ligament on the left side and on the right, the hepatocavopulmonary ligament that also supports the **liver**. The lungs are used as hydrostatic organs and only contribute about 2% of the gas exchange. Air is gulped via the mouth as it is in lungfish.

Necturus Heart and Aortic Arches

Carefully skin the insides of the pharynx, top and bottom, concentrating on the area between the gills to the transverse septa. Expose the **heart** on the ventral floor of the mouth and the **afferent arteries** leading to the **gills**. The heart consists of a **left** and **right atrium** and a single, large, muscular **ventricle**. Lift the ventricle to see the thin- walled, poorly injected, **sinus venosus**. Blood enters the sinus venosus via the lateral **common cardinal veins** and the **posterior, postcaval vein**. Unoxygenated blood enters the heart from the body via the right atrium and from the lungs via the left atrium. It enters the ventricle where it is pumped into the **bulbus arteriosus**. Follow the branches of the **ventral aorta** and its branches to the gills (afferent arteries) and head (external carotid artery). On the roof of the mouth, find the **efferent arteries** from the gills, **internal**

carotid going to the head and **subclavians** going to the arms. Note the thin **pulmonary artery**, which joins at the junction of the two posteriormost efferent arteries. These vessels join the **dorsal aorta**, which carries oxygenated blood to the body.

Mammalian Respiratory System

Open the thoracic cavity by cutting through the **diaphragm**, which separates the abdominal from the thoracic cavity. Cut through the ribs at both sides of the sternum, and deflect the flaps, breaking the ribs, but leaving the sternum in position. This exposes the thoracic cavity. Note the shiny membranes covering the lungs and the inside of the thoracic cavity. These are the **pleura**. Note also the **mediastinum** which is the shiny membrane dividing the right and left pleural cavities. The heart lies in the center of the thoracic cavity. Remove the sternum by cutting through the mediastinum. Be careful not to damage the heart or the accompanying blood vessels.

The **lungs** are the brownish lobes to the right and left of the heart. Entering the lungs on either side from the **trachea** are the **bronchi**. They are supported, as is the trachea, by incomplete cartilage rings. Cut through a lung and trace the divisions and subdivisions of the bronchi. They divide into: secondary bronchi, one to each lobe and bronchioles, within each lobe. Too small to see are the small end branches, the infundibula, which are lined with alveolar sacs. Different animals vary in the number of lobes to each lung. The cat and rat have 4 right lobes, humans have 3. The cat has 3 left lobes, rats have one and humans have 2.

Trace the trachea anteriorly. The rings supporting it are incomplete. Note that the esophagus lies dorsal to the trachea and the gaps in the rings allow the esophagus to attach on the dorsal surface of the trachea. Trace the trachea anteriorly to the **larynx**, or voice box. Note that it is supported by cartilages. These are the **hyoid bone** and **thyroid** and **cricoid cartilages**.

The air enters the nasal passageway at the nostrils and is separated from the oral passageway by the hard and soft palate. A nasal septum divides the air from the two nostrils. You should be able to look down the pharynx and see a triangular flap, the **epiglottis** which moves up to open the air passageway (glottis) or down to close the air passageway and allow food down the esophagus. Inside the larynx at the base of the epiglottis are two lateral flaps, the vocal cords, which open and close to produce sound.

In the upper part of the pharynx, slit the soft palate to see the nasal passage. Into the upper back of this passage way opens the **eustachian tubes** which lead to the middle ear. This opening allows you to "pop" your ears, thus equalizing the pressure on both sides of the tympanic membrane to prevent it from rupturing.

Mammal Heart and Aortic Arches

Remove the **thymus gland** on the anterior of the heart. The heart lies in the pericardial cavity and is enclosed by the **pericardial sac**. In the rat, these sacs have to be removed. It consists of **two atria,** and **two ventricles**. The **sinus venosus** is now incorporated in the wall of the right atrium. The auricles, or atria are small dark structures on the antero-lateral border of the heart. They are divided from the ventricles by a groove, and have much thinner walls than the ventricles. The ventricles appear as one externally, but if you feel them, the larger left ventricle is hard due to its thick walls, the smaller right ventricle is soft as its walls are thinner. When you have finished finding the arteries and veins below, slit open the ventricles from the posterior tip towards the atria and lift up the top flap to see the division of the ventricles and their valves.

Deoxygenated blood enters the heart from the body via the branched **superior vena cava**, which drains the head and arms, and the **inferior vena cava**, which drains the abdominal cavity. These both enter the right atrium and are injected blue (however, our rats are only single injected, thus the veins will appear brownish).

From the **right atrium**, deoxygenated blood flows through a **tricuspid valve** into the right ventricle which pumps the blood through a **pulmonary semilunar valve** to the **pulmonary trunk** which divides into **two pulmonary arteries**, one to each lung. In the lung the blood vessels subdivide into capillary beds around the alveoli and gas exchange takes place.

The oxygenated blood flows back from the lungs via the colorless **pulmonary veins**, which run a parallel, course to the pulmonary arteries but enter the **left atrium**. From the left atrium the oxygenated blood flows through the **bicuspid (mitral) valve** to the left ventricle. The muscular left ventricle must pump oxygenated blood to the entire body including the heart itself. Blood is pumped through the **aortic semilunar valve** to the **systemic aorta** where a branch, the paired coronary arteries go to the surface of the heart. The systemic aorta then bends to the left as the **aortic arch**. At the top of the arch, vessels go to the arms and head. In the rat and human there are three main vessels, first the **branchiocephalic trunk** then the **left common carotid** to the head then the **left subclavian** to the left arm. The branchiocephalic sends a branch, the **right subclavian** to the right arm and continues as the **right common carotid** to the head. The common carotids travel up the neck on either side of the larynx and supply the thyroid, larynx, throat, and face muscles, tongue and part of the brain. The **internal carotids** supply the deep parts of the head; the external carotids supply the more superficial areas.

After the head and arm vessels leave the aortic arch the systemic aorta continues towards the diaphragm as the **thoracic aorta** and posterior to the diaphragm as the **abdominal aorta**. These are equivalent to the dorsal aorta in the dogfish.

SHEEP HEART – Your instructor will guide you through the prosection.

Examine the sheep heart and note the blood flow through it. The anatomy is very similar to that of the human and the rate. During the removal of the sheep heart, the major vessels (vena cava, pulmonary trunk, pulmonary veins and aorta) may have been removed. Find the aforementioned structures heart structures in the sheep heart. Observe carefully the remnants of the structures important in fetal circulation. In the fetal pig you will see the **ductus arteriosus** which becomes the **ligamentum arteriosum** in the adult (sheep heart). You will feel for the **fossa ovalis** (an oval shaped depression between the right and left atria) in the adult heart, which was the **foramen ovale** in the fetus.

Make sure that you understand the correct orientation for the heart as it will be important in locating structures. The **anterior longitudinal sulcus** (a groove) separates the right and left ventricles. The **coronary vessels** can be found in this sulcus.

- Compare the thickness of the two ventricles.
- Compare the semilunar valves with the atrioventricular valves.
- Determine the number of cusps between the tricuspid and mitral valves.
- Find the **papillary muscles, chordae tendineae** and **moderator band** within the ventricles. Which of the three to the ventricles have? Do they possess all three structures?

Comparative Aspects

The purpose of this laboratory exercise is to give you an understanding of:

A) The loss in number of aortic arches in the evolution from Fish to Mammal, and the change in function of those arches that remain.
B) The increase in complexity that has occurred from the two-chambered fish heart to the four-chambered mammal heart. To study these features examine the models of hearts and aortic arches displayed in the lab, the illustrations in your textbook and what you have learned about the dogfish, mudpuppy, cat and rat.

CIRCULATORY SYSTEM

Dogfish Circulatory System

Arterial System

The arterial system in the dogfish or perch is injected in red. Find the efferent arteries leading from the gills and the **paired dorsal aorta** and **internal carotids** leading to the head. The **coronary arteries** leave the second and third gill loops, then join, to take blood to the heart. The efferent arteries join to form the dorsal aorta, which enters the pleuroperitoneal cavity. We will look at the somatic branches first. Find the first paired branch, the **subclavians**, which arise just anterior to the fourth afferent artery and serve the pectoral fins. The dorsal aorta gives rise to many **intersegmental arteries**, which carry blood to the segmented muscles and form renal arteries to the kidneys. Posteriorly, the dorsal aorta gives rise to the **paired iliac arteries** leading to the pelvic fins as the **femoral arteries**. The dorsal aorta continues in the tail as the **caudal artery**. The visceral branches may be paired or unpaired. There are four major branches off of the dorsal aorta. The first is the **celiac artery**, which departs above the liver to run in the mesentery and go to several organs. The branches indicate the organs they serve. The first branch is **ovarian or testicular**, then the gastrohepatic and pancreaticomesenteric**,** the duodenal and anterior intestinal arteries. The next artery leaving the dorsal aorta is near the spleen. The **anterior mesenteric artery** goes to the intestine and its valves. Just posterior to it is the **gastrosplenic artery** to the spleen, stomach and dorsal lobe of the pancreas. A little ways posterior to this branch is the **posterior mesenteric artery** leading to the rectal gland.

Venous Systems

The portal systems transport blood from one organ to a different part of the same organ or a different organ. The **renal portal system** takes the blood from the caudal vein in the tail to the kidneys via the **two renal portal veins**. The blood enters the kidneys on afferent renal veins, which connect, via capillaries to efferent renal veins, which drain the kidneys into the posterior cardinal sinuses.

The hepatic portal system takes the blood from the abdominal viscera to the liver. In the dogfish, this system is injected yellow. The liver can metabolize, detoxify and store substances in the blood. Branches from the organs (gastric, lienomesenteric, pancreaticomesenteric) veins come together to form the hepatic portal vein, which enters the liver and subdivides. From the liver, blood is drained via the **hepatic vein** to the **sinus venosus**.

Systemic veins usually run close to the arteries and share the same name. These are injected blue however our specimens are not double injuected. Sometimes larger pools of venous blood are found in sinuses. We have already examined the renal portal system. The posterior cardinal veins drain into the posterior cardinal sinuses, which also connect with the genital sinuses. The

posterior cardinal sinuses drain into the common cardinal veins and then the sinus venosus of the heart. Posteriorly the femoral, iliac and cloacal veins enter the **lateral abdominal veins** located in the lateral muscles of the body wall. Intersegmental veins join in, as do the subclavian veins just before they all enter the **common cardinal veins** and **sinus venosus**. The head is drained by sinuses, which enter the anterior cardinal sinuses. The small jugular veins also enter the common cardinal sinuses, which lead to the sinus venosus and ventricle of the heart.

Necturus Circulatory System

Arterial System

Just after the junction of the two radices of the dorsal aorta, the **two subclavian arteries** branch off to serve the arms. Note the **pulmonary artery** runs the length of each lung after leaving the junction of the second and third efferent arteries. The dorsal aorta gives off **intersegmental arteries**. Some of these supply the kidneys (renal arteries), gonads (genital arteries), and the hindlimbs (**iliac** and **femoral arteries**). The dorsal aorta continues to the tail as the **caudal artery**. The ventral arteries coming off the dorsal aorta are the single gastric artery taking blood to the stomach, which can be found just posterior to the subclavians. Just posterior to the gastric artery is the single, **celiacomesenteric artery** with branches to the organs (splenic, hepatic, pancreaticoduodenal, mesenteric). Posteriorly, a number of mesenteric arteries go to the large and small intestines. Note that this system shows little change from that of a dogfish, although the celiac and mesenteric arteries are joined.

Venous Systems

The renal portal system is more primitive than that of the dogfish in that the embryonic connection of the posterior cardinal veins to the sinus venosus is not lost anterior to the kidney. The blood from the tail and hindlimbs is taken to the kidneys via the renal portal veins, which run on the lateral edge of the kidneys.

The hepatic portal system is not injected in the mud puppy and will be difficult to find. Therefore, do not attempt to look for it! Venous blood enters the liver from branches that drain the tail and hindlimbs (**abdominal vein**), intestine (mesenteric vein), gastrosplenic vein and pancreaticoduodenal vein. The major change that has taken place is that now some of the blood from the hindlimbs, cloaca, bladder and body wall enters the hepatic portal system via the ventral abdominal vein. This vein is homologous to the lateral abdominal veins of the shark, which now forms a single vein and lays midventrally.

The lungs have **pulmonary veins** along their length, which unite anteriorly to form a single vessel entering the left atrium of the heart. A new, single vein, the **posterior vena cava**, drains the posterior region of the body. This is partly made up from the embryonic paired posterior cardinal veins and the right hepatic vein. It runs up the midline between the kidneys, receiving the renal veins, then the ovarian or testicular veins, hepatic veins at the liver and anterior to the septum splits into two hepatic sinuses, which join the common cardinal veins. Since the posterior cardinal veins persist in the mud puppy, some blood from the kidneys (subcardinal veins) and the body wall (intersegmental veins) is drained to the **common cardinals** via these vessels. The common cardinal veins also receive blood from the anterior of the body. The internal and external jugular veins drain into the subclavians from the arms and they enter the common cardinal veins. The common cardinal veins, after collecting blood from the posterior cardinal veins, and posterior vena cava, enters the **sinus venosus** and right atrium of the heart.

Mammal Circulatory System

Arterial System

Follow the dorsal aorta into the abdominal cavity. Note the small **intercostal arteries** and other **intersegmental arteries** which form the **adrenolumbar arteries** (to the adrenals), **renal arteries** (to kidneys), **spermatic or ovarian arteries** (to gonads), lumbar and iliolumbar arteries to back muscles, and **iliac** and **femoral arteries** to the limbs. The first unpaired artery, which goes ventrally to the organs, is the **celiac artery**. This artery has many branches, gastric, splenic, hepatic, gastroduodenal are the major ones. The branch to the pancreas joins with the pancreatic branch of the next visceral branch forming a loop. The anterior mesenteric artery lies just posterior to the celiac artery and has branches to the pancreaticoduodenal area (forming the loop), colic and intestinal areas. The posterior mesenteric artery is smaller. It branches to the colon and rectum and then joins with the loop from the anterior mesenteric artery. Note again that this system is similar to that of the dogfish.

Venous Systems

The renal portal system does not exist in mammals.

The hepatic portal system is not injected in your specimen. It drains the viscera from the mesenteric veins, gastrosplenic vein, coronary vein, pancreaticoduodenal vein and their branches. They all enter the hepatic portal vein, which leads to the liver. Note that the blood from the hindlimbs no longer flows into this system.

Venous blood from the hindlimbs flows via the femoral and iliac veins to the single median **posterior vena cava** (postcava). The caudal vein joins the left common iliac vein. Blood also enters from the iliolumbar and lumbar veins, the right spermatic or ovarian vein and the renal veins. The left spermatic or ovarian vein drains via the left renal vein as does the left adrenolumbar and phrenic veins (to diaphragm). Those on the right side enter separately. Near the diaphragm, the hepatic veins and superior phrenic veins enter the postcava, which then penetrates the diaphragm and enters the right atrium of the heart. In the head region, blood is drained via the **external and internal jugular veins**. The subclavian veins from the forelimbs join and together they descend as the branchiocephalic veins, joining to form the **anterior vena cava** (precava). This vessel enters the right atrium of the heart.

DIGESTIVE ORGANS

The digestive tract is a tube, with coils and branches, which begins at the mouth and ends either at a cloaca or anus. It processes food, which moves by peristalsis through the process of digestion, absorption and elimination. The general pattern is to have an oral cavity, pharynx, esophagus, stomach and intestine. Accessory organs are the pancreas, liver and gallbladder, which arise as evaginations from the embryonic digestive tract. We will be looking at the variations and similarities in the digestive tracts of the dogfish or perch, salamander and mammal in this lab.

Dogfish Digestive Tract

Use scissors to cut through the body wall. Make your longitudinal cut off center from the midventral line and out to the pectoral and pelvic fins, then turn back the flaps. Note the **falciform ligament** hanging midventrally from the **liver** in the anterior half of the pleuroperitoneal cavity. You will have to cut this ligament to look into the cavity. Other remnants of the ventral mesentery are the **lesser**

omentum from the liver to the **stomach** and **small intestine** and reproductive mesenteries, which will be looked at later. The dorsal mesentery is seen as the **greater omentum** holding the **esophagus** and stomach to the dorsal body wall and dorsal mesentery holding the intestine. From the stomach to the spleen is a gastrosplenic ligament.

The oral cavity contains the tongue and teeth. The **pharynx** is the portion leading past the spiracle and five gill slits and also contains the tongue in dogfish. Note the taste buds on the tongue. To view this area, cut through the left jaw of the dogfish and perpendicularly through the center of the gills to the pectoral fin. Fold a paper towel over the teeth (**these can still cut you**!) and use your scissors to open the mouth wide. Make sure you cut all the way through to the pharynx. Cut horizontally across to the other pelvic fin, making sure you are posterior to the transverse septum. You do not want to cut into the pericardial cavity. You will have to cut through the esophagus until you get to the gill slits on the other side. Pull the lower jaw open and clear out any debris. The esophagus extends from the pharynx at the transverse septum and is lined with papillae, which form a tight seal to keep water out. Cut into the esophagus to see the papillae and the stomach with its longitudinal folds called rugae. The "U" shaped **stomach**, with an anterior cardiac limb and a posterior pyloric limb ends in a constricted pyloric sphincter. The **small intestine** is composed of, anteriorly, a **duodenum**, and posteriorly, an **ileum**, which contains a **spiral valve**. Cut into the ilium to see the valve, which increases the surface area. The **large intestine**, a shorter section than the small intestine has a rectal gland entering it. The **rectal gland** is for salt excretion for osmoregulation. The rectum, the most posterior portion, ends in the anus which projects into the **cloaca**, a common opening with the urogenital ducts.

Digestive Accessory Organs

Liver, composed of three lobes, and a greenish **gall bladder**. These extend posteriorly from the transverse septum. Note the bile duct, from the gall bladder, which goes to the duodenum along with two hepatic vessels. The **pancreas**, consists of two lobes; a ventral lobe overlying the duodenum, and a dorsal lobe, in the curve between pyloric stomach and duodenum. The pancreatic duct is usually difficult to locate, it runs from the junction of the lobes into the duodenum.

Spleen, an organ of the circulatory system (lymphoid tissue), extends posteriorly from the curvature of the stomach.

Necturus Digestive Tract

Use your scissors to make a longitudinal cut off center from the cloaca to the transverse septum. Note the mid-ventral falciform ligament. Cut across the posterior edge of the transverse septum avoiding the pericardial cavity. Like the dogfish, the main digestive tract is in the pleuroperitoneal cavity. The greater omentum extends from the dorsal wall to the stomach and the gastrosplenic ligament goes from the stomach to the spleen. The dorsal mesentery holds the intestines to the dorsal wall; it is called the mesocolon at the large intestine. Other ligaments support the lungs and urogenital tract. **Be careful not to destroy these delicate membranes when observing the organs**.

Use your scissors to cut through the left jaw and ventral to the gills to the pectoral girdle. Cut horizontally through the esophagus to open up the mouth. Be sure to avoid the pericardial area and any blood vessels. In the oral cavity are teeth, two rows in the upper jaw, and one in the lower.

The **tongue** is better developed than that of the shark. The **pharynx** has **two pairs of gill slits**. On the posterior floor of the pharynx lies the **glottis**, a slit that leads into the **trachea**. From the pharynx to the stomach is a short, poorly defined **esophagus**. The straight **stomach** has internal rugae and ends with a muscular pyloric sphincter. The **small intestine** is the **duodenum** anteriorly, and then a long coiled portion with internal small folds called **plicae**, which increase the surface area. There is a short **large intestine**, which enters the **cloaca** via the **anus**.

Digestive Accessory Organs

The large **liver** is not lobed but weakly scalloped posteriorly. The **gall bladder** is on the liver near the duodenum. The hepatic ducts and bile duct empties into the duodenum as in the shark, but may be difficult to see. The irregular pinkish mass of the pancreas lies on the hepato-duodenal ligament and is fused into one. Two small ducts lead to the duodenum. The pancreas is both an exocrine gland, producing digestive enzymes and an endocrine gland regulating metabolism. The spleen, a lymphatic organ, lies to the left of the stomach.

Mammal Digestive Tract

In mammals, the coelomic cavity is divided into thoracic and abdominal cavities by the diaphragm. Make an incision in the midventral line through the abdominal wall muscles of the cat or rat from the sternum to about an inch anterior to the clitoris or penis. Make lateral incisions at the extremities of this first incision and deflect the flaps. Exposed is the abdominal or visceral cavity. Between the **diaphragm** and the liver are three ligaments, the most prominent of which is the **falciform ligament**, which connects the right and left liver halves to the abdominal wall. The **greater omentum** is double layered and filled with fat in rat. It extends from the greater curvature of the stomach to the dorsal body wall and extends to the pelvic region covering and tucking under the intestine. The portion of this mesentery from the stomach to the spleen is the gastrosplenic ligament. From the lesser curvature of the stomach and duodenum to the liver is the lesser omentum. The dorsal mesentery holds the intestines to the dorsal body wall. Other mesenteries hold the urogenital system in place. Try not to tear any of the mesenteries when doing your dissection.

Glands

During the course of your dissection you will remove or view the following glands. For todayÕs lab, observe the three salivary glands, the submaxillary, sublingual and parotid glands, which are located in the head and neck region.

Table of Glands and Functions

Gland	Location	Function
Submaxillary	central throat, large	salivary
Sublingual	anterior on submaxillary, whitish	mucous
Parotid	towards ear, outside submaxillary, soft	salivary
Lacrimal	below ear	tears
Lymph nodes	4, above submaxillary, dark, round	lymphocytes
Thymus	above heart, large on young animals	lymphatic-disease immunity
Thyroid	side of larynx, dark red	ion and calcium binding
Adrenal	above kidney	adrenalin or epinephrine

The digestive tract starts with the mouth and its associated salivary glands. To view the inside of the mouth, cut through the left jaw after prying the mouth open with a folded paper towel over the teeth. Be sure you are not trying to cut through the molars. Bone cutters may need to be used for the rat. To open the lower jaw, cut through the soft palate. In the oral cavity note the differentiated teeth and the mobile tongue. Lift the tongue to see the **lingual frenulim**. Note the papillae on the surface of the tongue. Feel the roof of the mouth with its anterior hard palate and posterior soft palate. The **pharynx** extends from the oral cavity to the larynx and allows passage of food and air. The food, when swallowed, travels down the tubular **esophagus**, which lies dorsal to the larynx. The soft, distensible esophagus penetrates the diaphragm separating the thoracic and abdominal cavities. Food is moved down it by peristalsis. The esophagus ends at the cardiac sphincter. The **J-shaped stomach** ends at the pyloric sphincter. The convex side is the greater curvature; the concave side is the lesser curvature. The **small intestine** starts at the pyloric sphincter with the **duodenum** a long curved piece, then begins looping back and forth, still descending as the **jejunum**. The ascending, looping portion is the **ileum** and it ends in a T-junction with the **large intestine**. The blind end of the T is the **caecum** or appendix, large in the rat, small in cats and humans. The other end is the **ascending portion** of the **large intestine** or colon followed by a short **transverse portion** and a **descending portion**, which ends in a muscular rectum hidden under the pelvic girdle. It opens at the anus, controlled by sphincter muscles, at the base of the tail. The enlarged and constricted areas of the colon are due to peristalsis.

Digestive Accessory Organs

The dark reddish brown lobes of the **liver** (five in rat, six in cat) are attached to the diaphragm. The central lobe has a **gall bladder** in a cat, but it is absent in the rat, although both animals have a bile duct leading to the anterior duodenum. The mesentery called the **greater omentum**, stretching from the spleen to the duodenum contains the two lobes of the **pancreas**, which look like pink granular bubble gum. One lobe runs from the pyloric sphincter to the spleen, the other along the edge of the duodenum. They meet anteriorly forming one duct, which enters the duodenum beside or with the bile duct. The dark reddish brown spleen is an elongate lobe on the left side just below the stomach.