THE DIGESTIVE AND RESPIRATORY SYSTEMS

In the shark these two systems are studied as one since the mouth and pharynx serve both as organs of digestion and respiration. We shall begin our dissection with the organs that are primarily related to the process of digestion.

The Dissection

Turn your specimen ventral side up. 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 to the *coracoid bar* of the pectoral girdle. At that point use your scissors and proceed with the blunt end to cut the skin and muscles laterally toward the right and to the left. Similarly, at the point you began the dissection, near the cloacal opening, cut laterally to the right and to the left. You have thus exposed the large body cavity known as the *pleuroperitoneal cavity*. Fold back the large flaps of body wall you have cut and secure them with large dissection pins.

PLEUROPERITONEAL CAVITY

COELOM — The *coelom* or body cavity of the shark is divided into the larger posterior chamber, the *pleuroperitoneal cavity,* and the smaller anterior *pericardial cavity* which contains the heart. The two cavities are separated by a partition, the *transverse septum*.

Recognize and identify on your specimen all of the structures listed. Make use of the labeled photographs.

PERITONEUM — A smooth, shiny membrane will be seen lining the inside of the body wall. This membrane is the *parietal peritoneum*. The membrane covering the surface of the visceral organs is the *visceral peritoneum*. As you move some of the visceral organs to the side, you will see that they are suspeneded dorsally by a double membrane of peritoneum know as *mesentery*. Different sections of mesentery have various names indicating the types of organ suspended. These will be named as the organs are discussed.

LIVER — The largest organ lying within the pleuroperitoneal cavity is the liver. Its two main lobes, the *right and left lobes,* extend from the pectoral girdle posteriorly most of the length of the pleuroperitoneal cavity. A third lobe, the *median lobe,* is much shorter than the others, and as the name indicates, is located medially. Locate the elongated sac, the green *gall bladder* along the right edge of the median lobe. The *common bile duct* extends from the anterior portion of the gall bladder to the duodenum.

The anterior portion of the liver is attached to the ventral body wall by a membrane, the *falciform ligament,* and to the transverse septum by the *coronary ligament*.

The great bulk of the liver can be visualized when compared to other organs. A giant 20-foot basking shark which weighed a total of 13,850 pounds had a 1,850-pound liver. The liver is rich in oil. This is the form in which the shark stores energy, not as fats. The oil's specific gravity is also responsible for giving the shark a limited amount of buoyancy, although it cannot keep him afloat as does the swim bladder of bony fish.

ESOPHAGUS — Move the large lobes of the liver laterally to reveal other organs of the body cavity. You will see a thick muscular tube extending from the top of the cavity at the mid-line posteriorly toward the left. This is the *esophagus*. It passes through the transverse septum to connect the oral cavity and pharynx with the stomach.

STOMACH — The esophagus leads into the "J"-shaped *stomach*. The upper portion, the cardiac region, continues as the *main body*, and ends at the duodenal end. The left-hand outer border of the stomach is called the *greater curvature* while the right-hand, inner border is the *lesser curvature*. Dorsally the stomach is supported by a membrane, a derivative of the mesentery, the *mesogaster (greater omentum)*. Another membrane, the *lesser omentum (gastrohepatoduodenal ligament)*, supports the stomach ventrally.

Cut the stomach open along its long axis. Avoid the large blood vessels seen externally. Note its contents. It will generally consist of partially digested remains of fish, squid, or other sea animals. Wash out the inside of the stomach under slowly running water. Note the *mucosa*, the inner lining membrane. The longitudinal folds, the *rugae*, help in the churning and mixing the food with digestive juices. A circular muscular valve, the *pyloric sphincter*, is located at the distel end of the stomach. It regulates the passage of partially digested food out of the stomach.

DUODENUM — A short "U"-shaped tube, the *duodenum*, the first portion of the small intestine, connects the stomach to the next part of the alimentary canal. The bile duct from the gall bladder enters the dorsal surface of the duodenum.

PANCREAS — Ventral to the duodenum and partially obscuring it is the whitish glandular tissue of the *pancreas*. The greater portion of the pancreas is not seen until one examines the dorsal surface of the stomach and duodenum. Here the dorsal elongated segment of the pancreas may be found. Connecting the dorsal and ventral lobes of the pancreas is the *isthmus*, a slender band of pancreatic tissue. The secretions of the pancreas enter the duodenum by way of the *pancreatic duct*.

SPLEEN — Near the posterior end of the stomach find the dark, triangular-shaped *spleen*. Although not a part of the digestive system but the lymphatic system, it is closely associated with the digestive organs of vertebrates. A part of the mesogaster membrane extends between the spleen and the stomach, the *gastrosplenic ligament*, which ties these two organs together.

VALVULAR INTESTINE — This second, and much larger, portion of the small intestine follows the duodenum. Its outer surface is marked by rings. This hints at the contour to be found within. Cut away the outer tissue of this portion of the alimentary canal. Exercise caution in not injuring the blood vessels which are located on the surface of the intestine. Wash out the contents. You will see a symmetrical spiral shape within, the *spiral valve*. It adds surface area for digestion and absorption to an otherwise relatively short intestine. In higher vertebrates, increases in surface area are accomplished by means of coiling and projecting finger-like villi.

COLON — This narrowed continuation of the valvular intestine is located at the posterior end of the pleuroperitoneal cavity. If the end of the colon has been everted through the cloacal opening, pull it back into the body cavity.

RECTAL GLAND (DIGITIFORM GLAND) — A slender, narrowed, finger-like structure, the *rectal gland*, closed at one end, leads into the colon by means of a duct. It has been shown to excrete salt (NaCl) in concentrations higher than that of the shark's body fluids or sea water. It is thus an organ of *osmoregulation*, regulating the shark's salt balance. The *mesorectum*, a section of the dorsal mesentery, attaches the colon and rectal gland to the mid-dorsal line.

CLOACA — This last portion of the alimentary canal collects the products of the *colon* as well as the *urogenital* ducts. This catch-all basin leading to the outside by means of the *cloacal opening* has rightly deserved its name which means sewer. In higher vertebrates, separate exits exist for the rectum (anus), for the urinary bladder (urethra), and for the reproductive system (vagina).

ABDOMINAL PORES — The coelomic cavity of higher vertebrates is closed and has no direct connection with the outside. In the shark, however, a pair of *abdominal pores* may be found posterolateral to the cloacal opening. Pass a blunt probe through the pores to confirm the connection between the coelom and the outside. In some specimens the lips of the pore may have grown together. Their function has not yet been determined.

NON-DIGESTIVE ORGANS — Several organs, not part of the digestive system, may be seen in the pleuroperitoneal cavity. Most are part of the reproductive and genital systems.

The *gonads (testes* or *ovaries)* may be found by moving the liver and digestive organs to one side. They are located in the anterodorsal portion of the body cavity. The supporting mesentery of the testes is the *mesorchium*, of the ovaries, the *mesovarium*. An additional mesentery, the *mesotubarium*, supports the oviducts of mature females.

The *kidneys* are dark elongated structures, running the length of the body cavity on either side of the mid-dorsal line. In mature animals the *oviducts* in females, and the *archinephric* ducts in males, may be seen running from the gonad to the cloaca.

All of these urogenital structures will be studied in more detail in a later chapter.

ORAL CAVITY AND PHARYNX

Although the mouth, the oral cavity, and the pharynx of the shark serve as passageways for food, they play a more active role in respiration.

RESPIRATION — Water taken into the mouth and pharynx passes over the gill filaments, through the gill slits, to the outside. During this process, oxygen is removed and transported into the circulatory system and carbon dioxide is released from the blood at the gill lamellae and exits via the gill slits.

The Dissection

With the shark lying ventral side up, insert the blunt blade of a strong pair of scissors into the right corner of the shark's mouth. Begin cutting posteriorly through the angle of the jaws across the gill slits as far back as the pectoral girdle. Cut across the ventral musculature to lay the entire preparation flat on your dissection pan. Your dissection should appear as in the photo on page 54. Secure the specimen with large dissection pins. Locate and identify each of the following on your specimen.

The Oral Cavity

This is the area enclosed by the jaws (mendibular arch) and the hyoid arch.

TEETH — These triangular sharp structures 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 within the mucosa, usually folded downward ready to replace any lost. It has been estimated that the mouth of the great white shark may contain 400 teeth!

TONGUE — The *tongue* of the shark is different from the true tongue of higher vertebrates. It is practically immovable, without muscles under the epithelium. It is supported anteriorly by the basihyal cartilage of the hyoid arch and posteriorly by the pharyngeal arch cartilages. These can be palpated by the fingertips.

Pharynx

The *pharynx* is the portion of the alimentary canal posterior to the hyoid arch between the gill slits. Posteriorly it narrows to form the *esophagus*.

SPIRACLES — The *spiracles* are openings in the anterior roof of the pharynx, in its dorsolateral wall. The shark can bring water into its pharynx to the gills by way of the spiracle even when its mouth is closed. Pass a blunt probe into one spiracle and note where it exits.

GILLS — The *gills* are the respiratory organs of the shark. They are composed of *gill lamellae, blood vessels,* and *supporting cartilaginous structures*.

As you look at the pharynx you will see five internal *gill slits*. They 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.

Branchial Bars — The partitions between gill pouches are referred as branchial bars. They include all of the following gill elements: the *interbranchial septa, anterior and posterior demibranchs, gill arch cartilages, gill rakers, gill rays, branchial blood vessels,* the *adductor muscle* and the *valve flap*.

Gill Lamellae and **Interbranchial Septa** — Look closely at the cut surfaces of the gills. Note the *primary gill lamellae (gill filaments)*. They are pink colored in injected specimens. They are a radially folded, highly vascularized tissue. They are attached to the surface of a tough connective tissue, the *interbranchial septum*.

Examine the primary gill lamellae with a hand lens and note that each bears many small, closely packed *secondary lamellae* extending perpendicularly from the surface of the primary lamellae.

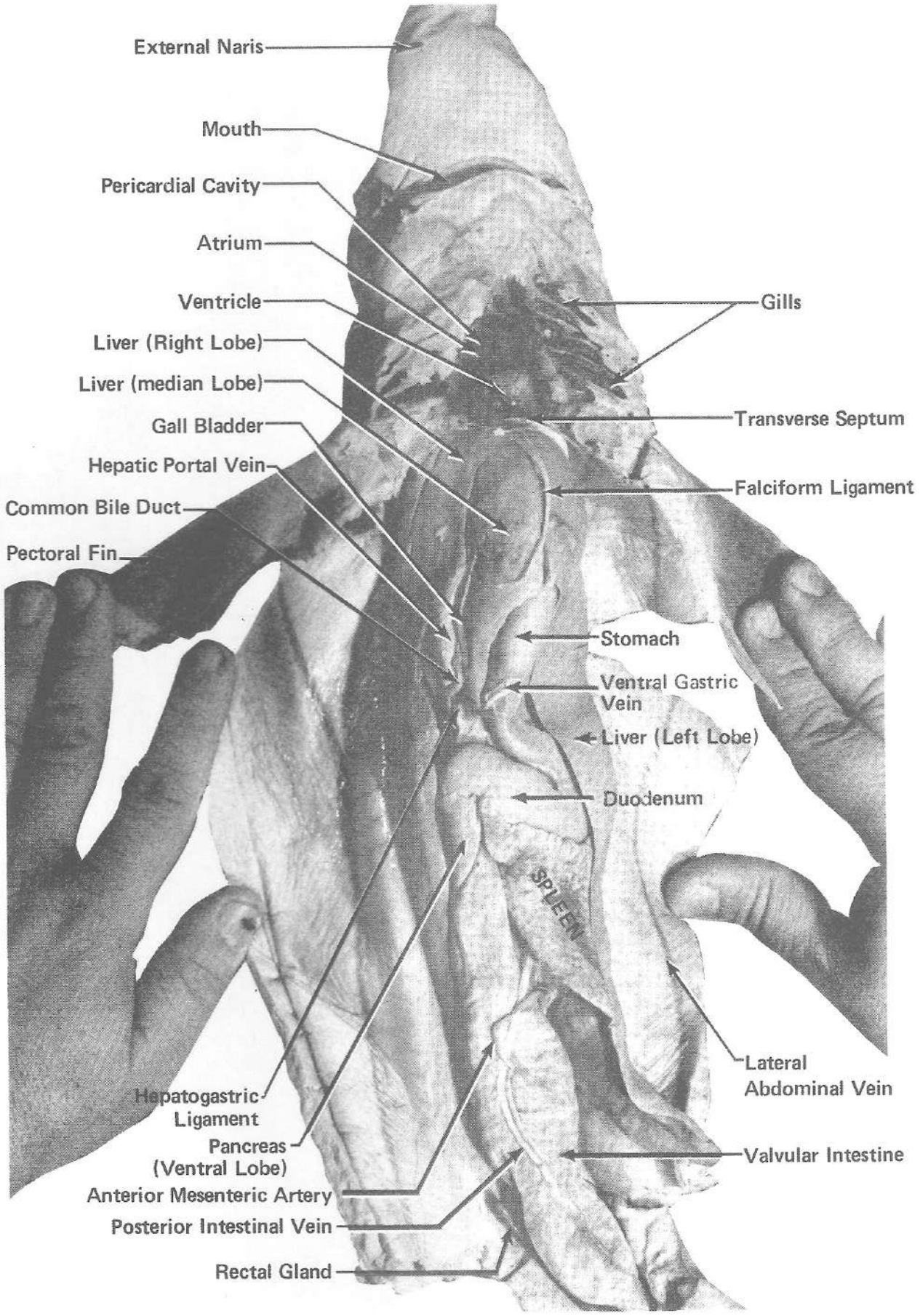
Each septum is attached medially to a portion of the cartilaginous gill arch. Distally they extend beyond the gill lamellae, to end upon the superficial constrictor muscles which act as flap-like *valves* to open and close the external gill slits.

Demibranchs and Holobranchs — The gill lamellae on one side of a branchial bar are called a *demibranch (hemibranch)*, or half gill. The demibranchs on the anterior and posterior surface of a single branchial bar are termed a *holobranch,* or complete gill. Thus, one holobranch belongs to two different gill pouches; the anterior half (demibranch) to the anterior gill pouch, the posterior gill demibranch to the posterior gill pouch. Note: There is no demibranch (gill filament) on the posterior wall of the last (fifth) gill pouch.

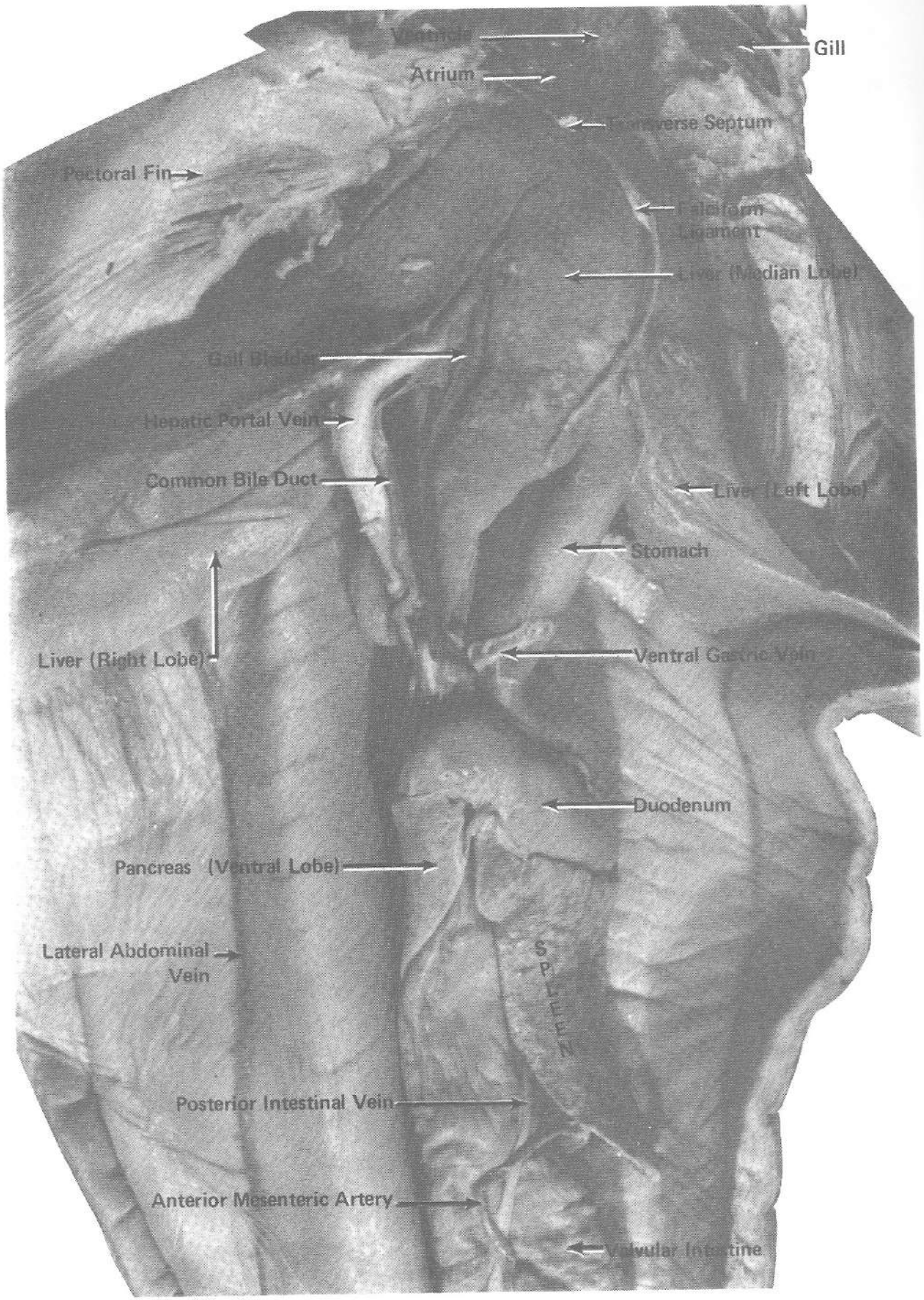
Pseudobranchs — Examine one of the spiracles. Use your scissors to cut into the spiracle. Examine its walls and the flap-like spiracular valve. A minute demibranch called a *pseudobranch,* or false gill, may be found on the anterior wall of the spiracle. Since oxygenated blood passes through the pseudobranch, it does not have any respiratory function. It is conjectured that it may have other functions such as excretory or endocrine.

Gill Rays — These are fine cartilagionous, finger-like, lateral extensions of the gill arch cartilages. They may be found by scraping off the gill lamellae from the surface of the supporting septa. The *gill rays* provide support for the interbranchial septa.

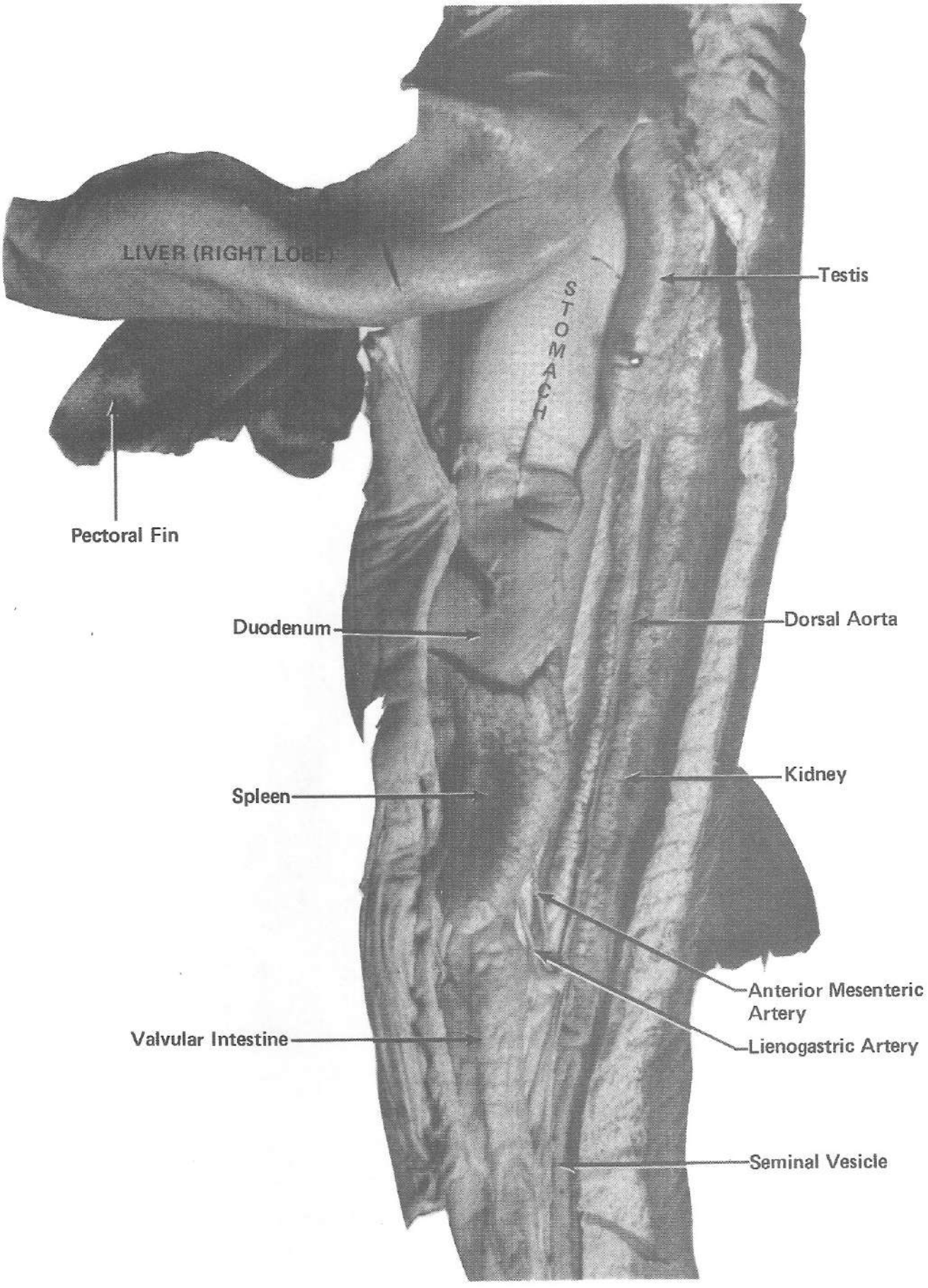
Branchial Blood Vessels — The gills are provided with a rich blood supply. Near the proximal end of each septum locate a single *afferent branchial artery,* which brings deoxygenated blood to the gill lamellae, in the middle of the septum, and two *efferent branchial arteries,* on either side of the afferent vessel, which carry oxygenated blood from the gills. A single *adductor muscle* lies medial to each gill arch. It compresses the gill cartilages.



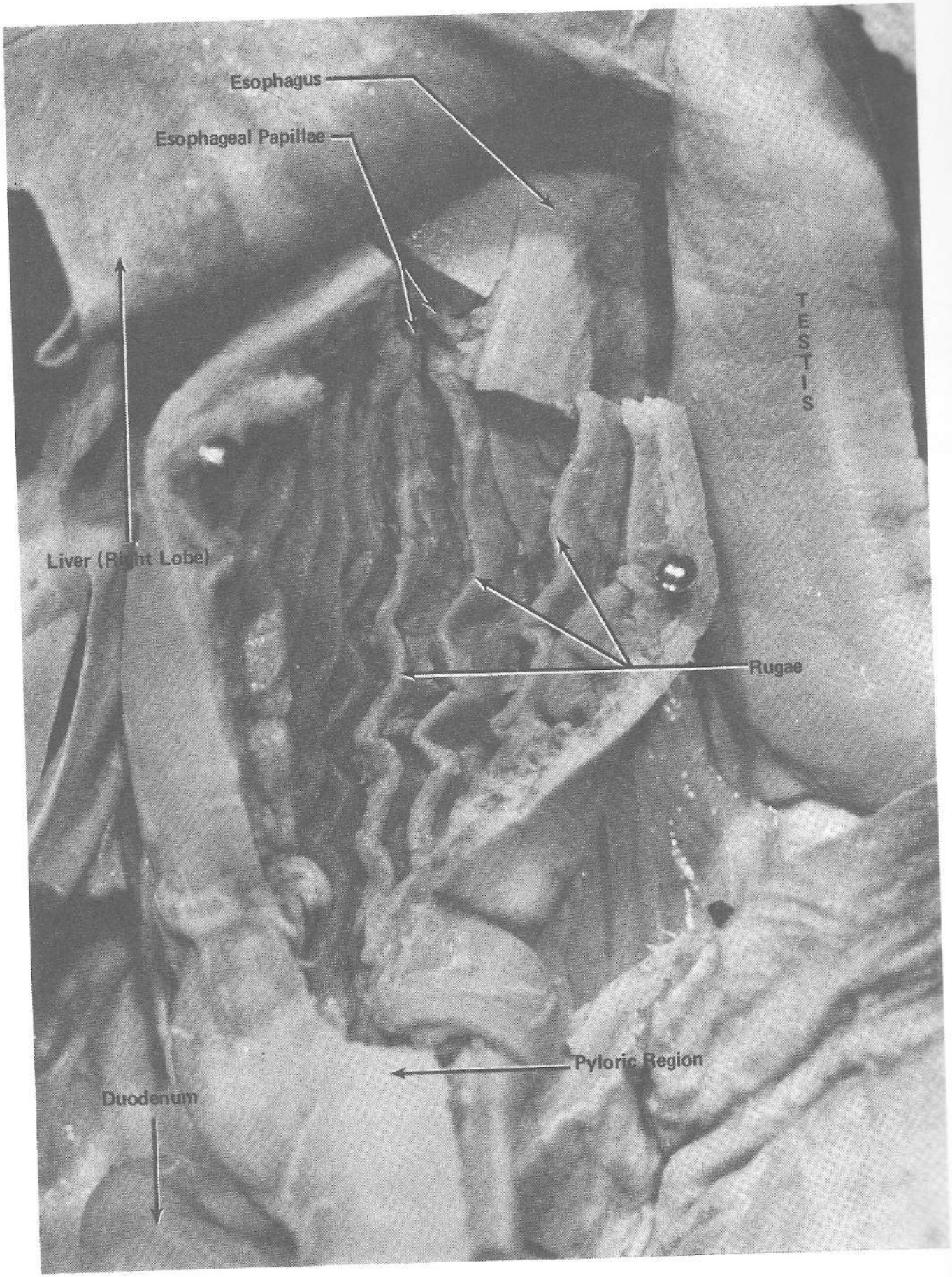
THE VISCERA – VENTRAL VIEW



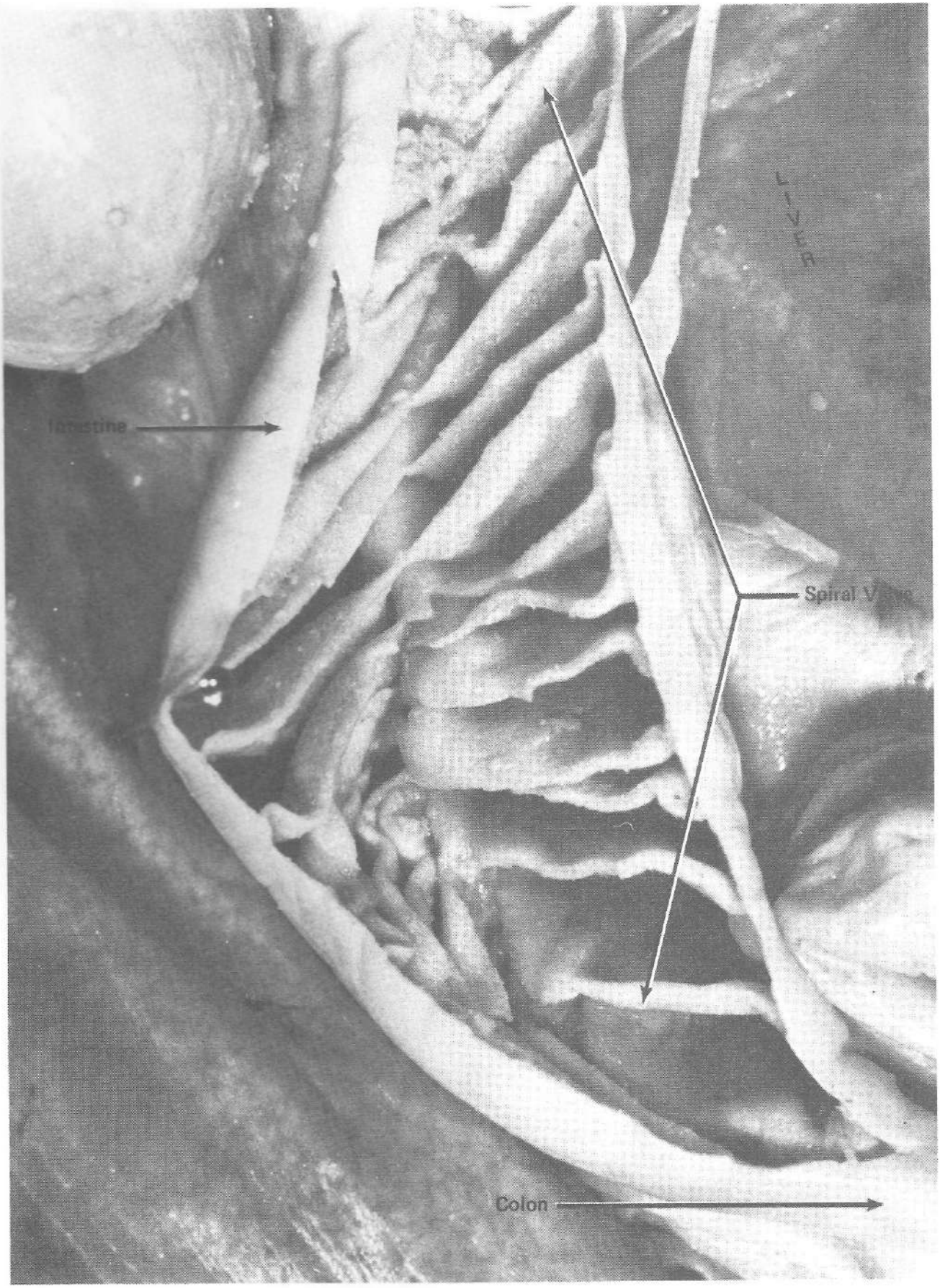
THE VISCERA (CLOSE-UP) – VENTRAL VIEW



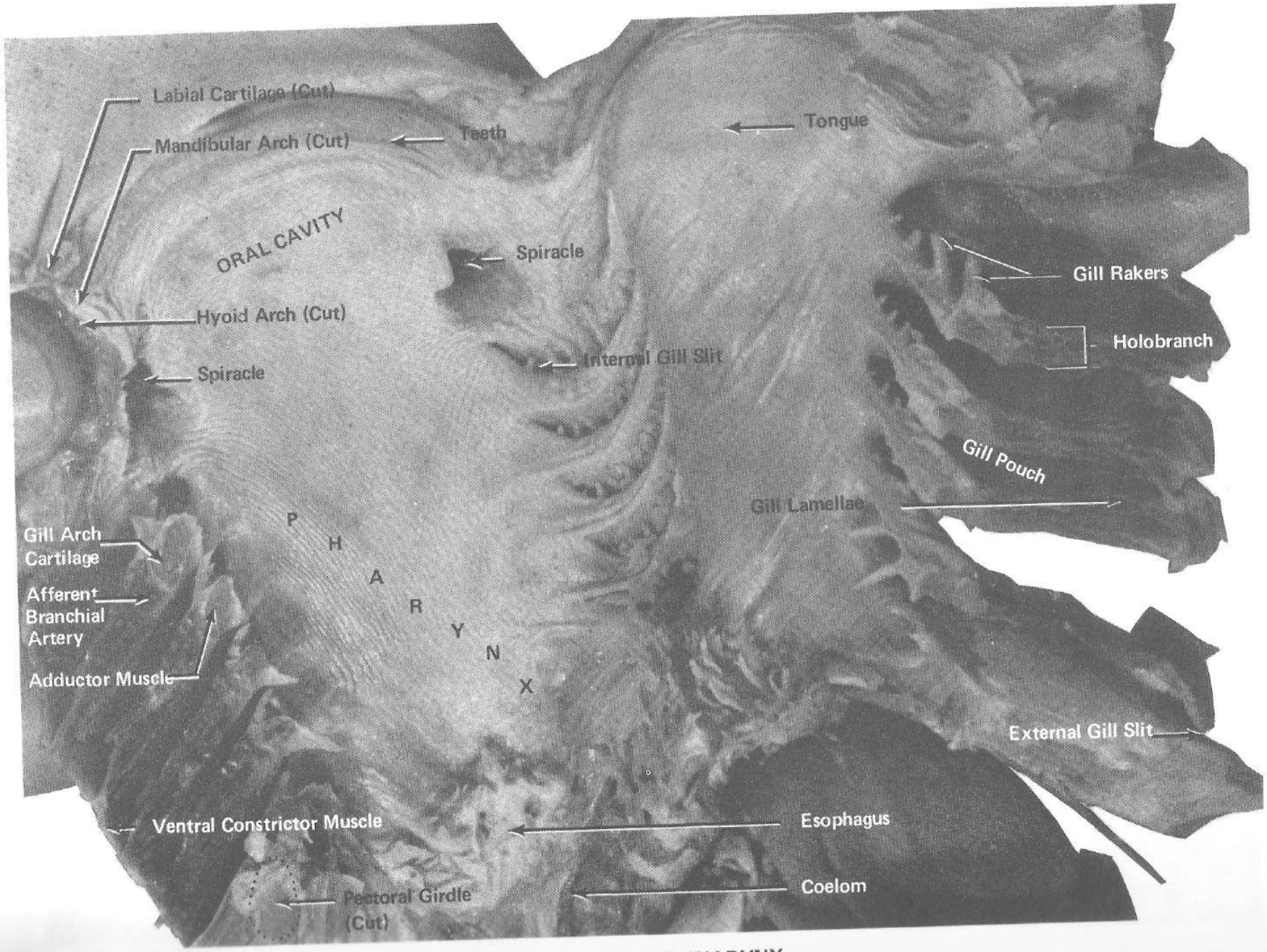
THE DORSAL VISCERA


Esophagus
Esophageal Papillae
TESTIS
Liver (Right Lobe)
Rugae
Pyloric Region
Duodenum

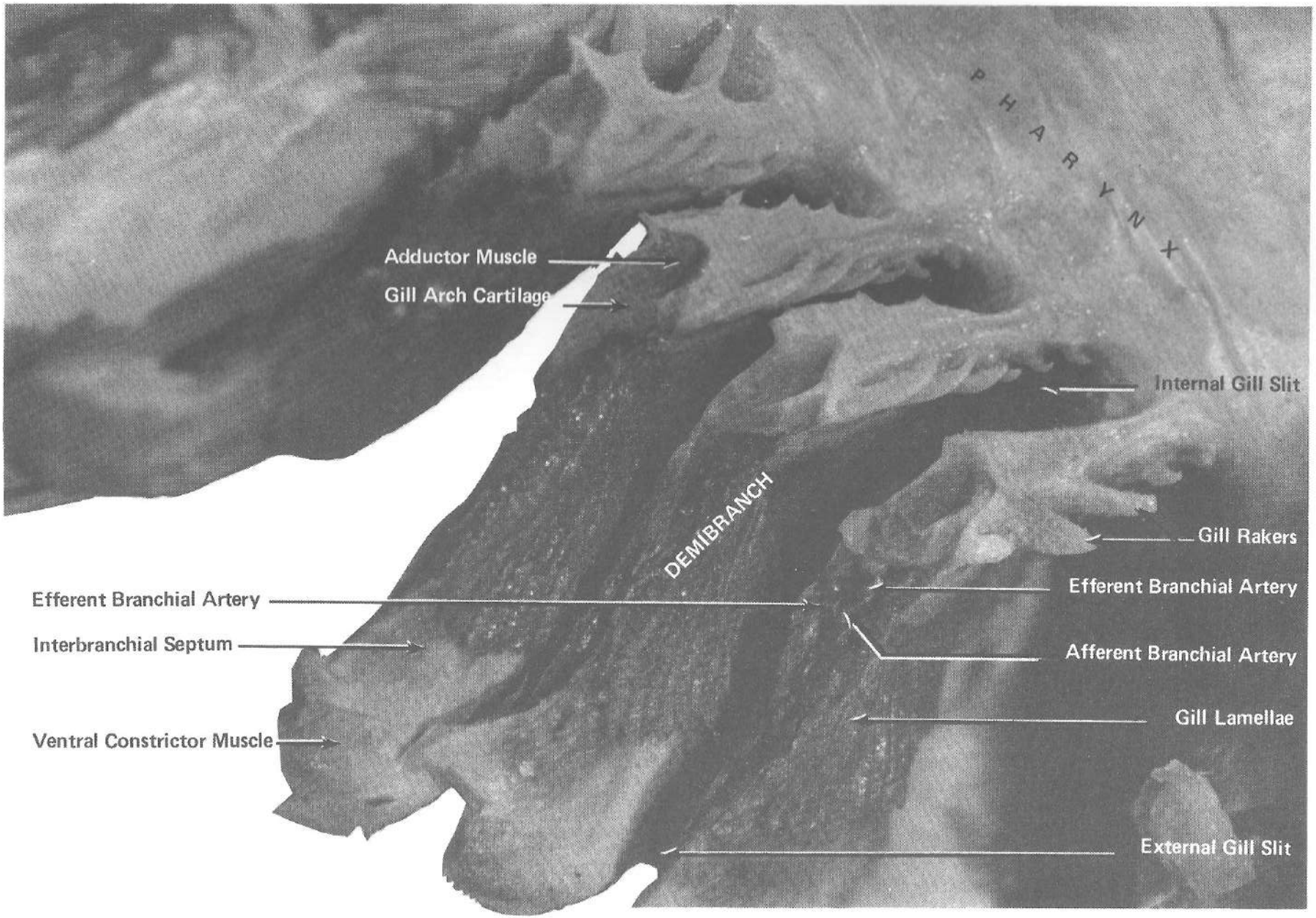
THE STOMACH

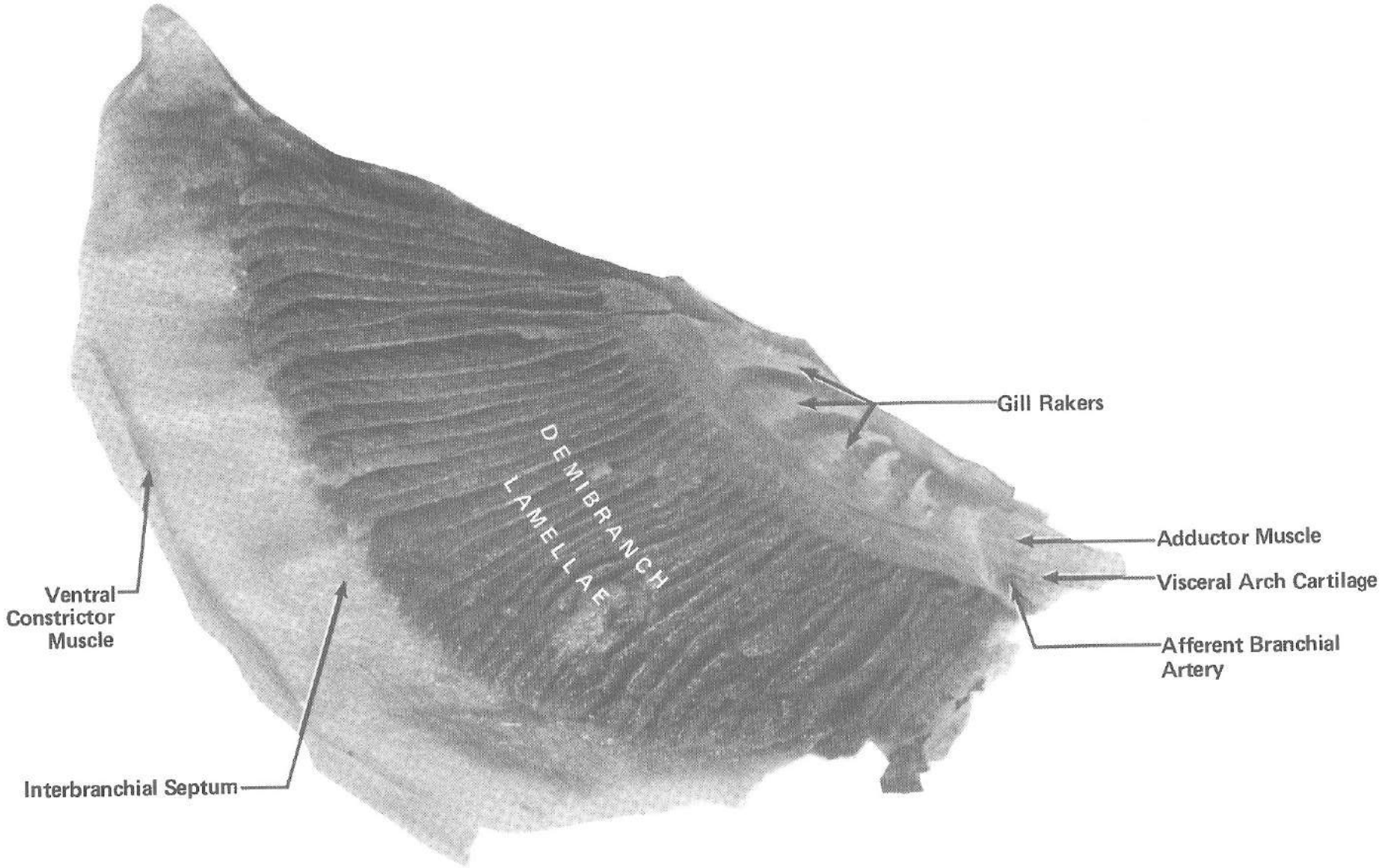


THE VALVULAR INTESTINE



THE ORAL CAVITY AND PHARYNX


PHARYNX
Adductor Muscle
Gill Arch Cartilage
Internal Gill Slit
DEMIBRANCH
Gill Rakers
Efferent Branchial Artery
Efferent Branchial Artery
Interbranchial Septum
Afferent Branchial Artery
Gill Lamellae
Ventral Constrictor Muscle
External Gill Slit



GILL SURFACE