THE DIGESTIVE SYSTEM

The structures of the digestive system include the *alimentary canal*, an elongated muscular tube that extends from the mouth to the anus, and associated *digestive glands*. The system will be considered in three distinct areas, as listed below.

The Salivary Glands — There are three pairs of *salivary glands* in the head and neck areas.

The Oral Cavity — This includes the mouth, pharynx, and associated structures.

The Abdominal Cavity — The abdominal visceral organs related to digestion will be studied.

THE SALIVARY GLANDS

The Dissection

Lay the rat in the dissection pan ventral side upwards. If this specimen was used to study the muscular system, the *salivary glands* were seen when you dissected the musculature of the head and neck. If the glands were not injured, they may now be studied in detail. If they were destroyed, begin with another animal as follows:

Carefully remove the skin from the ventral surface of the neck and the lateral surface of the head from ear to mouth, including the skin overlying the cheek, and the side of the neck. (In commercially prepared specimens some of the skin in this area may already have been removed in order to inject the arterial and venous systems with colored latex dye.) The *platysma* and other muscles associated with the skin are also removed at this time. Work carefully, especially in the cheek area, to avoid injuring the glands or their narrow ducts right below the skin.

Refer to the accompanying photograph on page 83 for help in identifying the glands. It is important to note that not all of the glands in this area are salivary glands. Some are *lymph glands* and others are *lacrimal (tear) glands*.

SUBMAXILLARY (MANDIBULAR) GLANDS — This large, elongated oval pair of salivary glands lies in the mid-ventral area of the neck. At its anterior border, each submaxillary gland is partially covered by several *lymph glands*. Its secretions pass anteriorly through a *duct, Wharton's duct*, between the masseter and digastric muscles. The duct ends in the floor of the mouth below the *tongue*, near the incisor teeth.

SUBLINGUAL GLANDS — This pair of salivary glands is closely associated with the *submaxillary glands*. The sublingual glands are smaller and located upon the antero-lateral surface of the submaxillary. The sublingual ducts extend anteriorly to join Wharton's ducts from the submaxillary glands before emptying into the mouth.

PAROTID GLANDS — Although this paired gland may be seen in ventral view, it is best seen upon the

lateral surface. These salivary glands are large and roughly triangular in shape. They extend dorsally behind the ear to the ventral border of the neck.

Lay the rat on its side to better observe one of the *parotid glands* and its duct. Three branches of the parotid duct join to form *Stensen's duct*, which runs anteriorly across the thick cheek muscle, the *masseter*. Stensen's duct enters the mouth to open opposite to the upper *molar teeth*.

EXORBITAL LACRIMAL GLAND — This large oval structure is *not* a salivary gland, but a *tear* gland. It lies upon the proximal portion of the *parotid duct*, upon the masseter muscle, just in front of the ear. Its secretions (tears) pass antero-dorsally to the eye. It must be lifted off the masseter in order to fully expose the parotid duct.

This gland can be readily seen in lateral view in the photograph, pages 63 and 64.

Note: Do not confuse branches of the *facial nerve*, leading to muscles of the face, with the *parotid duct*. Like the parotid duct, the nerve branches cross the masseter muscle from beneath the edges of the parotid gland. The parotid duct is generally thicker than the nerve branches and lies more ventrally.

THE ORAL CAVITY

The Dissection

For this part of the dissection it is best to use a freshly killed specimen. It is extremely difficult to pry open the mouth of preserved specimens. The likelihood that the more delicate mouth parts and even the teeth will be injured is greater in preserved rats.

Use a pair of strong scissors to cut into the corners of the lips. Cut posteriorly to the masseter muscle till you come to bone in the angle of the mouth. Then, use bone cutters to separate the upper from the lower jaw. Pry open the mouth as you cut posteriorly, parallel and just below the roof of the mouth. Continue to the *soft palate*. Pull down on the lower jaw to expose the *epiglottis*.

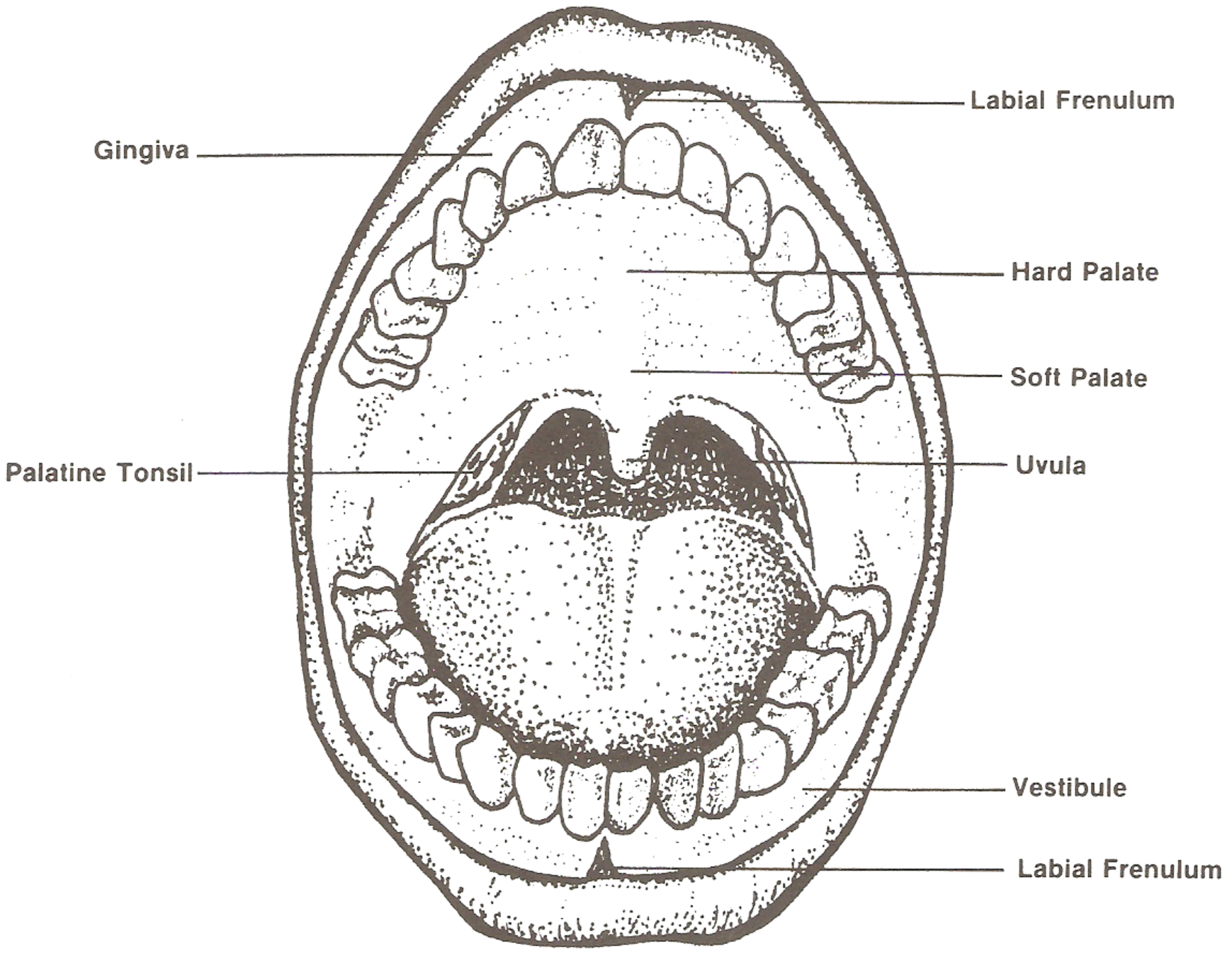
Teeth

An animal's diet is revealed by its *dentition* pattern. This refers to the types of teeth the animal possesses, their number, and their arrangement.

Sharp and pointy *incisors*, *canines*, and *premolars* predominate in *carnivorous* animals such as dogs, cats, lions, and tigers. *Herbivorous* animals such as horses and cows possess incisors for shearing grass and other vegetable matter. The incisors are followed by rows of molars. The large flattened molars, with broad grinding surfaces, are located toward the rear of the mouth.

Rats and humans are *omnivorous*, their diets consisting of both animal and plant matter. Their dentition combines sharp pointy incisors with flattened molars for grinding.

Enlarged, curved, and sharp *incisors* are characteristic of the entire order of rodents. The incisors grow throughout the life of the rat. Hard enamel is found only on their anterior surface. The action of gnawing on rough objects wears down the teeth continuously and files them to proper size. A rat eating only soft foods would soon find that it could not close its jaws without penetrating and lacerating itself with its elongated incisors.



THE HUMAN ORAL CAVITY

The *dental formulas* of the rat and man are compared below:

Rat $\quad I\,\frac{1}{1}\,,\ C\,\frac{0}{0}\,,\ P\,\frac{0}{0}\,,\ M\,\frac{3}{3}\,,$

Man $\quad I\,\frac{2}{2}\,,\ C\,\frac{1}{1}\,,\ P\,\frac{2}{2}\,,\ M\,\frac{3}{3}\,,$

The letters refer to the types of teeth:

I — Incisor, C — Canine, P — Premolar, M — Molar.

The upper set of numbers refers to the numbers of teeth in half of the upper jaw, while the lower set of numbers refers to the number of teeth in half of the lower jaw. Thus, the total number of teeth in the adult human is 32, and in the rat is only 16, namely, 4 incisors and 12 molars. There is no change of dentition throughout the life of the rat.

The large space between the anterior incisors and the much more posterior molars is known as the *diastema*. It separates the gnawing from the chewing areas of the mouth.

VESTIBULE — This is the region between the cheeks and the teeth.

THE TONGUE — This elongated muscular structure is readily visible upon the floor of the mouth, to which it is attached by two vertical membranes, the *lingual frenula*. These run along the antero-lateral

margins of the underside of the tongue. Most mammals, including man, having a single *frenulum* located medially beneath the tongue.

The surface of the tongue is covered by variously shaped projections known as sensory *papillae*. Upon the anterior surface one may find conspicuous *fungiform* papillae; vertical, filamentous *filiform* papillae are found between the molar teeth. More posteriorly, there are small, pointed, conical papillae directed backwards, and still more posteriorly, at the base of the tongue, there is a single large *circumvallate* papilla. Microscopic *taste buds* are found at the sides and bases of the papillae.

Palate

This structure forms the roof of the mouth. It is a partition which separates the oral cavity ventrally from the nasal cavity dorsally.

HARD PALATE — The anterior portion of the palate is supported by bone and is known as the *hard palate*. A series of transverse ridges, the *palatine rugae*, cross the roof of the mouth.

SOFT PALATE — This is the posterior continuation of the palate. It is muscular rather than bony. It separates the *oropharynx*, the continuation of the mouth, ventrally, from the *nasopharynx*, the continuation of the nasal passage, dorsally. In humans there is a finger-like process, the *uvula*, that hangs down from the center of the soft palate posteriorly. It is absent in the rat.

The *Eustachian tubes* are passages that connect the dorsal nasopharynx to the middle ear. The *internal nares* open at the anterior end of the nasopharynx. They are continuous with the *external nares*, or nostrils. Slit the soft palate mid-dorsally and deflect the flaps to the sides in order to observe these structures.

The Dissection

Continue cutting posteriorly with your scissors and press down upon the lower jaw and tongue to free the *epiglottis*. Expose the openings of the *trachea* and *esophagus*.

GLOTTIS — This is the opening into the *trachea*. (It may be seen if the tongue is pressed downwards.) The opening is guarded by a cone-shaped flap of cartilage, the *epiglottis*, located at the top of the *larynx* (voice box) near the base of the tongue. During eating, while swallowing, the *epiglottis* prevents food from entering the trachea.

TRACHEA — This tube is commonly called the *windpipe*. It is topped by the epiglottis and larynx. The trachea is kept open by rings of cartilage which extend around it at intervals. The rings are incomplete dorsally. The trachea branches to form two *bronchi*, which enter the lungs.

ESOPHAGUS — This muscular tube, located dorsal to the trachea, is known as the *gullet*. Unlike the trachea, however, it is collapsed. Food is pushed forward in the esophagus by the rhythmic contractions of its walls, a process known as *peristalsis*.

The esophagus extends posteriorly and dorsally within the thorax, then passes through the diaphragm into the abdominal cavity, where it ends at the stomach.

The Dissection

In order to find the trachea and esophagus, use two wooden probes. With one, penetrate the glottis and pass into the trachea. Move the probe up and down and observe the movement of the trachea. With the second probe, enter the esophagus dorsal to the glottis. Move the probe up and down and observe the corresponding movement of the esophagus.

THE ABDOMINAL CAVITY

The muscular *diaphragm* separates the upper from the lower ventral body cavity. The upper is the *thoracic*, the lower is the *abdominal cavity*. We shall study the abdominal area first, and later consider the thorax in relation to the lungs, heart, and circulatory vessels.

The Dissection

With your fingertips, locate the lower edges of the ribs. Your fingertips will trace an arc, an inverted letter "V." Refer to the photo entitled "Mapping Incisions," page 85. Make the cuts in the order indicated, beginning with No. 1. Do not make incisions No. 4 and No. 5 until you have completed the observations of the abdominal viscera and are ready to observe the *thoracic organs.* This will prevent the thoracic area of your specimen from drying out prematurely.

Use your scalpel to cut the musculature along the line you have traced with your fingertips, indicated as No. 1 on the photo. Do not cut too deeply. A sharp scalpel in an untrained hand may lead to the destruction of internal organs in the specimen and possible injury to the student.

Continue with incision No. 2. This will bring you about three-quarters of an inch above the *urogenital aperture*.

Continue with incision No. 3 from the midline laterally to the rear body wall.

After the muscle layers have been cut you will find a fine membrane, the *peritoneum*, which lines the inside of the abdominal cavity. The portion of this serous membrane that you see is the *parietal peritoneum*; the *visceral peritoneum* covers the abdominal viscera. Cut through the peritoneum and fold back the entire *ventral abdominal wall* to expose the organs below.

Some specimens may contain excess preservative fluid, coagulated blood, or dye that has escaped from the blood vessels. In such cases it is necessary to wash out the abdominal cavity. Hold the rat under a moderate flow in the sink and rinse gently under running water. Use paper towels to soak up excess water. Your view should now correspond to that in the photos on pages 86 through 88.

Identify the following structures:

DIAPHRAGM — This dome-shaped muscular wall separates the thoracic from the abdominal cavity. It is also the most important muscle for *breathing*, permitting inhalation and exhalation. Three major vessels pass through the diaphragm between the thorax and the abdomen. These are the *aorta, posterior vena cava*, and *esophagus*.

ESOPHAGUS — We have already noted the anterior end of this muscular tube lying dorsal to the *trachea*. The *esophagus* passes posteriorly through the diaphragm to enter the abdominal cavity, where it can be seen against the left dorsal body wall as a flattened tube entering an enlarged, pouched structure, the *stomach*.

LIVER — This dark brown organ, located under the dome of the diaphragm, dominates the upper abdomen. The *falciform ligament*, a ventral peritoneal membrane, attaches the liver to the underside of the diaphragm and to the ventral body wall.

Four lobes of the liver may be differentiated. These are: the *median*, or *cystic lobe*, which has a deep notch or fissure in the center; a *right lobe*, partially divided into an anterior and posterior lobule; a large *left lobe*, and the small *caudate lobe (Spigelian lobe)*, which is wrapped around the *esophagus* and is best seen when the liver is raised.

BILE DUCT (DUCTUS CHOLEDOCHUS) — The rat has *no gall bladder*. However, ducts from the various lobes of the liver unite to form a tube, the *bile duct (ductus choledochus)*, which carries bile into the duodenum. Thus there is no enlarged storage area for bile. The rat and other animals without gall bladders are characterized as feeding fairly continuously.

We will now continue to trace the alimentary canal posteriorly.

STOMACH — This large muscular pouch lies below the *liver* on the left side, extending toward the mid-line. Find where the *esophagus* joins and becomes continuous with the stomach. This is the *cardiac region*. In rats, this portion is not the true stomach, but similar to the rumen of cattle, both histologically and functionally. The next portion, the *fundus*, a blind sacular portion on the left side, is followed immediately by the main *body*, and finally by the *pyloric* portion. From here the partially digested, liquefied food, known as *chyme*, passes into the *duodenum* portion of the small intestine by way of a circular muscular valve called the *pyloric sphincter*.

The Dissection

Open the stomach with your scissors by cutting along its longer, convex border, which is known as the *greater curvature*. Begin on the left side and continue along the posterior border. Empty the contents of the stomach onto a paper towel. Do you recognize the remains of any plant or animal matter? Discard all stomach contents and wash out the inside of the stomach. Note the *cardiac sphincter*, which controls the entrance of food from the esophagus. Examine the *pyloric sphincter*, at the distal end, which regulates the release of partially digested food (chyme) into the duodenum. Look along the inner walls of the stomach and note the *rugae*, or folds, which help to churn and mix the food with digestive juices.

The shorter anterior, concave border of the stomach is known as the *lesser curvature*. A membrane, the *lesser omentum*, extends from the lesser curvature of the stomach and from the small intestine to the liver. Another membrane, the *greater omentum*, forms a sac that extends posteriorly from the greater curvature of the stomach and attaches to the dorsal body wall. The spleen is also supported by this membrane. In older, fatter specimens, this membrane stores much fat and forms an apron upon the surface of the intestines.

SMALL INTESTINE — The small intestine is about six times the length of the rat's body, from snout to anus. The large intestine is only once the length of the body.

The small intestine is divisible into three segments:

Duodenum — This is the first segment as well as the shortest of the three. It leaves the *stomach*, continuous with the *pyloric* region, as a "U"-shaped tube. Many ducts from the *pancreas* enter the *bile duct* (ductus choledochus) before it joins the duodenum. Thus, the distal portion of the bile duct brings not only bile but also pancreatic juice to the duodenum.

Jejunum — This section of small intestine follows the duodenum. It contains numerous finger-like *villi* along its inner walls for the absorption of digested food. Cut open the jejunum, wash out its contents, and feel the velvety texture of its inner surface. Use a hand lens or a low power dissection microscope to observe the villi more clearly. The inner walls of the jejunum also contain *intestinal glands* which secrete *intestinal juices*.

Ileum — This is the final portion of the small intestine. There is no clear demarcation between the *jejunum* and *ileum*, although there are histological differences. The two segments are about equal in size.

The small intestine opens into the large intestine by way of another sphincter muscle, the *ileocaecal valve*.

The coils of the intestine are held in place by a fine peritoneal membrane, the *mesentery*. It may be observed when a coil of the small intestine is lifted and the two ends are stretched. The mesentery will be

visible as a fine, thin membrane. It is responsible for the coiling observed. Note its shiny appearance. It is interlaced with narrow blood vessels, lymphatic vesels, adipose tissue, and lymph nodes. Some of the tiny blood vessels form the beginnings of the portal system, transporting digested food from the intestine to the liver. Cut through the mesentery to unravel the small intestine. Measure its length. How does it compare to the relative length of man's intestine (about twenty feet)?

LARGE INTESTINE — The name of the *large intestine* is derived from its larger diameter; it is very much shorter than the *small intestine*. It too is divisible into three segments:

Caecum — Extending posteriorly from the *ileocaecal valve* is a wide, blind-ended sac-like tube, the *caecum*. It is quite long in rodents and herbivores. It serves as a fermentation tank, an area of absorption, and as a site for the digestion of cellulose of wood. Many mammals, including man, have a short *vermiform* appendix at the end of the caecum. It is absent in the rat.

Colon — This is the major portion of the large intestine. It ascends to the level of the stomach, crosses towards the left, and descends against the dorsal body wall.

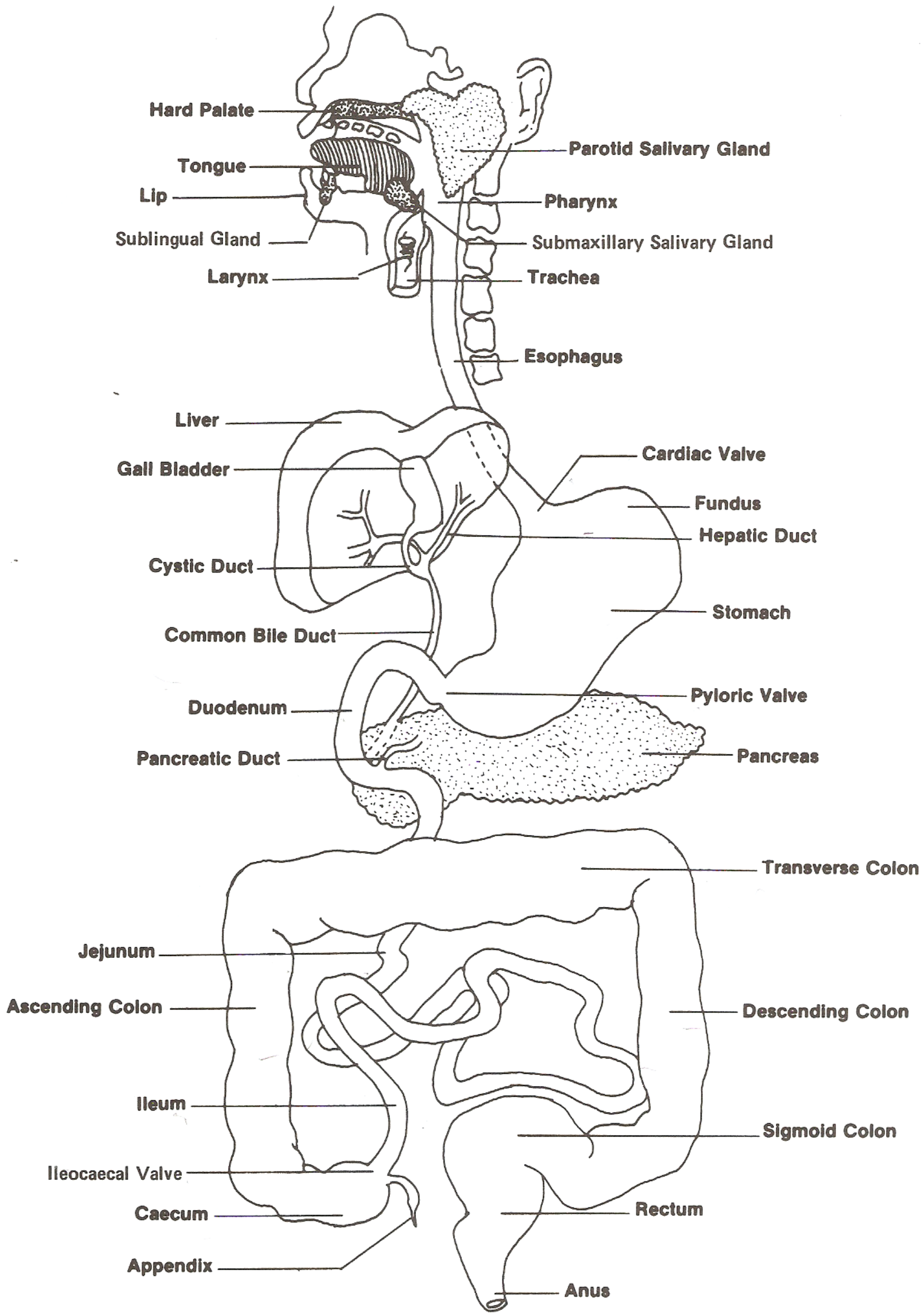
Rectum — This is the final segment of the large intestine. It is straight and thick, often with a beaded appearance due to the waste materials within. Water is absorbed here and wastes are stored for elimination. The orifice by which the rectal wastes leave the body is the *anus*.

PANCREAS — Lift the main portion of the small intestine. Expose the stomach and duodenum. Observe the *pancreas*, a lobulated glandular structure lighter in color than the neighboring intestines. Its main portion lies in the loop of the duodenum. An elongated portion may be observed extending to the left, toward the stomach and spleen. Parts of the gland may also be seen along the dorsal body wall extending to the right of the duodenum and along the dorsal mid-line. The human pancreas is much more compact. The main ducts of the rat's pancreas join the *bile duct* before entering the duodenum. The pancreas also secretes the hormone *insulin* directly into the bloodstream.

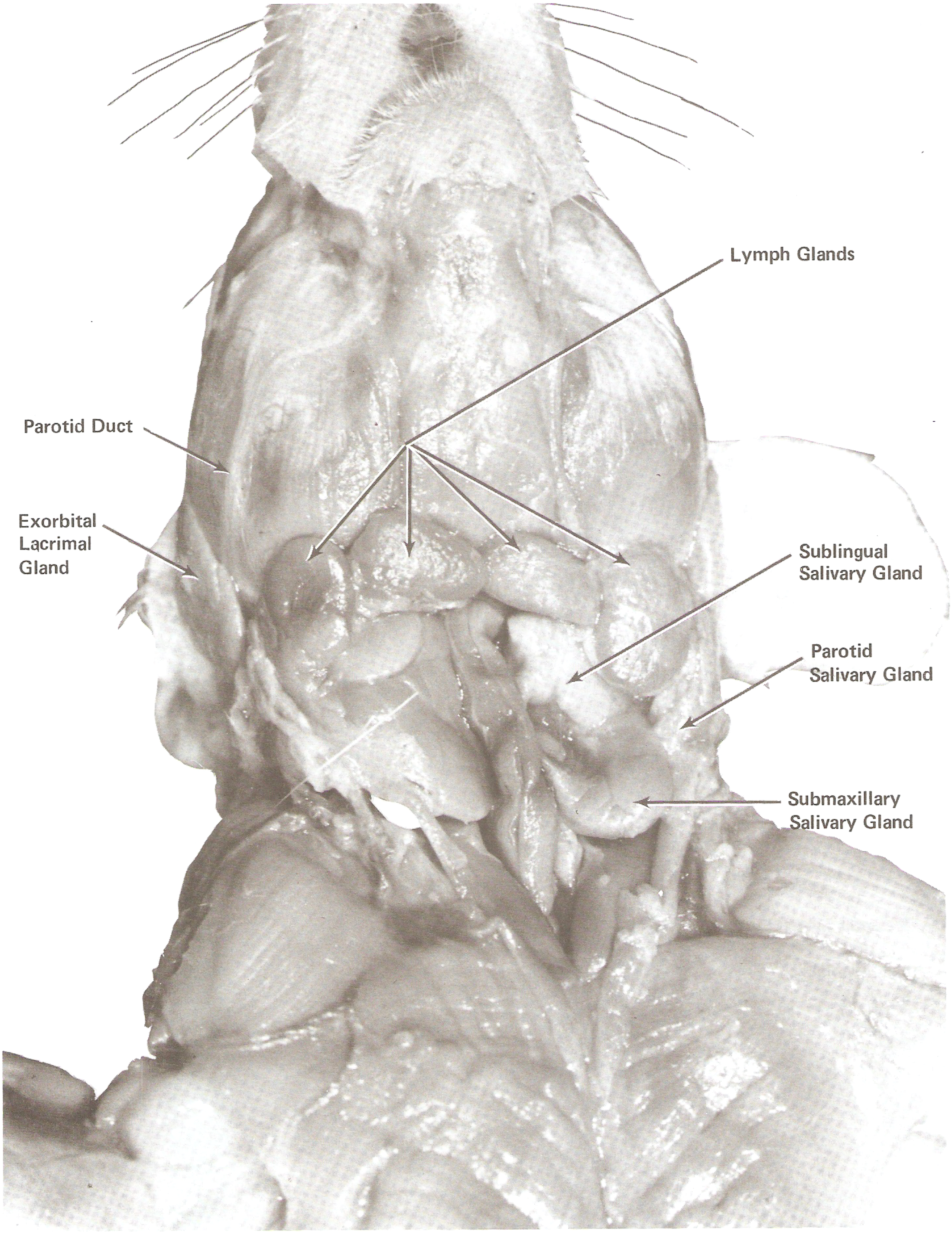
SPLEEN — This is not an organ of the digestive system, but of the circulatory. It acts as a reservoir for the storage of blood and also as a site for the manufacture of white blood cells. It is, however, considered here due to its physical proximity to some of the digestive structures.

The spleen is a dark-colored elongated organ that can readily be seen along the left side of the *stomach* without moving any other organs. It is tied to the stomach by a portion of the *greater omentum* known as the *gastrosplenic ligament*.

A number of organs that are seen in the abdominal cavity are unrelated to the digestive system. They include the *kidneys*, *urinary bladder*, and *reproductive structures*. Most of the female and some of the male reproductive structures are located in the abdominal cavity. The urogenital system and its associated structures will be studied in a later chapter.



THE HUMAN DIGESTIVE SYSTEM


Lymph Glands
Parotid Duct
Exorbital
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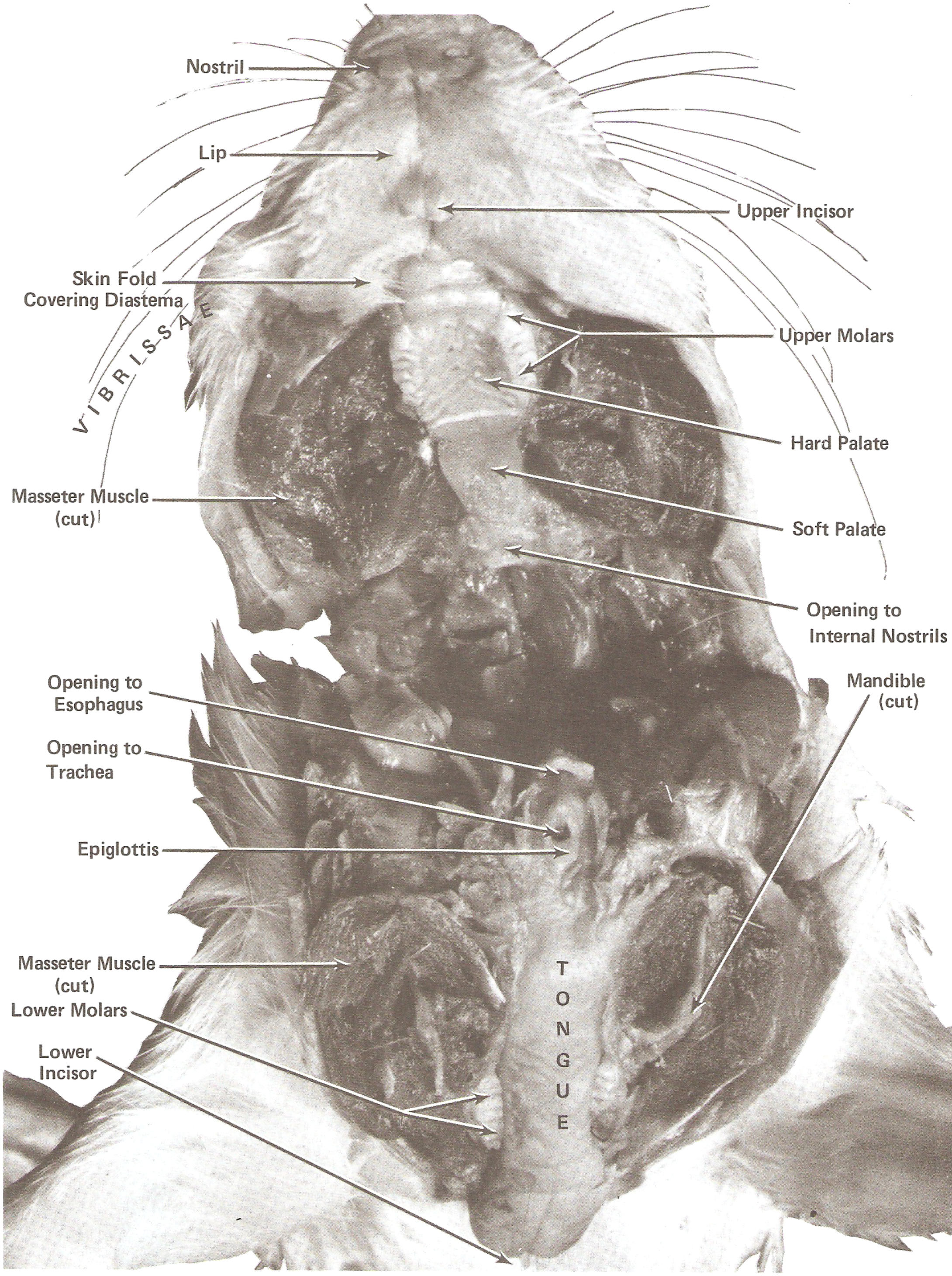
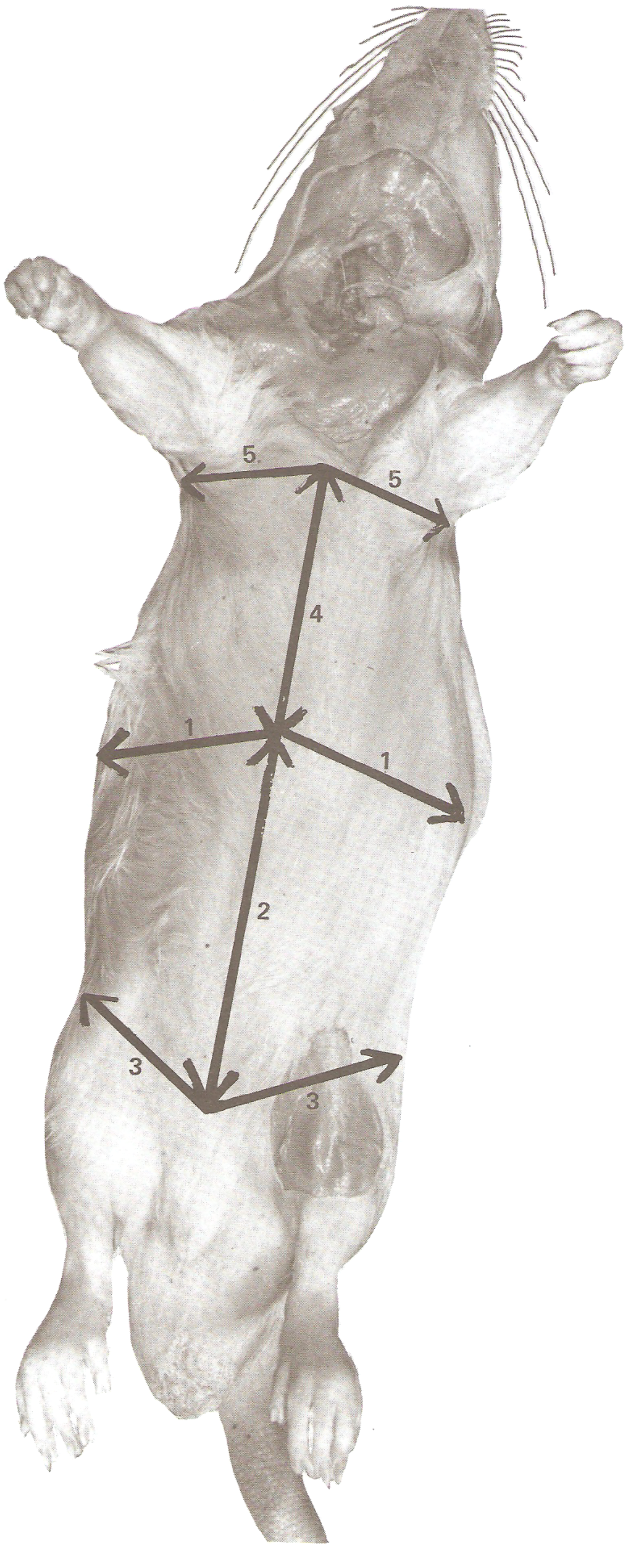
Gland
Sublingual
Salivary Gland
Parotid
Salivary Gland
Submaxillary
Salivary Gland


Nostril
Lip
Upper Incisor
Skin Fold
Covering Diastema
VIBRISSAE
Upper Molars
Hard Palate
Masseter Muscle
(cut)
Soft Palate
Opening to
Internal Nostrils
Mandible
(cut)
Opening to
Esophagus
Opening to
Trachea
Epiglottis
Masseter Muscle
(cut)
Lower Molars
Lower
Incisor
TONGUE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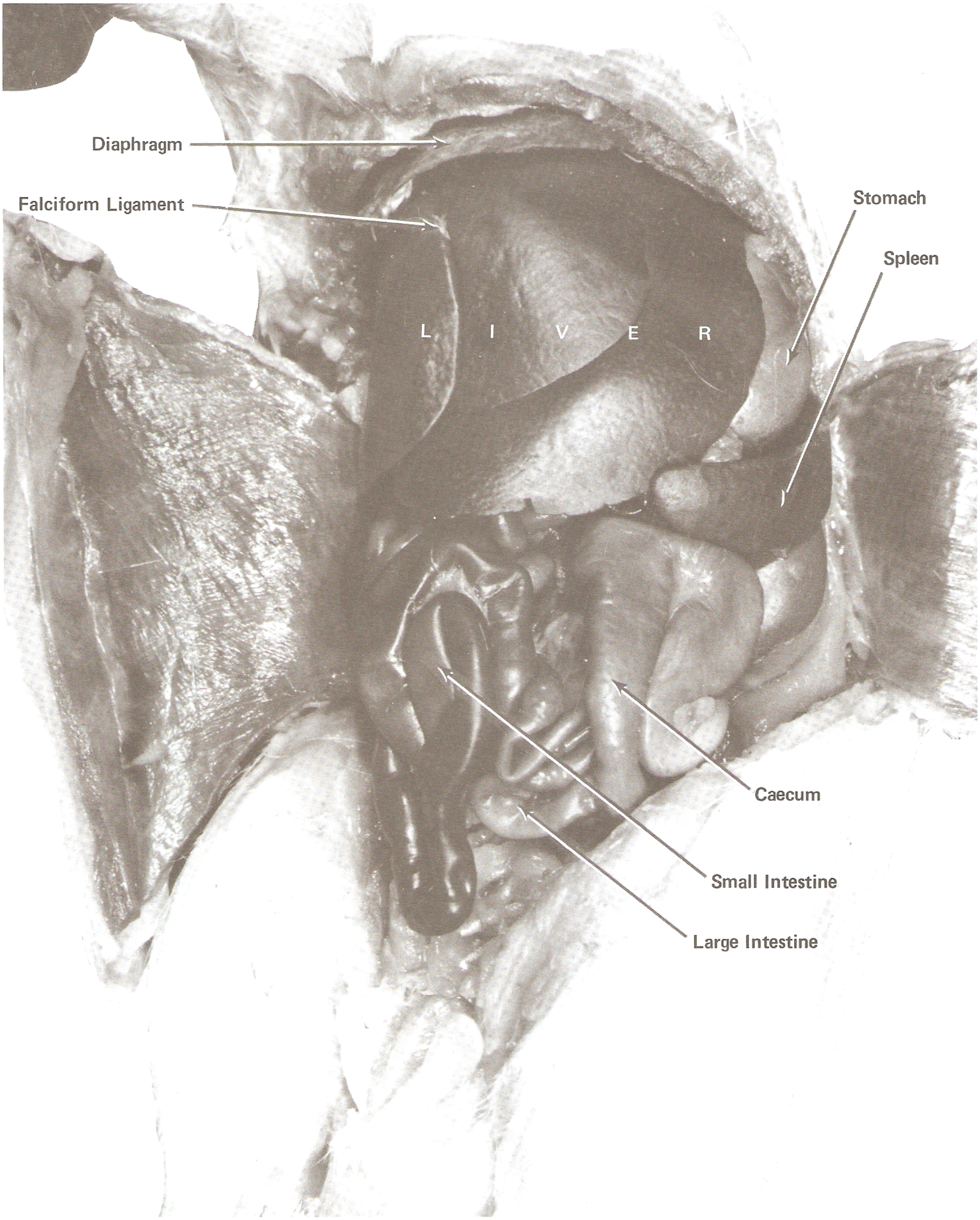
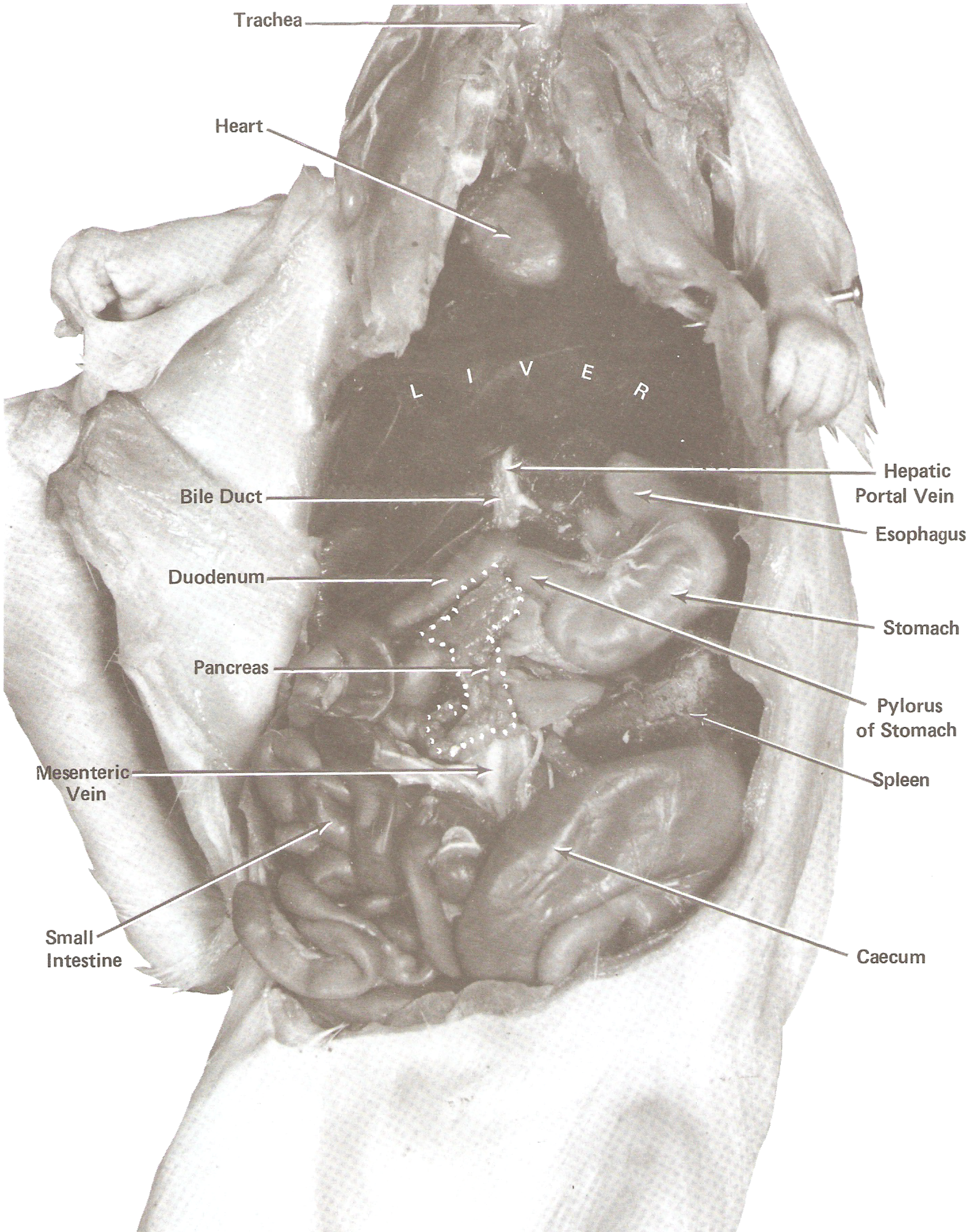
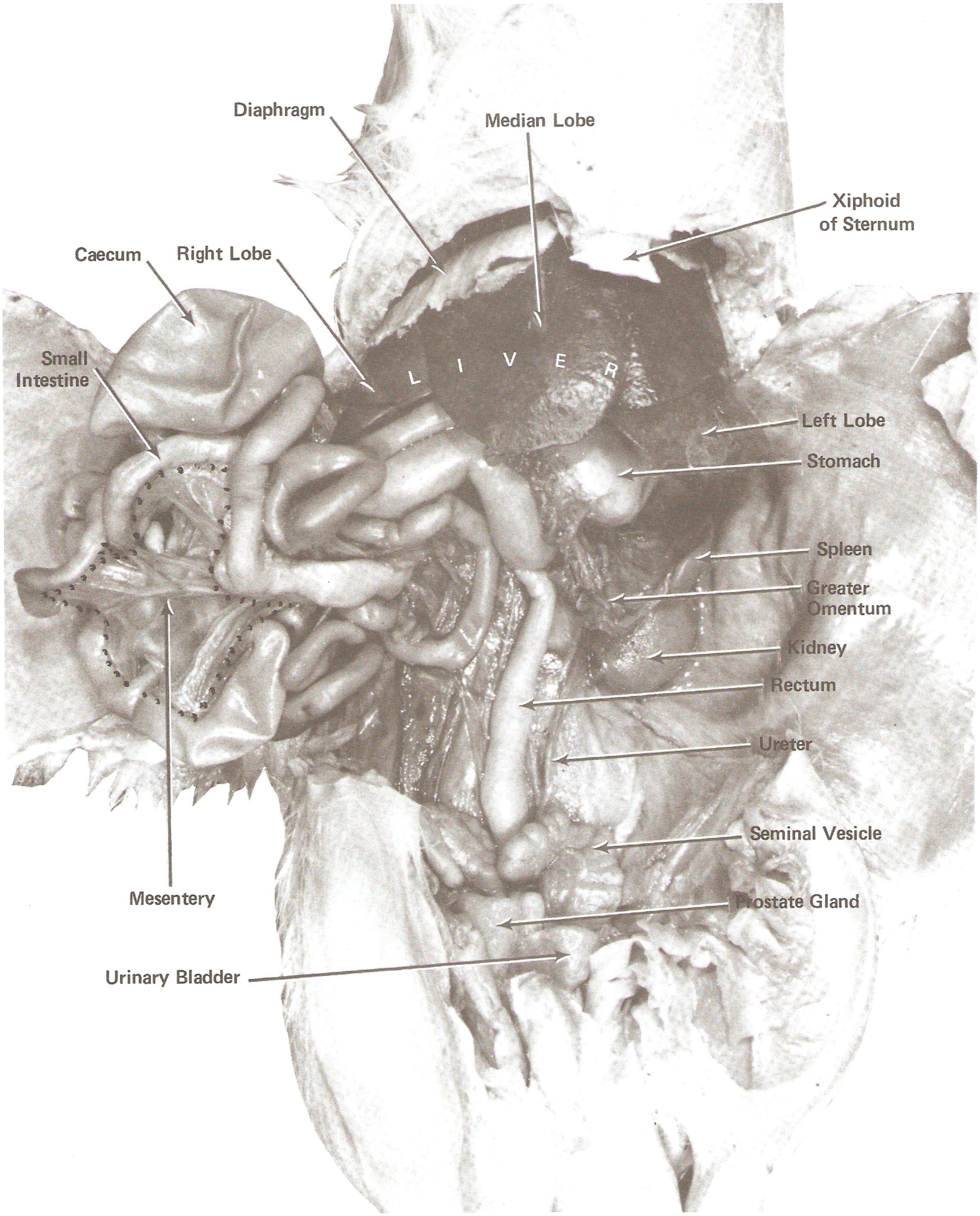


ABDOMINAL CAVITY (Undisturbed)



ABDOMINAL VISCERA (Liver Raised)



ABDOMINAL VISCERA (Intestine Deflected)