Exercise 11
The Digestive System

Objectives

After completing the laboratory exercise of the digestive system, you should be able to:

- Identify in the microscope sections of the oral cavity, esophagus, stomach, and intestines.
- Identify the tongue in the light microscope.
- Identify each layer in the tubular digestive system organs.
- Identify microscopic sections of any organ of the digestive system.
- Identify oral cavity structures by their appearance in the light microscope.
- Identify salient structural features of the tongue and lip in mammals.
- Identify the various types of lingual papillae and the taste buds on them.
- Identify the parts of a tooth.
- Identify the salivary glands in light microscopic preparations.
- Identify the external muscle of the esophagus, type of muscle present and its arrangement.
- Identify the villi border of the intestines.
- Identify the following junctions in the digestive system: cardiac, pyloric, anorectal.
- Identify in microscopic sections both the exocrine and endocrine pancreas.
- Identify the liver and its structural features in microscopic sections.
- Identify the principal cell types in the liver in microscopic sections.

Introduction

The digestive system consists of a long hollow tube or tract that starts at the oral cavity and terminates at the anus. The system consists of the oral cavity, esophagus, stomach, small intestine, large intestine, rectum and anal cavity. Associated with the digestive tract are the accessory organs: salivary glands, liver and pancreas. These organs produce numerous secretions that enter the digestive system through the excretory ducts. These secretions aid in the digestion of the ingested material and its eventual absorption.

The Oral Cavity

The oral cavity is the first portion of the digestive tract, and consists of the mouth and the structures which are enclosed within it. Because food is physically broken down in the oral cavity this region is lined by a protective, non-keratinized, stratified squamous epithelium, which also lines the inner or labial surface of the lip.

The lip

The lip is composed of striated muscles. The outer covering has cornified, stratified squamous epithelium containing hair follicles, sebaceous glands, sweat glands and elastic connective tissue. The epithelium of the free margin of the lip is richly supplied by blood vessels, which are responsible for the red color.

List of slides – Lip

OC-1 Lip, human, t.s.

The tongue

The tongue in mammals is an extremely muscular organ within whose substance there are a number of smaller salivary glands, and any number of motor and sensory nerve fibers. The bulk of the tongue is skeletal muscle, arranged in three layers, all at right angles to each other. This provides for an amazing degree of flexibility and is vital to vocalization. There may be a considerable amount of adipose tissue
present as well. The orientation of the muscle layers gives the tongue a distinctive appearance in LM sections that isn't easily mistaken for anything else.

The dorsal surface of the tongue is covered by a mucosa modified to form numerous elevations or **papillae**. There are four types of papillae:

- **Filiform papillae** – slender, conical structures, which project up, forming a velvety covering on the tongue. In some species (such as cats and cattle) filiform papillae are extremely large and rough, and the peculiar rasping effect of a cat's tongue due to these papillae. It's also what a cat uses to clean its fur. The stiff papillae make effective bristles for removing debris.

- **Circumvallate (Vallate) papillae** – This type of papilla is set into a deep pocket in the tongue's surface and anchored at the bottom by a short broad stalk. It does not protrude above the general level of the surface. It's surrounded by a deep "moat" into which some of the lingual salivary glands secrete. Vallate papillae are the largest type, easily visible with the naked eye in most animals. They are paired and located near the back of the tongue. Vallate papillae usually show **taste buds**. The taste buds are well defined, lightly staining areas which enclose several banana shaped sensory cells. You should see some on the undersides of the papilla proper, and you may also see some on the tongue side of the "moat." Taste buds are discrete and well encapsulated by CT, which can be demonstrated with special stains. The sensory cells of the buds are located below the level of the epithelium, and they communicate with the outside via a so called **taste pore**. Through this pore project the microvilli (or "taste hairs") on the tops of the sensory cells.

- **Fungiform papillae** – are mushroom shaped structures. They raise above the general level of the filiform papillae and they usually have taste buds.

- **Foliate papillae** – is best seen in rabbits. They are leaf-like, as in the pages of a book, in structure, are set in the sides of the tongue and carry taste buds.

**List of slides - Tongue**

OC-2  Mammal  
OC-3  Mammal  
OC-4  Monkey  
OC-5  Monkey, t.s.  
OC-6  Cat  
OC-7  Guinea pig  
OC-8  Hamster  
OC-9  Rat  
OC-10  Frog  
OC-11  Perch  
OC-12  Frog, t.s.

**List of slides - Papillae**

OC-13  Filiform  
OC-14  Filiform, human, t.s.  
OC-15  Foliate, rabbit  
OC-16  Fungiform, cat  
OC-17  Fungiform, monkey  
OC-18  Fungiform, monkey, t.s.  
OC-19  Fungiform, human, t.s.  
OC-20  Circumvallate, monkey  
OC-21  Circumvallate, horse  
OC-22  Circumvallate, monkey  
OC-23  Circumvallate, human, t.s.  
OC-24  Tastebuds, Rabbit  
OC-25  Tastebuds, monkey, t.s.
The palate

The palate is composed of the hard palate, the soft palate and the uvula and it separates the oral and the nasal cavities from each other. Like the rest of the mouth, the palate is covered by a thick stratified squamous epithelium supported by a tough, densely collagenous lamina propria. To assist mastication, the palatal mucosa is thrown up in transverse folds. The mucosa of the hard palate is bound to the underlying bone by a relatively dense submucosal tissue containing a few accessory salivary glands.

List of slides – Palate

OC-26  Hard palate
OC-27  Hard palate
OC-28  Soft palate
OC-29  Soft palate
OC-30  Hard and soft palate
OC-31  Hard and soft palate

Teeth

Each tooth has a crown, a cervix and a root. The portion of the tooth that is visible in the oral cavity is the crown. The region housed within the alveolus is the root and the portion between the crown and the root is the cervix. Use your textbook or your atlas to identify the parts of a tooth and the different stages in odontogenesis.

List of slides – Tooth development

OC-34  Early dental stage
OC-35  Late dental stage
OC-36  Dental cup
OC-37  Early dentin
OC-38  Late dentin
OC-39  Enamel organ
OC-40  Tooth, in situ
OC-41  Tooth, in situ
OC-42  Tooth, decalcified
OC-43  Skull, Salvelinus
OC-44  Mandible, chick

Tubular Organs

Once past the oral cavity, most of the digestive tract has a distinct structural pattern that typifies tubular organs in general. Although there are some minor variations from place to place, its structure usually includes four "tunics" or layers, a couple of which have subdivisions. From the innermost (i.e., closest to the lumen) to the outermost, these are the tunica mucosa (which has subdivisions); the tunica submucosa; the tunica muscularis; and an outermost tunica adventitia (or serosa).

- The mucosa – contains an epithelial lining bordering the lumen, a lamina propria containing areolar (loose) or reticular connective tissue and an outer muscularis mucosa.
- The submucosa – present from the esophagus to the anal canal. Consists of areolar CT with collagenous fibers, glands, small blood vessels, nerve fibers and ganglia.
- The muscularis – consists of two layers of smooth muscle fibers, the inner circular layer and the outer longitudinal layer.
The outer serosa or adventitia – consist of areolar connective tissue with nerves, blood vessels, adipose tissue and an outer mesothelium covering.

**The esophagus**

The lumen of the esophagus is lined with stratified squamous epithelium. In some species this epithelium may be keratinized. The underlying CT of the lamina propria has many small blood vessels, and probably a few formless aggregations of lymphatic tissue here and there.

At low magnification, you can see that the lumen of the organ is deeply folded. This plication is a result of the elasticity of the wall, which has to be capable of expanding considerably to swallow large chunks of food. The CT of the lamina propria and/or submucosa in the esophagus has a strong component of elastic fibers worked into the collagen weave to provide it with a substantial degree of elasticity.

In the dog the muscularis is absent in the cervical part of the esophagus, but becomes evident in the distal portion. Near the stomach, the muscularis may become complete.

Another characteristic of the cervical esophagus is the presence of glands in the submucosa. These are the esophageal glands proper, mucus secreting structures located outside the muscularis mucosae. This is an important clue for recognition of the esophagus: submucosal glands occur only in one or two places, and the combination of submucosal glands and stratified squamous epithelium is found only in this organ.

In the upper portion of the esophagus in most, if not all, mammals, the tunica muscularis is composed of skeletal muscle arranged in two layers: inner circular and outer longitudinal. In most species, skeletal muscle is replaced by smooth muscle as one descends deeper into the organ; the tunica muscularis near the junction with the stomach is wholly smooth muscle in most animals.

**List of slides - Esophagus**

| ES-1 | Dog, c.s. |
| ES-2 | Mammal, l.s. |
| ES-3 | Monkey, t.s. |
| ES-4 | Human, t.s. |
| ES-5 | Esophagus and trachea |
| ES-6 | Esophagus and trachea, guinea pig |
| ES-7 | Esophagus and trachea, chick |
| ES-8 | Middle, human |
| ES-9 | Lower, human |
| ES-10 | Frog |
| ES-11 | Necturus |
| ES-12 | Turtle |
| ES-13 | Opossum |

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**The stomach**

At the esophageal-stomach junction you can easily differentiate between the two organs. There is stratified squamous epithelium on the esophageal side and simple columnar epithelium on the stomach side. Note the absence of goblet cells in the stomach.

Once inside the actual stomach, you will find that the mucosal epithelium of the digestive tract differs in appearance and in function in different regions. While in most of the digestive tract the lining epithelium is protective in function (as, for example, in the esophagus) or absorptive (as in the intestines), in the stomach the mucosal epithelium is secretory, and produces products essential to the digestive process.

You should be able to see that the lumen of the stomach is lined with an ordinary looking simple columnar epithelium. There are no goblet cells in it (in which respect it differs from the intestines). If you were somehow able to stand inside the stomach and look at it *en face*, you'd see deep depressions in the "floor" representing *gastric pits* or *foveolae*, also lined with this simple columnar epithelium. Small openings into the underlying regions of the mucosal tunic are found at the bottom of these pits. If you took
out your Swiss Army Knife and started excavations into the lamina propria and the regions beneath the pits, you'd find the actual secretory structures, the various types of \textit{gastric mucosal glands}.

There are three major categories of these glands, associated with different parts of the stomach. The glandular regions are wholly confined to the tunica mucosa. Unlike some other portions of the tract, submucosal glands are not found in the stomach at all.

- **The first category** – is the \textit{cardiac glands}. These are found in the most proximal region of the stomach (\textit{i.e.}, that part closest to the input of the esophagus), called the "cardiac region," because it's located close to the heart. At the bottom of the gastric pits are the openings into the secretory portions of the glands. The glands themselves are tubular, extending deep into the mucosa, and are mucous secreting in nature. They are limited in their distribution to the region immediately adjacent the esophagus. (Occasionally similar glands can be found in the esophagus itself. These are called "esophageal cardiac glands," and probably represent individual variations in development.)

- **The second category** – and by far the most numerous type of gastric gland is the \textit{fundic gland}. These are found underlying the bulk of the gastric mucosa. These glands produce the bulk of secretions in the stomach. The fundic glands, like the other types, open into the base of gastric pits. They are deep, straight glands, with a mixed population of cells. You may be able to identify two principal cell types; chief cells and parietal cells. The chief cells have cytoplasmic basophilia, a vesicular nucleus and prominent nucleoli. The parietal cells are round, much larger than the chief cells, and very strongly eosinophilic.

- **The third category** – of gastric glands is the \textit{pyloric glands}, found in the region of the pylorus, the junction between the stomach and the duodenum. Structurally they resemble the glands of the cardiac region, though in the pyloric stomach the gastric pits tend to be deeper and the glands larger and more obvious.

The muscularis of the stomach, unlike the bulk of the tract, is generally considered to have three layers. The innermost layer is obliquely oriented with respect to the long axis of the organ. There is a circularly oriented layer next outward of that, and the outer layer is longitudinal. This arrangement of muscle causes the stomach to "wring" itself and to contract in length and diameter.

**List of slides – Esophagus/stomach junction**

- ES-14 Mammal
- ES-15 Dog
- ES-16 Mammal
- ES-17 Monkey
- ES-18 Monkey, t.s.

**List of slides – Stomach**

- ES-19 Cardiac, human
- ES-20 Cardiac, mammal
- ES-21 Cardiac, monkey, t.s.
- ES-22 Fundic, mammal
- ES-23 Fundic, human
- ES-24 Fundic, human, t.s.
- ES-25 Fundic, monkey
- ES-26 Fundic, monkey, t.s.
- ES-27 Pyloric, human
- ES-28 Pyloric, monkey, t.s.
- ES-29 Pyloric, human, t.s.
- ES-30 Rat
- ES-31 Guinea pig
- ES-32 Rabbit
- ES-42 Stomach - review slide
- ES-43 Stomach, primary carcinoma
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List of slides – to review if time allows

ES-33  Crop, chicken
ES-34  Proventriculus, chicken
ES-35  Gizzard, chicken
ES-36  Stomach, chicken
ES-37  Necturus
ES-38  Anolis
ES-39  Ambystoma
ES-40  Rana
ES-41  Frog

Small Intestine

The small intestine is divided in three segments; duodenum, jejunum, and ileum, but the general structure of the organ is similar throughout. The tunica mucosa covering the lumen of the small intestine is formed by simple columnar epithelium. The apical surfaces of the cells have villi. In the duodenum the villi are all quite regular in size and in shape. Jejunum villi are longer and more irregular that the short, blunt villi characteristic of the duodenum. In the ileum the villi are even more leaf-like and you probably will see islands apparently floating free in the lumen. These are actually the tips of villi whose bases are out of the plane of the section, and which have been cut off.

Between the villi are the intestinal crypts which extend downward to the deepest levels of the tunica mucosa. In the depths of the crypts, you will find clusters of 3 to 5 cells with coarse red staining granules at the apical end. Note that these cells are polarized downward to the lumen. They are the Paneth cells, named for Joseph Paneth (1851 – 1890) an Austrian physician. They are believed to produce bactericidal material.

Throughout the epithelium of the intestine tract from the duodenum distally, you will see numerous goblet cells. Immediately below the epithelial cells enterocytes is a network of fine collagenous and elastic fibrils, heavily infiltrated with cells, which is the lamina propria. The core of each villus has numerous small capillaries in its LP, and there will also be seen in the cores, a single large lymphatic vessel, called the central lacteal. This is a blind ended structure which represents the beginning of the intestine's lymphatic drainage. The LP is demarcated from the more peripheral layers by the muscularis mucosae, a thin band of smooth muscle which runs all the way around the mucosal layer and which sends strands up into the villi.

Outside the muscularis mucosae, you will be able to identify the submucosa, which in the duodenal sections can be characterized by the presence of branched tubulo-alveolar duodenal Brunner’s glands. The submucosa has a fair number of blood vessels and lymphatics in it, too, and if you look carefully you will be able to distinguish localized collections of neuron cell bodies. These are elements of the submucosal plexus discovered by Georg Meissner (1829-1905), a German histologist. This plexus, together with another one located in the tunica muscularis helps to coordinate the movements of the intestine and facilitate the passage of food through its lumen.

The tunica muscularis is quite thick, and in the duodenum (as well as in the rest of the intestines) has the typical two layers, inner circular and outer longitudinal. Between these two layers is the second nervous plexus of the intestine, the myenteric plexus (formerly called the plexus of Auerbach, for Leopold Auerbach (1828-1897), another German). You will see this plexus as discrete areas of neuron cell bodies, located at fairly regular intervals between the inner and outer muscle coats. If you could peel away the outer longitudinal muscle coat you’d see the myenteric plexus as a net-like structure, with axonal fibers extending from one “knot” of neurons to another.

In the jejunum, the muscularis mucosa is sparse or even absent and there are gross folds which involve not only the tunica mucosa, but also the underlying submucosa. These folds, the plicae circulares, are permanent structures, and another means for increasing surface area. Notice that there are no glands in the submucosa in this region.
The most prominent landmark in the ileum is the presence of large aggregations of lymphatic tissue in the submucosa. These are the **aggregated lymphatic nodules** (called **Peyer's patches** after Johannes K. Peyer, (1653-1712), a Swiss anatomist). These are often so large that they will infiltrate past the muscularis mucosae and up into the mucosa proper sometimes obliterating the enterocytes. The

**List of slides – Stomach/Intestine junction**

| SI-1 | Mammal |
| SI-2 | Cat    |
| SI-3 | Mammal |
| SI-4 | Monkey, t.s. |

**List of slides – Small intestine**

| I-1   | Mammal                  |
| I-2   | Duodenum, monkey, t.s. |
| I-3   | Duodenum, human, t.s.  |
| I-4   | Jejunum, monkey, c.s., t.s. |
| I-5   | Jejunum, monkey, l.s., t.s. |
| I-6   | Jejunum, human, t.s.   |
| I-7   | Ileum, monkey          |
| I-8   | Ileum, monkey, c.s., t.s. |
| I-9   | Ileum, monkey, l.s., t.s. |
| I-10  | Ileum, human           |
| I-11  | Paneth cells           |
| I-12  | Intestine, review slide |
| I-13  | Intestine, review slide |

**REVIEW BOX SLIDES 38, 39, 40**

**Large intestine**

Between the ileum and the colon proper is a diverticulum, called the **cecum**. The layers of the cecum are similar to those of the small intestine, but note that **villi are absent; there are only crypts**. The number of goblet cells has increased, there is a great deal of fat in the CT of the submucosa, and the tunica muscularis is much scantier. There are some small lymphatic nodules present. The histology of the cecum is very similar to that of the colon, lending strength to the belief that it's really part of the colon. In the colon, the mucosal layers are similar in arrangement and histology to the cecum, and frankly you will not be able to tell them apart.

The **rectum** is the last part of the colon, and it's distinguished by the presence of an enormously enlarged tunica muscularis, forming the anal sphincter. The **anorectal junction** is where these two portions of the tract come together. While the rectum forms from embryonic endoderm, the **anus**, is derived from surface ectoderm. Therefore, the anus, the last few centimeters of the digestive tract, is lined not with simple columnar epithelium, but with stratified squamous, usually keratinized. The transition point is easily seen. Just as it is at the oral end, the changeover from one type of epithelium to another is very noticeable.

**List of slides – Large intestine**

| I-14  | Cecum, horse             |
| I-15  | Cecum, monkey, t.s.     |
| I-16  | Cecum, human, t.s.      |
| I-17  | Appendix                |
| I-18  | Appendix, normal and infected |
| I-19  | Appendix, human, t.s.   |
| I-20  | Colon, Mammal           |
| I-21  | Colon, cat              |
| I-22  | Mammal, c.s.            |
The salivary glands consist of a glandular epithelium, the parenchyma, a supportive interstitial connective tissue, and a connective tissue capsule. The glands are composed of structural and functional units called the adenomeres, containing serous or mucus acini and a conducting portion. Connective tissue septa divides the glands into lobules and collecting ducts, blood vessels and nerve elements are located in the septa. The salivary glands are the parotid, submandibular (submaxillary), and sublingual.

- **The parotid gland** – the largest salivary gland, is entirely serous and has a complex duct system. The ducts are lined with simple columnar epithelium.

- **The submandibular (submaxillary) gland** – is a mixed gland containing both serous and mucous alveoli. The serous cells are wedge-shaped with rounded central nuclei. The mucous cells are cuboidal or low columnar and are grouped around the lumen, containing flattened, basal nuclei and paler cytoplasm. The serous cells do not border the lumen of the alveolus.
and are arranged in the form of a cap outside the mucous cells, often appearing in sections as crescent-shaped demilunes.

- **The sublingual gland** – is also a mixed gland, lacks intercalary ducts and is the smallest of the salivary glands. The gland does not have a distinct capsule but the connecting tissue septa are well developed.

**List of slides – Salivary glands**

G-1  Submaxillary, human  
G-2  Submaxillary, mammal  
G-3  Submaxillary, opossum  
G-4  Submaxillary, chronic inflammation  
G-5  Submandibular, t.s.  
G-6  Submandibular, monkey, t.s.  
G-7  Submandibular, human, t.s. (infected, atypical)  
G-8  Sublingual, dog  
G-9  Sublingual, mammal  
G-10  Sublingual, human  
G-11  Sublingual, cat  
G-12  Sublingual, t.s.  
G-13  Parotid, mammal  
G-14  Parotid, human  
G-15  Parotid, t.s.  
G-16  Salivary glands, dog  
G-17  Salivary glands, review slide

**REVIEW BOX SLIDES 31, 32**

**The pancreas**

The bulk of the tissue in the pancreas is exocrine in nature. This is the pancreatic acinar tissue and its associated ducts. The cells of the acinar tissue are arranged into blind-ended acini (that's a plural--the singular is "acinus") as in other glands. The lumen of an acinus is small, but if you have a favorable section you should be able to make it out. The acinar cells have a deeply basophilic basal region and an eosinophilic apical area.

In your slide you should be able to resolve the apical region as containing distinct granular material. These **zymogen granules** are precursor forms of digestive enzymes. The deep basophilia of the basal regions is due to the presence of large amounts of rough endoplasmic reticulum, which binds the hematoxylin of the H&E stain heavily. In a transverse section you will be able to make out the nucleus of a centro-acinar cells. This represents the very beginnings of the duct system. The ducts in the pancreas are not as obvious as those in salivary glands, but the layout of the glands is similar.

The endocrine portion is the **pancreatic islets of Langerhans** (Paul W. Langerhans (1847-1888), a German anatomist). They are regions of lighter staining tissue in the mass of the exocrine part. The islets are demarcated by a very fine investment of delicate CT fibrils. They're well vascularized (as you would expect in any endocrine organ) and you can probably find an erythrocyte or two inside them. The cells produce the hormones insulin and glucagon.

**List of slides - Pancreas**

G-18  Mammal  
G-19  Mammal  
G-20  Cat  
G-21  Mammal  
G-22  Human  
G-23  Human, t.s.  
G-24  Human, t.s.  
G-25  Monkey, t.s.
The liver

The liver's structure and anatomical placement reflect its function as the site for removal of impurities and for conditioning of the blood. It is, in essence, a large scale "trickle filter" through which the blood must pass before being released to the general circulation. It works in some ways like a sewage treatment plant which purifies wastewater before releasing it back into a river system. The analogy is physically accurate, because the liver slows down the flow of blood by breaking it up into innumerable channels, just as a trickle filter in a wastewater plant passes a large volume of water through sand or gravel to slow the flow for purification to take place. This breakup of the flow is important to normal function.

The classic liver lobule is considered by most authorities to be the functional unit of the organ. Each is a roughly hexagonally shaped, three dimensional unit, demarcated by connective tissue and constructed of the parenchymal cells of the liver, hepatocytes, in large numbers.

At each corner of the liver lobule, you should be able to make out a so called portal canal or hepatic triad. These classically include at least one each of the following elements:

- a branch of the hepatic artery;
- a branch of the portal vein; and
- a bile ductule.

You will not see one at every corner, but rest assured that if you could view the lobe in 3-D you would. It's at the triads that blood enters the lobule and bile leaves.

The hepatic sinusoids are lined with endothelial cells containing small, dark nuclei, with cytoplasm forming a thin film along the border of the sinusoid. In addition, large stellate, phagocytic cells with pale, oval nuclei, pseudopodia and microvilli are observed. These cells are the stellate reticuloendothelial Kupffer’s cells (Karl Wolfgang von Kupffer, German anatomist). These liver-resident macrophages engulf particulate matter that passes through the sinusoids (especially bacteria and senescent blood cells). They are a little difficult to make out, but you should be able to spot them by the presence of brownish pigment particles inside. This pigment is the product of cell breakdown.

The archetypical cells of liver, and by far the most numerous cell type, are the hepatocytes. Plates of hepatocytes are radially arranged around the central vein. These plates are usually one cell thick. Hepatocytes are fairly uniform in size, and perhaps as many as 25% of them are binucleated. The hepatocyte is the cell which enables the liver to do all of its tricks of synthesis, storage, and secretion. They make bile, sequester and release carbohydrates, and produce the amazing varieties of protein products for which the liver is responsible. By virtue of their arrangement they create the hepatic sinusoids as blood channels between the plates of cells.

List of slides - Liver

- G-32 Mammal
- G-33 Pig
- G-34 Monkey
- G-35 Monkey, t.s.
- G-36 Human
- G-37 Human, t.s.
- G-38 Kupffer cells
- G-39 Cirrhosis
- G-40 Carcinoma
Gall bladder

The gall bladder is yet another tubular organ, and it fits the typical pattern. Its *tunica mucosa* is a very regular simple columnar epithelium, with no goblet cells or glands. The deep folds in the bottom of the mucosa, which are often cut in cross section, sometimes look like "glands," but they have no secretory activity and they are really parts of the lumen. There is a scanty lamina propria, there is no muscularis mucosa and the tunica muscularis is thin and stringy. The serosal covering (i.e., visceral peritoneum) that covers the portion of the organ that's not nestled up to the liver is probably absent from your slide, having been removed in handling.

List of slides – Gall bladder

- G-43 Bile duct or pancreatic duct
- G-44 Gall bladder, cat
- G-45 Gall bladder, human
- G-46 Gall bladder, human, t.s.
- G-47 Gall bladder, monkey, t.s.

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List of optional slides – Gall bladder

- G-48 Liver, ambystoma
- G-49 Liver, amphiuma
- G-50 Liver, frog
- G-51 Liver, perch
- G-52 Liver, Anolis
- G-53 Liver, turtle
- G-54 Liver, chicken
- G-55 Liver, sea gull
- G-56 Liver, shark
- G-57 Gall bladder, amphiuma, t.s.
- G-58 Gall bladder, frog, t.s.