I. ORAL CAVITY & TEETH

OBJECTIVES:

At the end of this lab, you should be able to:

1. identify the various types of papillae and glands associated with the tongue: filiform, fungiform, foliate and vallate (circumvallate)
2. describe the structure of a taste bud
3. distinguish between the three salivary glands: parotid, sublingual and submandibular
4. identify the parts of a tooth: crown, neck, and root
5. locate the following tissue types within a tooth:
   - enamel
   - dentin
   - cementum
   - pulp
6. recognize the following parts of a developing tooth:
   - enamel organ (including outer enamel epithelium, stellate reticulum, stratum intermedium, ameloblasts, and enamel)
   - dental papilla (including dentin, predentin, & odontoblasts)
   - dental lamina
   - dental sac
7. understand why enamel production ceases at the time of tooth eruption whereas dentin normally continues to be laid down as long as a tooth remains viable
8. distinguish between the three types of tonsils: lingual, pharyngeal and palatine

LABORATORY:

Please study the following slides in your set:

A. Vallate & Filiform Papillae; Taste Buds
   Slide 11 (HU Box): Vallate Papillae
   Slide 56A: Taste Buds, or
   Slide 56B: Taste Buds, Trichrome

Identify a vallate (circumvallate) papilla. It is the largest type of papilla and is characterized by:
- a deep moat-like crypt surrounding the papilla
- numerous taste buds embedded in the walls of this moat
- large serous glands (von Ebner's glands) that empty into the base of the moat
Vallate papillae lie in a single row just anterior to the v-shaped sulcus terminalis that divides the tongue into an anterior 2/3 and a posterior 1/3. There are roughly 8-12 vallate papillae in humans. They are separated from one another by considerable distances. This helps to distinguish them from foliate papillae, which lie directly next to one another. Identify the filiform papillae. These are the most common type and the smallest. They have a characteristic pointed shape and carry no taste buds.

Observe the taste buds of the vallate papillae. Each contains several nerve fibers that mediate the sensation of taste. These fibers are associated with the neuroepithelial (sensory) cells of the taste bud. In addition the taste bud contains supporting or sustentacular cells, and a population of basal cells, which are believed to be stem cells for both the neuroepithelial and sustentacular cells. It is not necessary to distinguish between the neuroepithelial and sustentacular cells, both of which are elongated in shape. However, the rounder basal cells may be identifiable. Taste buds are almost completely covered by the stratified squamous epithelium of the tongue, except for a small opening called the taste pore. (Wheater, Fig. 21.1b, p. 402).

Study the skeletal muscle bundles making up the intrinsic muscles of the tongue. Notice that they are oriented in three mutually perpendicular directions (vertical, horizontal and longitudinal). This arrangement is diagnostic for tongue.

B. Foliate papillae

Slide 55 (HU Box): Tongue

Some versions of this slide show foliate papillae, which actually are a series of vertically oriented ridges rather than individual cylindrical or fungiform structures. They are located on the posterolateral sides of the tongue. In sections where the adjacent ridges are cut in cross section, you will see what looks like a row of papillae lying immediately next to one another with no other structures intervening between them. This distinguishes them from vallate and fungiform papillae, which are widely separated from one another. Foliate papillae carry taste buds that are mainly located on their lateral surfaces. In humans, these taste buds decrease in number with age, and the foliate papillae themselves become somewhat less prominent.

There are no examples on your slides of fungiform papillae. Fungiform papillae carry taste buds (usually on their dorsal surface), and are scattered over the dorsum of the anterior 2/3 of the tongue (see Wheater, Fig. 13.13, p. 247).

C. Salivary Glands


Study and compare the three major salivary glands. To distinguish between them, decide whether the gland contains only serous cells (parotid), or a mixture of serous and mucous cells. If a mixture is present, determine whether the mucous cells predominate with serous cells present mainly as serous demilunes (sublingual), or whether the balance between serous and mucous cells is more equal, with serous cells present as pure serous acini as well in demilunes (submandibular).
Be sure you can distinguish secretory acini from the various types of intralobular ducts including striated ducts and intercalated. In the parotid gland, also look for the adipose tissue that tends to increase with age.

**Slide 96 (HU Box): Salivary Gland Complex, Rat**

The rat possesses a unique arrangement of salivary glands at the angle of the jaw that includes the parotid, submandibular and sublingual glands. Depending on how this tissue complex was sectioned, you should find at least two of these three glands. Embedded in the connective tissue supporting the complex are isolated lymph nodes. Do not mistake these for salivary gland acini.

**D. Teeth**

**Slide 58: Development of Tooth**

**Slide 58A: Tooth Formation, Infant, and**

**Slide 58B: Tooth Development, Late Stage of Dentine**

These slides all show stages in the development of the crown of a tooth. None of them show the root of a tooth. Find the components of the enamel organ: outer enamel epithelium, stellate reticulum, and inner enamel epithelium (this has differentiated into ameloblasts in many locations). What hard layer of the tooth do ameloblasts produce? (Answer: Enamel)

Identify odontoblasts and the dental papilla. Odontoblasts differentiate from the mesenchymal cells of the dental papilla, which are of neural crest origin. Odontoblasts produce predentin, which then becomes mineralized to form dentin. Notice that the ameloblasts are located on the outer surface of the tooth, whereas odontoblasts line the inner surface next to the dental papilla. As the ameloblasts and odontoblasts lay down enamel and dentin respectively, the two cellular layers are gradually pushed further and further apart. Ameloblasts can usually be distinguished from odontoblasts in a high magnification light micrograph because they form a “neater”, more-orderly looking layer of cells than the odontoblasts.

Development of the tooth proceeds from the crown downward towards the neck and finally the root of the tooth. Follow the layers of enamel and predentin/dentin down toward the neck of the tooth on slide 58 or 58A and note that you eventually come to a point where predentin/dentin is present, but there is no enamel yet. This is because odontoblasts begin to produce predentin/dentin before ameloblasts produce enamel (even though ameloblasts differentiate before odontoblasts do).

**E. Tonsils**

**Slide 10 (HU Box): Tonsil, Palatine, Human, or**

**Slide 22: Tonsil (Faucial)**

(NOTE: All versions of Slide 22 are palatine tonsil unless labeled “Pharyngeal”.)

The faucial or palatine tonsil is a group of lymphatic nodules lying in the tonsillar fossa on each side of the oropharynx. These are the tonsils you can see when you stick out your tongue and say “Ahhhh.” They are characterized by a surface epithelium which is minimally keratinized stratified squamous, and which invaginates to form numerous deep tonsillar crypts (see Wheater, Fig. 11.15, p. 216). Beneath the epithelium many lymphoid nodules line up along the crypts. In any type of tonsil, it is common for lymphocytic infiltration of the epithelium to be so heavy in places that it is difficult to identify the epithelial cells.
When enlarged and inflamed, the pharyngeal tonsil is commonly called adenoids ("adeno" means gland; "oid" means like). Although it is difficult to see in this section due to heavy infiltration of the epithelium by lymphocytes, the pharyngeal tonsil is covered for the most part by pseudostratified ciliated columnar epithelium (the respiratory epithelium), with some patches of stratified squamous epithelium as well. The pharyngeal tonsil lacks crypts but has instead a folding (plication) of the surface epithelium. Although this distinction is readily apparent when viewed by SEM, to distinguish between crypts and folds in sectioned material you would have to examine serial sections. The unpaired pharyngeal tonsil lies in the posterior-superior wall of the nasopharynx. Enlargement may lead to partial obstruction of the choanae (the openings from the nasopharynx to the nasal cavity), leading to mouth breathing. Similarly, enlarged pharyngeal tonsils may obstruct the opening of the auditory tube into the nasopharynx, leading to ear infections.

Our slide sets include no examples of the lingual tonsils. A lingual tonsil can be identified by the minimally keratinized stratified squamous epithelium that covers it and by the fact that each lingual tonsil has a single short unbranched crypt (Wheater, Fig. 13.13, p.247). They are embedded in the posterior third of the dorsum of the tongue.

II. ESOPHAGUS

OBJECTIVES
1. name and identify the layers of the esophageal wall
2. distinguish between cross and longitudinal sections based on the orientation of the muscle layers
3. distinguish esophagus from stomach
4. describe the specific structural variations that allow you to distinguish between the upper, middle and lower regions of the esophagus

LABORATORY:

Please study the following slides in your set:
Slide 56 (HU Box): Esophagus, c.s., or Slide 60: Esophagus

In these cross sections of the esophagus, note the four-layers that make up the wall of the organ: mucosa, submucosa, muscularis externa and adventitia. This same arrangement was seen in the airways of the respiratory tract, and is typical of many of the hollow visceras of the body.

The mucosa of the esophagus includes: the epithelium, the lamina propria (a connective tissue layer), and the muscularis mucosae (a layer of smooth muscle that separates lamina propria from submucosa). The epithelium is a minimally keratinized stratified squamous epithelium. This epithelium allows you to distinguish esophagus from stomach and intestines, which are lined by simple columnar epithelia.
Examine the muscularis externa. This is composed of an inner circular layer and an outer longitudinal layer. The type of muscle present in the muscularis externa changes as you move down the organ toward the stomach. Which end of the esophagus do you think will have smooth muscle in its muscularis externa and which will have skeletal? Why? (Answer: The upper portion has skeletal muscle in the muscularis externa, while the lower portion has smooth. This makes sense because the upper end is continuous with the pharynx whose walls contain skeletal muscle, while the lower end is continuous with the stomach, which contains only smooth muscle. The midsection of the esophagus has a mixture of skeletal and smooth muscle in the muscularis externa.)

The wall of the esophagus contains scattered mucous glands, which can be located either in the lamina propria (esophageal cardiac glands) or in the submucosa (esophageal glands proper). Esophageal cardiac glands are more common at the upper and lower ends of the esophagus, whereas esophageal glands proper can be found in the submucosa anywhere along the length of the esophagus. Decide whether your sections were taken from the upper, middle, or lower portion of the esophagus by noting the kinds of muscle in the muscularis externa and the location of any glands that may be present.

III. STOMACH

OBJECTIVES:

1. describe the specific structural variations that allow you to distinguish between:
   - esophagus and stomach
   - cardiac, fundic and pyloric regions of the stomach
2. identify and explain the function(s) of the epithelial cell types of the stomach, including:
   - surface mucous cells
   - mucous neck cells
   - parietal cells
   - chief cells
   - enteroendocrine cells
3. understand the relationship between gastric pit and gastric glands and be able to identify each in all regions of stomach
4. indicate the location of the stem cell population in the gastric epithelium
5. describe and identify a ruga

LABORATORY

Please study the following slides in your set:

- Slide 15 (HU Box): Esophagus and Stomach, l.s., or
- Slide 60A: Cardio-Esophageal Junction
- Slide 57 (HU Box): Stomach, Cardiac Region
Slides 15 (HU) and 60A are longitudinal sections through the gastro-esophageal (cardio-esophageal) junction, i.e., the lower end of the esophagus and the first portion (cardiac region) of the stomach (see Wheater Fig. 14.6, p. 256). What type of epithelium lines each organ? (Answer: Minimally keratinized stratified squamous epithelium lines the esophagus, and simple columnar epithelium lines the stomach.) Notice that there is quite an abrupt change from one type of epithelium to the other at this cardio-esophageal junction rather than a gradual thinning down to one layer.

In these slides and in slide 57(HU) study the cardiac region of the stomach. Locate the gastric pits and the cardiac glands. A gastric pit is a tubular invagination of the surface epithelium. In all regions of the stomach several glands empty into the base of a single pit. Both gastric pits and gastric glands are located in the lamina propria. Identify the surface mucous cells that line the lumen of the stomach and the gastric pits. The surface mucous cells usually have their mucous granules limited to the apical region of the cytoplasm, forming what is sometimes referred to as an apical mucus cup. The nucleus remains uncompressed in the basal region of the cell. Cardiac gland cells also produce mucus, but have a different morphology in that they lack such an obvious apical cup. Enteroendocrine cells are also present in the surface epithelium, pits and glands but are difficult to identify in cardiac stomach since they are light-staining like the other cell types present here.

Where are the epithelial stem cells located in the stomach? (Answer: In the neck of the glands) Look for mitotic figures in that region. The same stem cell population gives rise to the surface mucous cells, enteroendocrine cells and gastric gland cells. That means that some differentiating cells move up toward the surface of the stomach and others move down into the glands in a well-orchestrated procession.

Identify the lamina propria, muscularis mucosae, submucosa and muscularis externa in esophagus and stomach. Note elements of the myenteric plexus between layers of the muscularis externa. On some slides the mesothelium of the serosa of the stomach is visible. On others the entire serosa may have been torn off.

Slide 58 (HU Box): Stomach, Fundic Region, Human, or Slide 61A: Fundic Stomach

The fundic stomach is characterized by long gastric glands that contain parietal cells and chief cells. Why do parietal cells have an intensely eosinophilic cytoplasm? [Answer: Because they have so many mitochondria. The many proteins in the membranes of a mitochondrion (cytochromes, etc.) cause it to be extremely eosinophilic.] What accounts for the basal basophilia of the chief cells? (Answer: The RNA in the ribosomes of their extensive RER. These cells secrete large amounts of enzymes including pepsinogen and, in humans, lipase)

If possible identify an enteroendocrine cell. These cells have a pale cytoplasm and are usually scattered singly among the other cell types of the epithelium. They may be in the surface epithelium, in the pits or in the fundic glands. They are easiest to identify in the glands where their pale cytoplasm contrasts with the eosinophilia of parietal cells and the basophilia of chief cells and makes them easier to see. In what part of the cytoplasm are the secretory granules of enteroendocrine cells localized? Why? (Answer: Enteroendocrine cells have secretory granules at their basal ends because they secrete into the connective tissue surrounding the glandular epithelium, rather than into the lumen. They do this because they are endocrine cells. Their hormonal products either affect target cells in the immediate vicinity or are picked up by blood vessels and carried to distant target organs.)
See if you can confirm the fact that several glands open into the base of a single pit. This is true for all regions of the stomach, but is usually easiest to see in the fundic region. Be aware that the morphology described here as fundic stomach is found in what the gross anatomist would call the body of the stomach as well as in the fundus.

Rugae are temporary folds that form in the relatively empty stomach and disappear as the stomach fills and distends. What layers contribute to the formation of a ruga? *(Answer: Mucosa and submucosa)*

On any of the stomach slides look for the muscularis externa. It is traditionally described as having three layers: outer longitudinal, middle circular and inner oblique, but the arrangement is actually much more complex than that, and differs in different regions and on different surfaces of the stomach. This less regular arrangement does however help to distinguish stomach from small or large intestine where the outer longitudinal and inner circular layers of the muscularis externa are consistently present.

Slide 59 (HU Box): Stomach, Pyloric Region, Human, or Slide 62: Stomach, Pyloric

In the pyloric stomach the gastric glands are composed of mucous cells and enteroendocrine cells, which again are difficult to identify. The glands resemble those of the cardiac region. However, pyloric stomach can be distinguished from cardiac because it has extremely deep pits. Notice that in all three histological regions of the stomach the surface mucous cells have the same morphology.

IV. ELECTRON MICROSCOPY

A. ORAL CAVITY & SALIVARY GLANDS

Identify the following:

1. The various types of papillae on the tongue:
   - Filiform (Fig. 26-13 to 26-15): carry no taste buds.
   - Fungiform (Fig. 26-19): taste buds on dorsal surface; are scattered as single papillae among the filiform.
   - Circumvallate (vallate) (Fig. 26-20): large size, deep moat and taste buds on lateral walls of papilla and moat
   - Foliate (Fig. 26-21) (rare or absent in adult humans): formed by folds on the lateral surface of the tongue; when the folds are sectioned transversely, the papillae appear to be in rows right next to one another.

2. Taste buds (Fig. 26-23): identify the taste pore and the light and dark cells. Light and dark cells extend the full length of the taste bud from its base to its taste pore. At least one good example of the rounder, shorter basal cells (#6) is shown at the lower border of the taste bud.

3. Serous vs. mucous cells of the salivary glands (Figs. 27-3 vs. 27-8 & 27-9) and serous demilunes (Figs. 27-8 & 27-9). The serous cells of the demilune secrete into very narrow channels between mucous cells that empty into the lumen of the acinus.

4. Intercalated ducts (Fig. 27-10) and striated ducts (Fig. 27-11, 27-12 & 27-15) of salivary glands. Since, in salivary glands, the intercalated
ducts and striated ducts are normally found within the lobules, they both represent types of intralobular ducts in these glands.

5. In the ground sections of a mature tooth (Figs. 27-16, 27-17 & 27-19) identify crown, neck, root, pulp cavity, enamel, dentin, and cementum. In Fig. 27-20 notice that cementoblasts can become entirely surrounded by the matrix they secrete, occupying lacunae in the cementum. In demineralized sections of a mature tooth also identify the location of the periodontal ligament (called periodontal membrane in Rhodin) and the bony socket of the tooth (Figs. 27-21 and 27-25). The bundles of collagen fibers that make up the periodontal ligament are anchored at one end into the bone matrix and at the other end in the cementum of the tooth root. These entrapped bundles are referred to as Sharpey’s fibers. Notice that in decalcified sections the enamel is usually missing because mature enamel consists mainly of inorganic salts that are removed by the decalcification process.

6. In the developing tooth (Figs. 27-27 to 27-30) identify the stellate reticulum, stratum intermedium, ameloblasts, enamel, dentin, predentin, odontoblasts, and dental papilla. The stellate reticulum eventually collapses on itself so that the outer enamel epithelium approaches the ameloblasts. As it does so, the stellate reticulum forms a compressed layer up against the ameloblasts. This layer of mesenchymal cells is called the stratum intermedium.

B. STOMACH

Identify the following:

1. Surface mucous cells: Observe that the mucous granules which are usually lost during tissue processing for LM (Fig. 28-10) are often preserved in samples prepared for EM (Figs. 28-11 & 28-12).

2. In the light micrograph shown in Fig. 28-10 identify the gastric pit (#2), a gastric gland (#3), and the neck of the glands (#4) where the stem cells are located.

3. In the fundic glands (called gastric glands proper in the figure captions) identify the two main cell types: chief cells and parietal cells (Figs. 28-15 & 28-16).

4. In a high power view (Fig. 28-17) observe that chief cells are typical protein secretors, characterized by well-developed RER and Golgi and by numerous secretory vacuoles. Parietal cells are ion pumpers that contain numerous mitochondria, and also intracellular canaliculi lined by microvilli. These canaliculi are a mechanism for increasing the apical membrane surface area to make room for more ion pumps. The parietal cell secretes hydrogen and chloride ions into the lumen of the stomach. Note the extensive system of tubular and vesicular membranes in the parietal cell cytoplasm adjacent to the canaliculi. These can rapidly fuse with the plasma membrane to increase its surface area even further. Compare the parietal cell with the oxyphil of the parathyroid gland, which also contains many mitochondria.

5. Mucous gland cells & enteroendocrine cells (Figs. 28-20 & 28-21). Note that the secretory granules of the enteroendocrine cells are stored in the basal rather than the apical end of the cytoplasm since
they are released across the basal plasma membrane and not into the lumen. The secretory granules of the mucous gland cells are apically located near the lumen.

**LABORATORY 15 CHECKLIST**  
**ORAL CAVITY & UPPER GI TRACT**

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<thead>
<tr>
<th>LIGHT MICROSCOPY</th>
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<tr>
<td>circumvallate (vallate) papilla</td>
<td>submucosa of esophagus &amp; stomach</td>
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<tr>
<td>taste bud</td>
<td>adventitia of esophagus</td>
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<tr>
<td>von Ebner’s gland</td>
<td>serosa of stomach</td>
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<tr>
<td>filiform papilla</td>
<td>upper vs. middle vs. lower esophagus</td>
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<td>foliate papilla</td>
<td>esophageal cardiac glands</td>
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<tr>
<td>striated duct</td>
<td>esophageal glands proper</td>
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<td>parotid vs. submandibular vs. sublingual gland</td>
<td>muscularis externa of esophagus &amp; stomach</td>
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<tr>
<td>3 parts of the enamel organ</td>
<td>cardio-esophageal junction</td>
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<tr>
<td>ameloblast</td>
<td>surface mucous cells of stomach</td>
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<tr>
<td>enamel</td>
<td>gastric pits vs. gastric glands</td>
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<td>predentin</td>
<td>cardiac vs. fundic vs. pyloric stomach</td>
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<tr>
<td>dentin</td>
<td>location of epithelial stem cells in stomach</td>
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<td>odontoblast</td>
<td>myenteric plexus of stomach</td>
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<tr>
<td>dental papilla</td>
<td>parietal cells</td>
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<tr>
<td>cementum</td>
<td>chief cells</td>
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<tr>
<td>periodontal ligament</td>
<td>enteroendocrine cells</td>
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<td>palatine vs. pharyngeal vs. lingual tonsil</td>
<td>rugae</td>
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<td>mucosa of esophagus &amp; stomach</td>
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| ELECTRON MICROGRAPHS                                                            |  |
| taste bud                                                                        | odontoblast                     |
| serous vs. mucous gland cell                                                    | dental papilla                  |
| stellate reticulum                                                             | parietal cell                   |
| ameloblast                                                                      | chief cell                      |
| enteroendocrine cell                                                            |  |

**NOTE:** These checklists include MOST of the structures that you should be able to identify. Exams may include structures not on these lists.
FOCUS QUESTIONS
LAB 15: ORAL CAVITY & UPPER GI TRACT

See whether you can answer the following questions. The correct answers are posted on
the course website (http://neurobio.drexelmed.edu/education/ifm/microanatomy) under
“Lab Focus Questions”.

1. Older individuals sometimes report that their mouth feels very dry. This is
because the volume of saliva that is produced decreases gradually with age.
What change occurs in the in the morphology of the aging parotid gland that
could contribute to a decrease in secretory volume?

2. What is the embryological origin of the cells that produce tooth enamel? Of
the cells that produce predentin and dentin?

3. Why do we have to visit the dentist if we have a serious defect in the enamel
(i.e., a cavity) in one of our teeth? Why can’t teeth produce more enamel to
repair the defect?

4. How would you distinguish between the upper, lower, and middle portion of
the esophagus?

5. Why are the esophageal glands that are located in the lamina propria called
esophageal cardiac glands?

6. What is the morphological difference between a serosa and an adventitia?

7. Intraperitoneal organs are suspended directly or indirectly from the body
wall by a mesentery. What is the function of a mesentery other than to keep
our intraperitoneal organs from sloshing around randomly? Describe the
histology of a mesentery.

8. What is the structural relationship between a gastric pit and a gastric gland?

9. How can you distinguish the cardiac stomach from the fundic or pyloric
stomach?

10. What are the functions of parietal cells and chief cells?

11. Oxyphils (parathyroid gland) and parietal cells (fundic stomach) both contain
unusually large numbers of mitochondria. How could you distinguish
between them in a medium magnification electron micrograph?