COMPARATIVE VERTEBRATE HISTOLOGY

THE VERTEBRATE DIGESTIVE SYSTEM

All digestive systems perform common functions: breaking down ingested food to its constituent monomers, absorbing these monomers across the alimentary epithelium, and getting rid of indigestible components. The vertebrate digestive tract consists of a longitudinal tube through the body with a common basic wall plan; the length of the tube and the modifications in the wall depend partly on diet. Within any individual the histology of the wall varies by region along the length of the tract according to the function(s) of each region. Therefore the variations among vertebrate digestive systems can be understood by examining and comparing the regional histological structure of the mucosal, submucosal and muscular layers of the gut wall in species representative of the vertebrate groups. You should review laboratory material on the mammalian (human) digestive system (laboratory module for Gastrointestinal System, available on Anatomy and Neurobiology website for ANAT 2160/BIOL 3430).

FISH

There are usually no salivary glands associated with the oral cavity in fish, as their food tends to be ingested with a lubricant included (water). However the lack of salivary glands also means that no digestive enzymes are mixed with food in the mouth, so these must be entirely supplied by glands in the stomach or intestine. Some species of fish have no distinct stomach; in these species the esophagus joins the intestine directly. In these species the anterior portion of the intestine secretes digestive enzymes and hydrochloric acid as well as mucus, thus fulfilling the secretory function of the stomach. The posterior part of the intestine in these species is mainly concerned with absorption. The species examined here possess a stomach, so regional functions along the gut are similar to those of humans.

CVH138, teleost esophagus. The esophageal epithelium in many species of fish is partly secretory and partly non-secretory. The secretory regions release mucus from groups of goblet cells (the lighter-staining, columnar cells, there may be multiple layers of these cells). Epithelium in the non-secretory regions is stratified squamous, similar to human oral/esophageal epithelium (Human slide 4). In the teleost esophagus there will also be some ciliated columnar epithelial cells among the goblet cells, but the cilia will be difficult to see. The role of these cilated cells is to aid the movement of food toward the stomach; they are particularly prominent in species in which there is a relatively sparse muscularis externa. Identify as many layers of the gut wall as you can. There may be no muscularis mucosa in this specimen.

CVH60, elasmobranch esophagus. This is a segment of a cross-section of the esophagus. The epithelium has glandular (mucus-secreting) and stratified squamous regions, as in the teleost, but even within the stratified squamous epithelium there are scattered goblet cells. Note that the glandular epithelium is organized into folds and tubular glands resembling the organization of stomach epithelium, although no digestive enzymes are secreted here.

The other layers of the wall are clearly identifiable. What is the orientation of the smooth muscle in the muscularis externa? In the deep lamina propria and submucosa there is a large cluster of unencapsulated lymphocytes that is part of the gut-associated lymphoid system. This cluster of lymphocytes runs the full length of the esophagus and into the stomach wall in elasmobranchs, and is named Leydig's organ.

CVH71/72 elasmobranch stomach. Slide 72 shows the wall of the fundus (main body) of the stomach, while slide 71 shows the wall of the stomach pylorus region (near the junction with the small intestine). Identify the layers. These sections were taken at different angles so the orientation of the muscle layers in the muscularis externa will be different, but the submucosa will look similar. Compare the histology of the mucosa, particularly the arrangement of the glands, in the two stomach regions. Secretion of acid and digestive enzymes is reduced in the pylorus; what is the histological evidence for this? The structure of the teleost stomach is similar to that of elasmobranchs.

CVH 145 trout small intestine cross-section. The mechanism for increasing surface area for absorption in the teleost intestine is similar to that in the mammalian small intestine: large numbers of villi are present in the mucosa. Analyze the structure of these villi and compare with mammalian villi. At the base of the villi small glands are present which secrete mucus and some types of peptide hormones, as in the mammalian small intestine. Identify the layers in the trout intestine wall.

CVH133 elasmobranch small intestine cross-section. A portion of a spiral valve can be seen in this cross-section. The core of connective tissue in this valve is continuous with the connective tissue of the submucosa in the external wall. Note that the surface of the spiral valve is covered on both sides with a mucosa that has short villi-like structures extending into the lumen. This arrangement is similar to the mucosal structure lining the teleost gut wall. Both the spiral valve and the mucosal arrangement act to increase surface area for absorption in elasmobranch fishes. There are no glands present at the base of the villi-like structures.

CVH66 elasmobranch large intestine cross-section. Compare this with the wall structure of the mammalian large intestine. The mucosa of the elasmobranch large intestine has mucus-secreting epithelium folded to form glands with much wider lumens than those in the mammalian gut. Identify the layers in the wall.

AMPHIBIA

The basic structure of the amphibian digestive system is very similar to that of fishes, but all amphibians,unlike some fishes, possess a stomach. Oral and esophageal epithelium is ciliated, stomach glands tend to be short, straight and simple tubular, the small intestine is coiled with large mucosal villi that have no associated glands at the base, and the large intestine ends in the cloaca. For each of the slides below, identify and describe the characteristics of all layers in the gut wall, comparing these features by region within the

amphibian gut, and with the equivalent region in other vertebrate groups. Highlights for each slide are indicated.

CVH21 frog oral epithelium. Ciliated apical cells.

CVH26 frog esophagus. Ciliated apical epithelial cells and goblet cells present. Note the secretory portions of glands in the submucosa; what might these glands secrete?

CVH50 salamander esophagus. Gut-associated lymphatic tissue is prominent near the epithelium.

CVH55 salamander stomach. Note the arrangement of the mucosal glands.

CVH16 frog small intestine, **CVH46** salamander small intestine. Large villi are present in both species; the mucus in the salamander small intestint has been stained blue-grey; note mucus emerging from goblet cells into the lumen.

CVH45 salamander large intestine. Mucosa is folded to form longitudinal ridges with goblet cells lining the grooves between the ridges.

REPTILE

Many aspects of the reptilian gut are similar to those of amphibians and fishes. The gizzard, a heavily muscled part of the pyloric stomach, first appears in some reptiles, and is involved in mechanical breakdown of food by grinding the food against ingested pebbles and grit. The time for food to remain in the gut to facilitate digestion is increased in these animals by sequestering food in cecae, pouches attached at the border between the small and large intestines. Analyze the material on the following slides as you did the material for the amphibian and fish digestive tract.

CVH174 snake tongue. Your slide may include two cross-sections of the tongue. What type of epithelium is present? Identify the musculature (what type of muscle is this?) and its orientation. Why do you think there are such large nerves in this organ?

CVH91 turtle esophagus. In some reptiles the columnar epithelial cells are ciliated in the esophagus (not true in turtles), and goblet cells are present in the epithelium. The mucosa is typically thrown into longitudinal folds.

CVH94 turtle stomach. Secretory cells in the mucosal glands (called "granular" cells) secrete both acid and digestive enzymes.

CVH85 turtle small intestine. The reptile small intestine does not have villi; instead the mucosa is in folds running transversely. Note that there are some goblet cells in the epithelium, but these are hard to distinguish from the absorptive columnar enterocytes on this slide.

BIRD: no useable material available in slide boxes

MAMMALIAN

CVH196 guinea pig esophagus/trachea. This section shows cross-sections of both trachea and esophagus midway between the pharynx and the stomach. The normal diet of guinea pigs in the wild is tough herbaceous material (fibres and seeds) so the apical layer of the esophageal epithelium is cornified (keratinized), appearing similar to the stratum corneum of the skin to resist wear.