PCB 4023 – Cell Biology

Lab 8: Organology II – Digestive tract and accessory organs

Name: ____________________ SSN: _______________
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N.B. Since this document is in “pdf” format, the URLs (web addresses) cannot be linked. To use them, simply highlight and copy the address and paste it into the address box of your browser.

Preparation assignment (to be completed before lab):

2) Kerr (1999) Chapter 14: Liver, Gall Bladder, Pancreas (pp. 263-280)

Web resources:

N.B. Again, you may wish to examine the “Stomach and Intestine” and “Liver, Gall Bladder and Pancreas” modules (review & quizzes) at the University of Florida College of Medicine histology tutorial. As before, these modules may contain information that is not covered in this course and you will not be held responsible for any information presented there. However, you may wish to consider using them as additional preparation and/or review. The URL is as follows: http://www.medinfo.ufl.edu/year1/histo/index.html

Know of any other web sites pertaining to the integument and its derivatives that you have found helpful or interesting? E-mail me the link at condon@fiu.edu and let me know what and why you found it informative and/or interesting.

Organology II – Digestive tract and accessory organs

This week we continue our examination of organology. As noted previously, time does not permit an examination of all the organ systems found in craniates, nor is it necessary. Once identification of the basic tissues has been accomplished, one can identify organs by learning and recognizing their unique combination and arrangement of specific tissues and/or cells. Nowhere is this principal better illustrated than in the alimentary canal where the same four tissue layers are found throughout, yet each portion is unique and easily distinguished.

This week, in deference to the physician wannabe’s who always seem to hold a [to my mind unhealthy] fascination with the guts, we’ll examine the histology of the alimentary canal and two of its [tasty] accessory organs, the liver and pancreas.

I. Alimentary Canal

figure: 3K13.22
The alimentary canal is a hollow muscular tube that begins at the caudal end of the pharynx or oropharynx and is made up of the esophagus, stomach, intestines, and, in most craniates, the cloaca (except in meta- and eu-therian mammals where the large intestine terminates in a (dedicated) anus). Each region exhibits a common plan or organization, specifically a hollow tube with walls composed of four layers. The innermost layer is the mucosa (mucous membrane) which consists of a lining epithelium and a thin layer of smooth muscle (the muscularis mucosae) separated by the loose connective tissue lamina propria. The submucosa consists of a vascularized layer of loose connective tissue; it also contains nerve plexi (Meissner’s) of the enteric nervous system (ENS). External to this is the muscularis externa composed of circular and longitudinal sheets of smooth muscle. [N.B. In histological sections, the orientation of the muscle fibers may not appear purely circular or longitudinal due to variation in the plane of sectioning.] The surface layer is the adventitia, a fibrous connective tissue. If the organ is intraperitoneal, then the adventitia is covered with a mesothelium and is referred to as a serosa.

The esophagus is a distensible tube that connects the pharynx to the stomach. In mammals the mucosa is a stratified squamous epithelium to resist the abrasions of the passing bolus. [The presence or degree of keratinization varies between species and correlates with the abrasiveness of the diet.] Secretions from mucous glands in the mucosa or submucosa assist in the passage of the bolus by peristaltic contractions of the muscularis externa. Interestingly; the proximal muscularis externa, like the adjacent pharynx, is skeletal rather than smooth muscle.

The stomach is an expanded region of the alimentary canal, its expansion facilitated by folds known as rugae which open in an accordion-like fashion to accommodate a meal. The stomach is the site of mechanical, acid and enzyme digestion as well as the site of limited absorption (water, salts, vitamins, ethanol, caffeine, etc.). The mucosa consists of columnar mucous epithelial cells which line both the surface and indentations known as gastric pits. The gastric pits lead to the branched, tubular gastric glands which also contain the acid-secreting parietal cells and enzyme-secreting chief cells.

The mucosa of the intestines differs substantially from the stomach. Instead of pits, the opposite holds with thousands of villi projecting into the lumen from the wall, increasing the...
surface area. Within the villi are arterioles, venules and lacteals, specialized lymphatic vessels that absorb long-chain fats. The lining epithelium is comprised of (1) columnar enterocytes (absorptive) which are covered with hundreds to thousands of microvilli and (2) secretory goblet cells. Mucous secretions from the goblet cells protect the epithelial lining from digestive agents and serve as a lubricant to facilitate passage of the food. At the base of the wall are the intestinal glands (crypts of Lieberkühn) which are sunken into the mucosa and are the source of digestive enzymes.

In many craniates the intestine is divided into two major regions, small and large. The small intestine is of smaller diameter (hence its name) but of greater length than the latter is divided into three successive and histologically distinct parts (from proximal to distal): duodenum, jejunum, and ileum. The duodenum receives chyme from the stomach, digestive enzymes from the exocrine portion of the pancreas, and bile from the liver. The secretions of the duodenal (Brunner’s) glands within the submucosa serve to neutralize the hydrochloride acid of the stomach. The jejunum has the most extensive villi and generally lacks Brunner’s glands and lymphatic nodules. In contrast, the submucosa of the ileum is rich in aggregated lymphoid follicles (Peyer’s patches). The small intestine is the major site of nutrient absorption (amino acids, carbohydrates, and fatty acids).

The large intestine is named for its large diameter and it passes to the cloaca or anus. It’s mucosa is rich in goblet cells and its enterocytes absorb water and metabolic ions.

II. Accessory organs

The accessory organs of the digestive tract arise as diverticuli or outpocketings of the endoderm from the developing gut tube into the adjacent mesenchyme (splanchnic mesoderm). These include the liver, gall bladder and pancreas.

The liver is typically the second largest organ in craniates (after the skin) and serves a variety of functions (carbohydrate, protein and fat metabolism, detoxification, bile production, etc.). Despite this diversity of functions, its histological appearance is remarkably uniform. The liver is composed of sheets of hepatocytes separated by blood sinuses (sinusoids) which carries blood from the nutrient-rich hepatic portal vein and oxygen-rich hepatic arteries. The products of liver metabolism are released to the central veins and
conducted to the caval venous system. Bile is transported to the small intestine by a series of canaliculi and ducts.

figure: 3K15-11

The pancreas actually arises from two diverticuli (dorsal and ventral) that may or may not fuse together during subsequent development. The pancreas has both exocrine and endocrine components. The exocrine cells form acinar glands that dump their enzymatic secretions ("pancreatic juice") to a duct system terminating in the duodenum. Embedded among the acinar glands are clusters of endocrine glands called pancreatic islets (isles of Langerhans). While at least four major cell types are known (alpha (producing glucagon), beta (producing insulin), delta (producing somatostain), and pancreatic polypeptide cells), they can not be distinguished in H&E stained sections.

Lab Assignment: Organology II – Digestive tract and accessory organs

Work through the following sections using your atlas as a guide. Make sure to answer the questions (marked by "?") at the end of the lab; these will be evaluated when you turn in your handout next week. A list of structures which will form the basis for next week’s quiz is given at the end of the handout.

To learn how to identify the structures, write down criteria which will assist you in your identification (e.g., simple squamous epithelium: single layer, flat cells with flattened nuclei). Your text is a good source for such material as well as your own observations. Some students find it helpful to make rough sketches of the structure to assist in their learning.

N.B. Due to [unprogrammed] slide death, your slide box may not contain the required slide. If this is the case, notify an instructor and they will provide a replacement or suggest an alternative. If you end up borrowing a slide from one of your colleagues’, please don’t forget to return it to them.

I. Digestive tract

A. Esophagus

trachea and esophagus: 93W4875

Identify:
mucosa (mucous membrane)
stratified squamous epithelium
lamina propria
muscularis mucosae
submucosa
mucous glands (variable; can be within mucosa)
muscularis externa
adventitia
B. Stomach (gaster)

stomach, fundus: HK 6-23

Identify:

mucosa
rugae
gastric pits – simple columnar epithelium (surface mucous cells)
gastric glands
   parietal (oxyntic) - predominately apical
   chief (zymogenic) - predominately basal
lamina propria
muscularis mucosae
submucosa
muscularis externa
serosa

C. Small Intestine

small intestine: HK 7-24; 93W4526 (duodenum only)

Identify:

mucosa (simple column epithelium)
villi
   enterocytes
goblet cells
crypts of Lieberkühn
lamina propria
muscularis mucosae
submucosa
muscularis externa
adventitia or serosa

Be able to distinguish the three parts of the small intestine:
duodenum - submucosal duodenal (Brunner’s) glands
jejunum - tall villi; scarcity of Brunner’s glands and lymphoid follicles
ileum - aggregated lymphoid follicles (Peyer’s patches) in submucosa

D. Enteric nervous system

The enteric nervous system (ENS) is not directly connected to the central nervous system and thus is considered distinct from the autonomic nervous system (ANS). It modifies local gut behavior (e.g., peristalsis, secretion, epithelial proliferation, etc.). Although it can act independently of the ANS, parasympathetic fibers from cranial nerve X (CN X; vagus) and the sacrum and sympathetic fibers from abdominal ganglia terminate on ganglia of the ENS and influence their behavior. Small ganglia of the ENS can be observed in the submucosa (Meissner’s “plexus”) and between the layers of the muscularis externa (Auerbach’s “plexus”).

Auerbach’s plexus: 93W3675

Identify:
   Auerbach’s plexus - between inner circular and outer longitudinal layers of the muscularis externa
   Meissner’s plexus - submucosal
E. Large Intestine (colon)

colon: 93W4542

Identify:

- mucosa
- enterocytes
- goblet cells
- crypts of Lieberkühn
- submucosa
- muscularis externa
- adventitia

II. Accessory organs of the digestive tract

A. Liver

liver: H3230 (extras available); HK 10-2; 93W4567 (pig; clearest structure)

Identify:

- liver lobule
- central vein
- portal triad
  - hepatic arteriole
  - portal venule
  - bile duct
  - canaliculi
- hepatocytes
- sinusoids

B. Pancreas

pancreas: H3130 (extras available); HK 9-2 (extras available); also look for portions of the pancreas on 93W4526 (duodenum)

Identify:

- acinar glands (exocrine)
- ducts
- connective tissue septa
- pancreatic islets (isles of Langerhans; endocrine)

IV. Questions (Due the following lab)

? What three layers form the mucosa (mucous membrane) of the alimentary tract? What type(s) of tissue(s) forms each?

? What tissues can be found within the submucosa?

? What tissues is often found between the inner and outer layers of the muscularis externa?

? What is the difference between an adventitia and a serosa in the alimentary tract?

? What two types of muscle are found in the muscularis externa of the esophagus?
? In what tissue layer (i.e., mucosa, submucosa, muscularis externa, adventitia) are the esophageal glands found? What type of glands are these and what is the function of their secretion?

? What are the major functions of the stomach?

? What is the purpose of the mucous secretions by the surface epithelia of the stomach?

? How can you distinguish histologically the parietal and chief cells within gastric glands (i.e., describe their histological appearance)? What is the major secretion of each? How do they interact to perform a common function?

? Which cells of the gastric gland secret the hormone gastrin?

? How can you distinguish (differentiate) histologically the three regions of the small intestine (i.e., duodenum, jejunum, ileum)?

? What are the major functions of the duodenum? The jejunum? The ileum?

? Why are duodenal (Brunner's) glands found primarily in the proximal portion of the small intestine?

? What morphological feature found on the apical surface of enterocytes suggests it is an absorptive cell?

? Who was Lieberkühn? In what organs will you find his “crypts”?

? Who was Langerhans and where are his “Isles”? Where are his cells?

? Who was Peyer? Where are his “patches”? What are they?

? Why are the ganglion cells of Meissner and Auerbach incorrectly described as “plexi”? [Hint: look up the definition of plexus in a good medical dictionary.]

? What are the major functions of the large intestine?

? How can the large and small intestine be distinguished histologically?

? What are the three components of a liver lobule?

? What are the three components of a portal triad?

? What is the function of bile salts? Describe their activity.

? What is the function of bile pigments? Describe their activity.

? If alcohol (ethanol) is metabolized in the liver (into acetaldehyde and acetate), how is it that the amount of alcohol consumed can be assayed in the urine and breath?

? What is the unique feature of the structure of the pancreatic acini that differentiates it from all other exocrine glands?

? What enzyme in the duodenum activates the enzymes of the pancreatic juice? Why is it necessary for the pancreatic enzymes to remain inactivated in the pancreas?
? Why aren’t the many enzymes of the pancreatic juice and the bile of the liver delivered to the stomach, rather than the duodenum?

? What are the four cell types found in the pancreatic isles? What hormone(s) does each produce and what is its function.

V. Quiz: Be prepared to identify the following structures on next week’s quiz.

Esophagus

mucosa (mucous membrane)
  stratified squamous epithelium
  lamina propria
  muscularis mucosae
submucosa
  mucous glands (variable; can be within mucosa)
muscularis externa
adventitia

Stomach (gaster)

mucosa
  rugae
  gastric pits
  gastric glands
    parietal cells
    chief cells
  lamina propria
  muscularis mucosae
submucosa
  muscularis externa
serosa

Small Intestine

mucosa (simple column epithelium)
  villi
    enterocytes
    goblet cells
  intestinal glands (crypts of Lieberkühn)
  lamina propria
  muscularis mucosae
submucosa
  muscularis externa
  adventitia or serosa

Be able to distinguish the three parts of the small intestine: duodenum, jejunum, ileum

Enteric nervous system

Auerbach’s plexus
Meissner’s plexus

Large Intestine (colon)

mucosa
enterocytes
goblet cells
intestinal glands (crypts of Lieberkühn)
submucosa
muscularis externa
adventitia

Liver
liver lobule
central vein
portal triad
  hepatic arteriole
  portal venule
  bile duct
hepatocytes
  sinusoids

Pancreas
acinar glands (exocrine)
ducts
connective tissue septa
pancreatic islets (isles of Langerhans)