Pancreas, Liver and Gallbladder
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Pancreas, Liver and Gallbladder Objectives

• Describe the histology of the pancreas and be able to differentiate the exocrine pancreas from the endocrine pancreas.

• List the main digestive enzyme precursors secreted by the pancreas.

• Describe the histology and architecture of the liver, and list its main functions.

• Describe the histology and function of the gallbladder.
Pancreas, Liver and Gallbladder Outline

• Introduction
• Pancreas
• Liver
• Gallbladder
Pancreas, Liver and Gallbladder Outline

• Introduction
Basic Functions of the Accessory Glands

**Salivary glands**: secrete saliva to moisten mouth and food and initiate digestion. These will be discussed in Oral Histology.

**Pancreas**: makes digestive enzymes and secretes them into duodenum (also has endocrine glands, discussed under Endocrine System).
Basic Functions of the Accessory Glands

Liver
- Metabolizes carbohydrates, lipids and proteins
- Makes proteins like albumin and blood clotting factors
- Secretes bile
- Gets rid of drugs and toxins

Gallbladder
- Stores and secretes bile
Formation of the GI tract starts with lateral folding

The lateral plate mesoderm splits in two. One part remains near the ectoderm. The other part follows the endoderm.
Endodermal layer (lined by mesoderm) bends, the edges reaching towards each other, meeting in front to form the gut.

Ectodermal layer (lined by mesoderm) grows forward, reaches around the gut, and zips up the front to form the anterior body wall.
Lateral Folding of the Embryo

Amnion (and amniotic cavity) comes along for the ride, eventually surrounding entire embryo.

Back, with ectoderm overlying neural tube

Gut (lined by endoderm, surrounded by mesoderm)

Anterior thoracic wall (mesoderm covered with ectoderm)

Paraxial mesoderm
Intermediate mesoderm
Lateral plate mesoderm
Day 28

Day 35

Gut tube
Foregut, midgut and hindgut
Stuff that develops from the foregut
Stuff that develops from the midgut

- Duodenum (½)
- Small intestine
- About half of the large intestine (down to proximal ⅓ of transverse colon)

Stuff that develops from the midgut
Stuff that develops from the hindgut

Rest of large intestine (everything except inferior anal canal)
Derivatives of ectoderm, endoderm and mesoderm

**Ectoderm** gives rise to:
- Epithelium of oral cavity
- Epithelium of anal canal

**Endoderm** gives rise to:
- Lining of gut (except mouth and anus)
- Glands of most of the digestive tract
- Hepatocytes
- Pancreatic acinar cells
- Bile duct system

**Mesoderm** gives rise to:
- Muscular and connective tissue components of the digestive tract
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Functions of the Pancreas

- The pancreas has both exocrine (duct-containing) and endocrine (ductless) glands.
- Endocrine portion (small islands) secretes hormones that regulate blood sugar.
- Exocrine pancreas (most of the pancreas) secretes digestive juice containing enzymes that help break down carbohydrates, lipids and protein
Accessory pancreatic duct (dorsal pancreas)

Pancreatic duct (ventral pancreas)

Common bile duct

Head

Neck

Body

Tail

Duodenum
Pancreas
Morphologic Structure of the Pancreas

• Has capsule, septa and lobules
• Endocrine pancreas consists of islets of Langerhans (we studied this in our Endocrine lecture)
• Exocrine pancreas consists of serous acini with no mucous cells
• Drainage is by a series of ducts (intercalated, intralobular, interlobular, then big excretory duct) which dump into duodenum
Goblet cell

Intercalated duct

Excretory duct

(simple columnar epithelium)

B.M.

Main pancreatic duct

Interlobular duct

Lobule

Intralobular duct

Intercalated duct

Acinus (serous)

Excretory duct
Pancreas: super low-power view
Pancreas: parenchyma and capsule

Endocrine parenchyma

Exocrine parenchyma

Capsule
Pancreas: endocrine glands (Islet of Langerhans)
Pancreas: exocrine glands (serous acinar cells)
Lumen of acinus

Zymogen granules being discharged

Base of acinar cell of pancreas

Formed secretory vesicles (zymogen granules)

Forming secretory vesicle

Golgi saccules
Stuff Secreted by Pancreatic Acinar Cells

- Main thing: trypsinogen
  - Present in precursor (zymogen) form
  - Broken down by intestinal enzymes into trypsin, which digests protein and activates the other enzymes

- Also secreted (in precursor forms):
  - Lipase (breaks down fat)
  - Amylase (breaks down carbohydrates)
  - Nucleases (break down nucleoproteins)
What makes the pancreas secrete enzymes?

• Secretin and cholecystokinin (CCK) are made and stored in duodenal cells. Released when acidic gastric contents enter duodenum.

• Secretin stimulates pancreas to secrete bicarbonate (to neutralize stomach acid so enzymes can function properly).

• CCK stimulates pancreas to release zymogens.

• CCK also stimulates gallbladder to release bile salts (which emulsify fats so they can be broken down by lipase).
Each acinus is lined by centroacinar cells and drained by an intercalated duct.
Pancreas: intercalated duct
Pancreas: intercalated duct (longitudinal section)
Pancreas: INTRAlobular duct
Pancreas: INTERlobular duct
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Functions of the Liver

• Metabolism of carbohydrates, lipids and proteins
• Storage of carbohydrates (glycogen)
• Production of proteins like albumin and blood clotting factors
• Secretion of bile (helps emulsify fats so they can be digested) into duodenum
• Removal of old red cells from blood
• Transformation and excretion of drugs and toxins
Morphologic Structure of the Liver

• The liver has four lobes.

• The porta hepatis is a deep fissure on the inferior surface of the liver. Three main structures pass through the porta hepatis:
  • Hepatic portal vein (enters)
  • Hepatic artery (enters)
  • Common hepatic duct (exits)
What vessels carry stuff in and out of the liver?

**IN**
- **Hepatic artery**: brings oxygenated blood to liver from the aorta
- **Portal vein**: brings deoxygenated, nutrient-rich blood to the liver from the intestine.

**OUT**
- **Hepatic vein**: carries blood from liver to inferior vena cava
- **Bile ducts** (fuse to form common hepatic duct): drain bile from the liver into the intestine.
Liver Parenchyma and Stroma

- The parenchymal cells of the liver are called hepatocytes. They are arranged in plates like “bricks in a wall.”
- The stroma of the liver consists of a connective tissue capsule. Vessels and ducts are surrounded by connective tissue.
- Connective tissue also divides the liver into lobules. Reticular fibers support hepatocytes and endothelial cells of sinusoids.
Hepatocytes

• Large, polyhedral cells with one or two nuclei
• Tons of smooth and rough endoplasmic reticulum
• Glycogen granules and lipid droplets often present
Functions of Hepatocytes

- Production of proteins (albumin, clotting proteins)
- Secretion of bile acids (10% made by hepatocytes, 90% recirculated)
- Conjugation of bilirubin to produce water-soluble, excretable bilirubin glucuronide
- Detoxification of drugs in smooth ER
- Storage of glycogen and triglycerides
- Gluconeogenesis
Liver cell (hepatocyte)
Bile acids absorbed in the intestines

90% of bile acids are synthesized de novo

90% of bile acids are recirculated

10% of bile acids are synthesized de novo

Synthesis of bile

Liver cell (hepatocyte)
The liver is organized into “lobules” with the central vein in the middle and the portal triads (portal vein, hepatic artery, bile duct) at the periphery.
The Liver Lobule

- Central vein
- Bile canaliculi
- Reticuloendothelial cell
- Hepatic sinusoid
- Hepatocyte
- Portal triad (Branch of bile duct, Branch of hepatic portal vein, Branch of hepatic artery)
Blood and bile flow within the liver lobule
Liver: low power (lobules are pale in center, darker at edges)
Lobule with central vein in center, portal triads at edges
Lobule with central vein, hepatocytes in cords or plates, and sinusoids.
Portal triad: Bile duct, hepatic portal vein, hepatic artery
Blood Flow in the Liver Lobule

- Portal vein and hepatic artery
- Branches of portal vein and hepatic artery
- Hepatic sinusoids
- Central veins
- Sublobular vein
- Hepatic vein
- Inferior vena cava
Sinusoids

Bile canaliculi

Bile duct

Branch of portal vein

Branch of hepatic artery

Central vein
Bile Flow in the Liver

• Bile canaliculi are tubular spaces surrounded by plasma membranes of 2 adjacent hepatocytes.
• Cell membranes of hepatocytes are joined by tight junctions (zonula occludens).
• Bile flows from the center to the periphery of the lobule, then into bile canaliculi.
• Bile then flows through bile ductules (Hering's canals), then through ducts in portal spaces.
Hepatic Sinusoids

- Hepatic sinusoids are large, leaky capillaries lined by one discontinuous layer of fenestrated endothelial cells and macrophages called Kupffer cells.
- Sinusoids carry blood from the branches of portal vein and hepatic artery at the periphery of lobule to central vein.
- Sinusoids contain a mixture of arterial and venous blood.
Perisinusoidal Space (of Disse)

- Perisinusoidal space of Disse lies between hepatocytes and sinusoids.
- Hepatocyte microvilli project into this space. Blood in the sinusoids passes readily through the endothelial wall and bathes the hepatocyte microvilli.
- Exchange of nutrients and metabolites occurs here.
Perisinusoidal space (of Disse)
Hepatocyte

Endothelial cell lining sinusoid

RBCs in sinusoid lumen

Perisinusoidal space (of Disse)
Kupffer cells (stained black) are macrophages bound to endothelial lumen of sinusoids.

Functions include detecting and removing old red cells, eating bacteria and debris in blood, and presenting antigen to lymphocytes.

Kupffer cells (liver macrophages)
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Functions of Gallbladder

• Stores bile and concentrates it by reabsorbing water.

• If gallbladder is removed, bile flows directly from liver to gut or is stored in bile ducts. Usually this is no problem.

• Cholecystokinin causes contraction of smooth muscle in gallbladder wall.
Bile flow within liver

- Bile canaliculi
- Hepatocytes
- Bile ductule
- Bile duct
Bile flows to bile ducts in portal triads

Right and left hepatic ducts

Common hepatic duct

Cystic duct from gallbladder

Common bile duct

Duodenum
Gallbladder: super low-power view
Gallbladder wall

- Epithelium
- Lamina propria
- Muscularis
- Serosa

Gallbladder wall
Gallbladder epithelium and lamina propria
Gallbladder tunica muscularis
Gallbladder serosa
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