

Digestive System IV: Pancreas, Liver, Gall Bladder and Extrahepatic Bile Ducts

Department of Anatomy

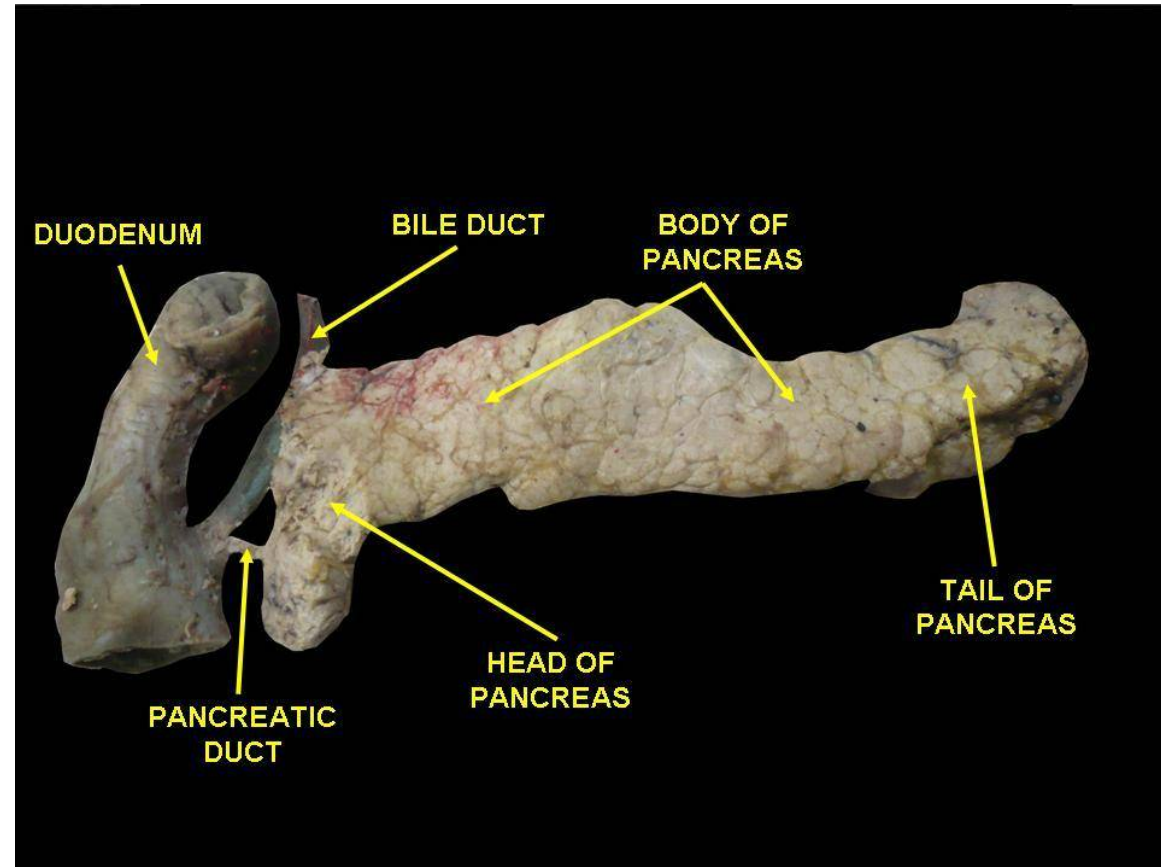
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26.03.2020 II stream (group 11-20)

25.03.2020 I stream (group 1-10)

Pancreas

- The **pancreas** (Gr. pan, all and kreas, flesh) is one of the largest digestive glands.
- It is soft, lobulated, greyish-pink gland composed of two separate types of glandular tissue:
 - ✓ The major part of the gland is **exocrine**.
 - ✓ It has an additional **endocrine** clusters of cells scattered throughout the substance of the gland.
- It has an average volume of 70–80 cm³.
- In adults it measures 12–15 cm in length with transverse size of 4 to 5 cm.
- Its thickness (anterior-posterior size) is 2 to 3 cm.



Functions of the Pancreas

Pancreas serves two main functions:

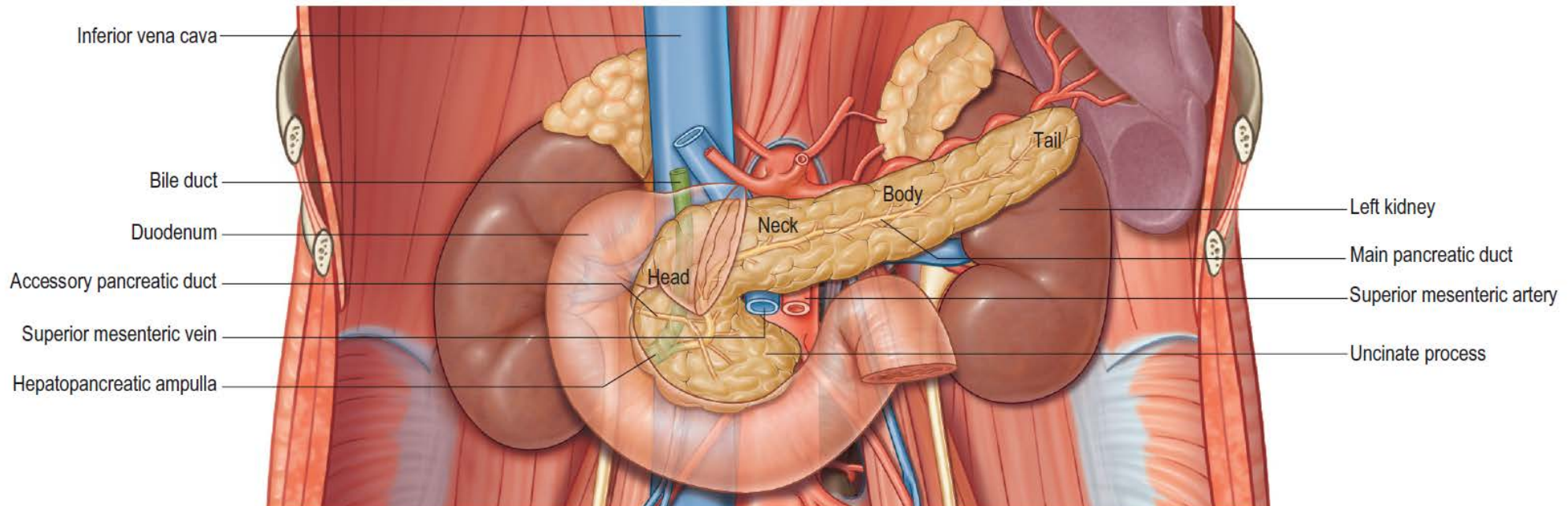
- **Exocrine role** – synthesis and secretion of pancreatic juice:
 - ✓ Water and bicarbonate ions (neutralize the acidic gastric juice in chyme).
 - ✓ Digestive enzymes:
 - **Proteolytic endopeptidases** (trypsinogen, chymotrypsinogen) and **proteolytic exopeptidases** (procarboxypeptidase, proaminopeptidase).
 - **Amylase** (diastase).
 - **Lipase**.
 - **Nucleases** (RNase and DNase).
- **Endocrine role** – synthesizes and secretes the hormones **insulin** and **glucagon** into the blood. These hormones regulate glucose, lipid, and protein metabolism in the body.

Pancreas

External features and anatomical relations

➤ **Head**, Lat. caput pancreatis.

- ✓ It lies within the C-shaped concavity of the **duodenum**.
- ✓ It is the thickest and broadest part of the pancreas but is still flattened in the anteroposterior plane.
- ✓ The anterior surface of the head is covered by peritoneum and related to the origin of the **transverse mesocolon**.
- ✓ Posteriorly is the **common bile duct**, the **inferior vena cava**, the right crus of the diaphragm and the termination of **the right gonadal vein**.

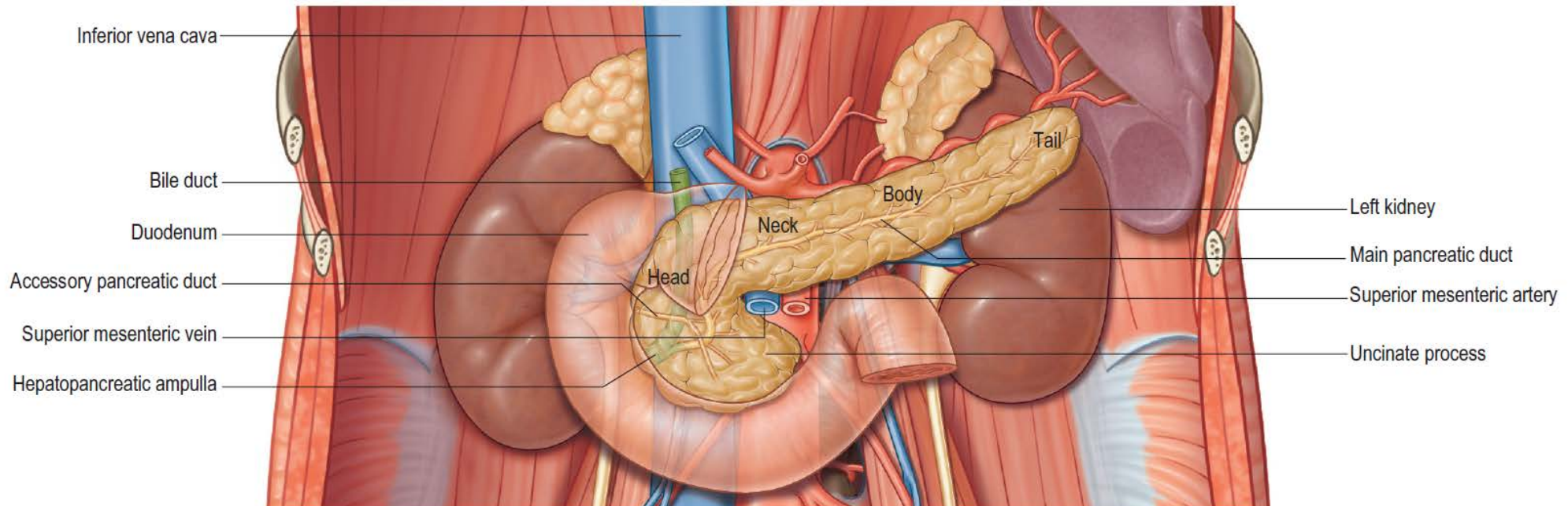


Pancreas

External features and anatomical relations

➤ **Neck**, Lat. collum pancreatis.

- ✓ The neck of the pancreas is approximately 2 cm wide and links the head and body.
- ✓ The anterior surface of the pancreatic neck is covered by peritoneum and lies adjacent to the **pylorus**.
- ✓ Posteriorly is the union of the **superior mesenteric vein and splenic vein** to form the **portal vein**.

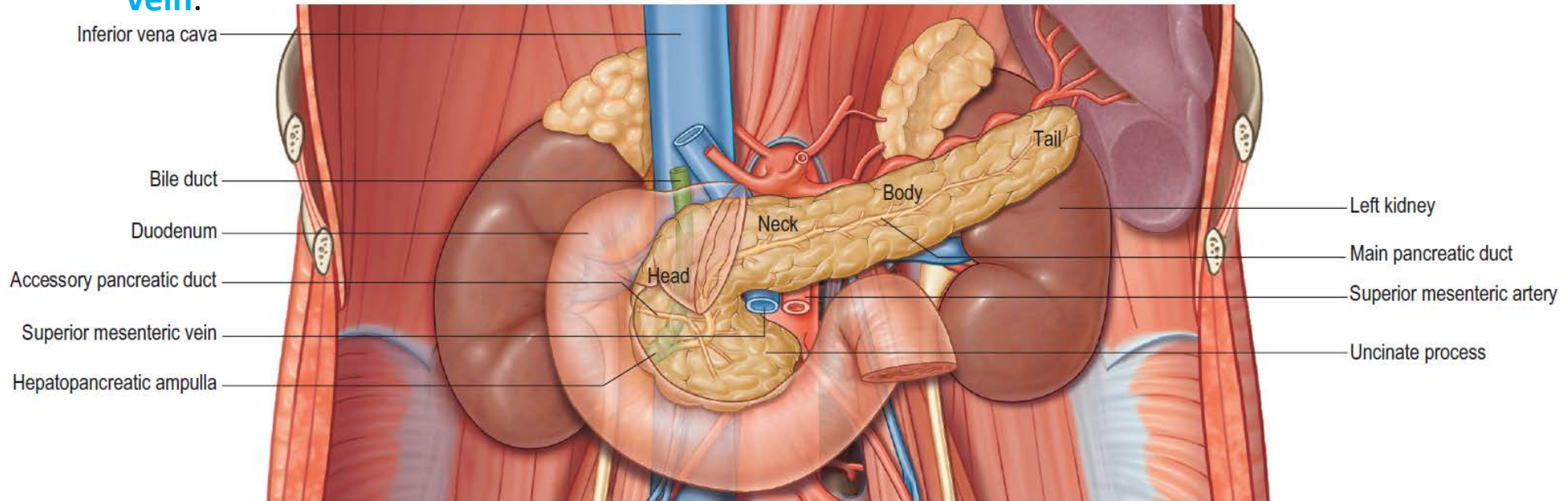


Pancreas

External features and anatomical relations

➤ **Body**, Lat. corpus pancreatis.

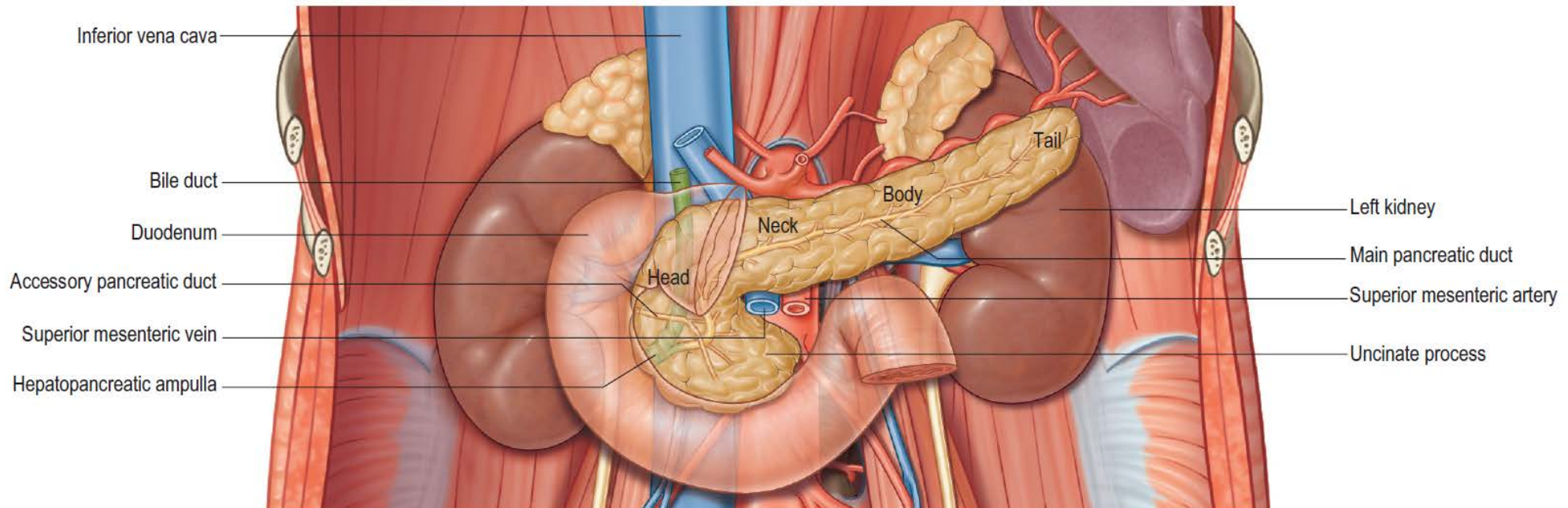
- ✓ It is slightly triangular in cross-section, and has anterior and posterior surfaces and superior and inferior borders.
- ✓ The anterior surface is covered by peritoneum. The two layers of the **transverse mesocolon** diverge along this surface.
- ✓ The posterior surface of the pancreas is devoid of peritoneum. It lies on fascia (the fusion fascia of Toldt) anterior to the **aorta** and the origin of the **superior mesenteric artery**, the left crus of the diaphragm, **left suprarenal gland**, the upper pole of the **left kidney**, and **left renal vein**.



Pancreas

External features and anatomical relations

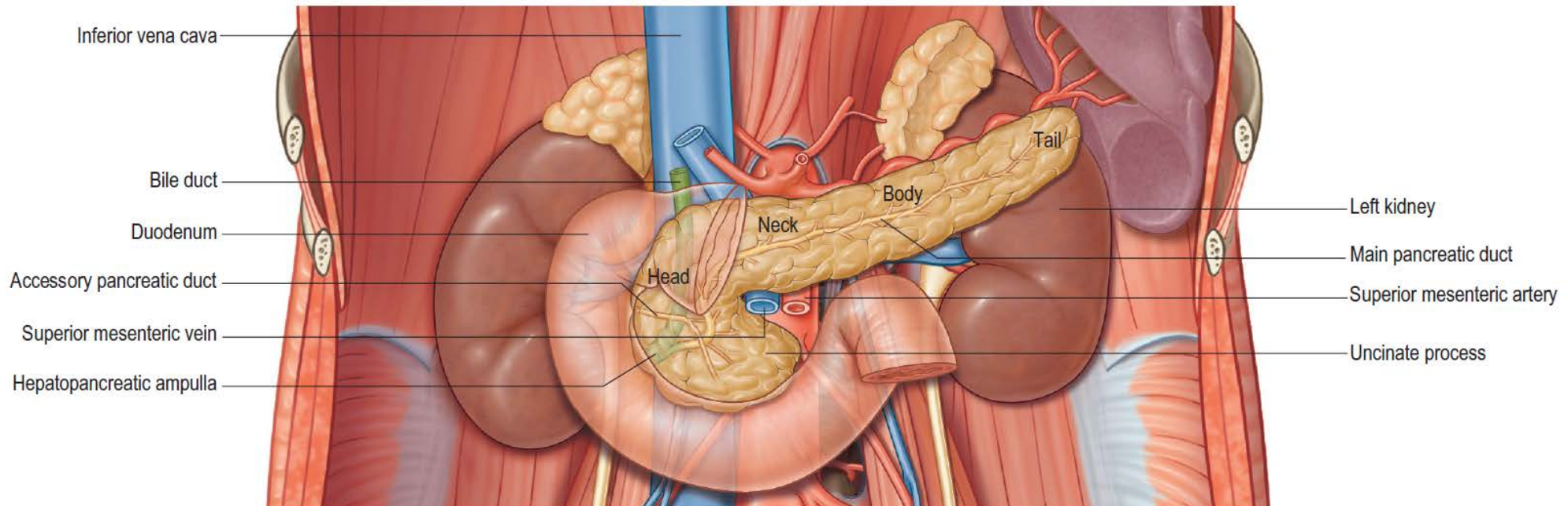
- **Tail**, Lat. cauda pancreatis.
 - ✓ It is the narrowest, most lateral portion of the gland.
 - ✓ It is between 1.5 and 3.5 cm long in adults and lies between the layers of the **splenorenal ligament** up to the **splenic hilum**.



Pancreas

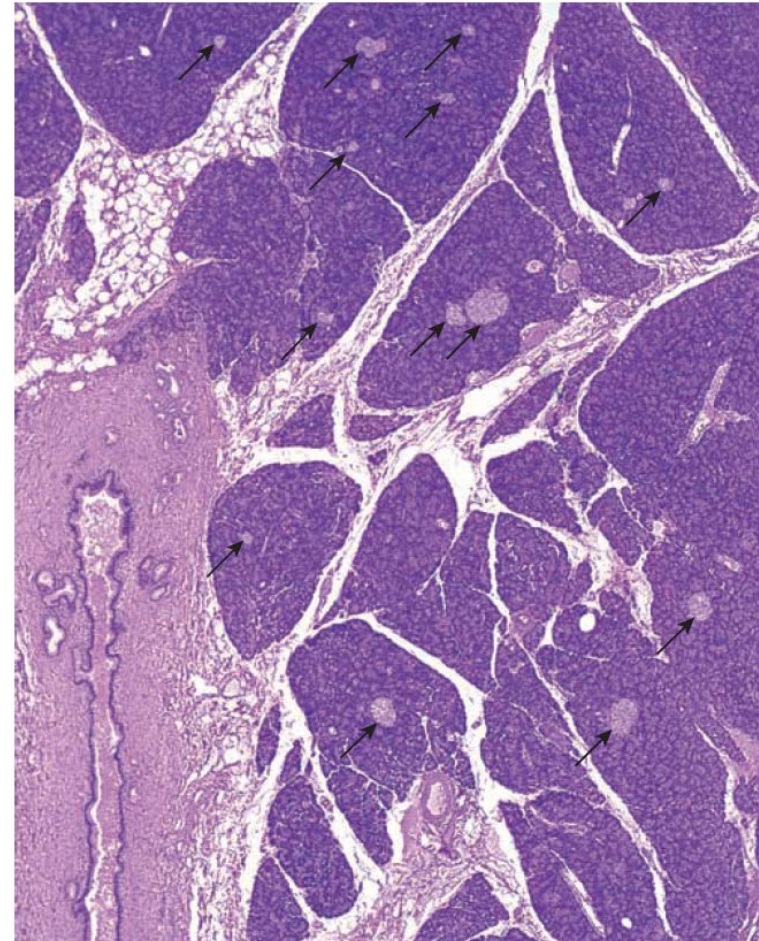
External features and anatomical relations

- **Uncinate process**, Lat. processus uncinatus.
 - ✓ The uncinata process is a hook-shaped continuation of the inferomedial part of the head of the gland.
 - ✓ The **superior mesenteric vein** and the **superior mesenteric artery** descend on its anterior surface before running forwards into the root of the mesentery of the small intestine.



Microstructure of the Exocrine Pancreas

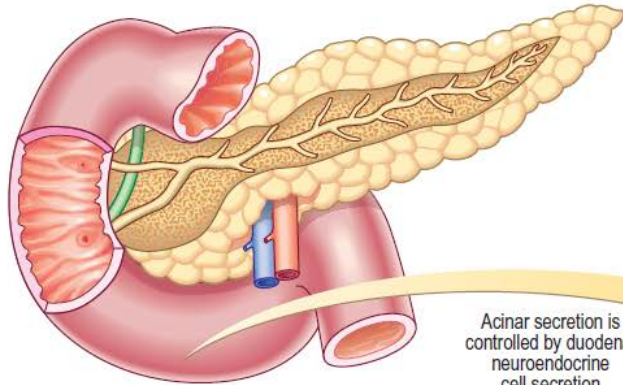
- The exocrine pancreas is a branched acinar gland, surrounded and incompletely lobulated by delicate loose connective tissue.
 - ✓ **Capsula pancreatis.**
 - ✓ **Interlobular septa.**
 - ✓ **Lobules**, Lat. lobuli pancreatici.
- The secretory units are **acinar** in shape and are formed by a simple epithelium of pyramidal **serous cells**.
- Pancreatic **stellate cells** are myofibroblast-like cells distributed mainly in the peri-acinar space.
- Pancreatic acini are unique among glandular acini because the initial duct that leads from the acinus, the **intercalated duct**, actually begins within the acinus.
- The duct cells located inside the acinus are referred to as **centroacinar cells**.



Microstructure of the Exocrine Pancreas

SPHINCTERIC TONE

Neural control Parasympathetic fibres
Sympathetic fibres

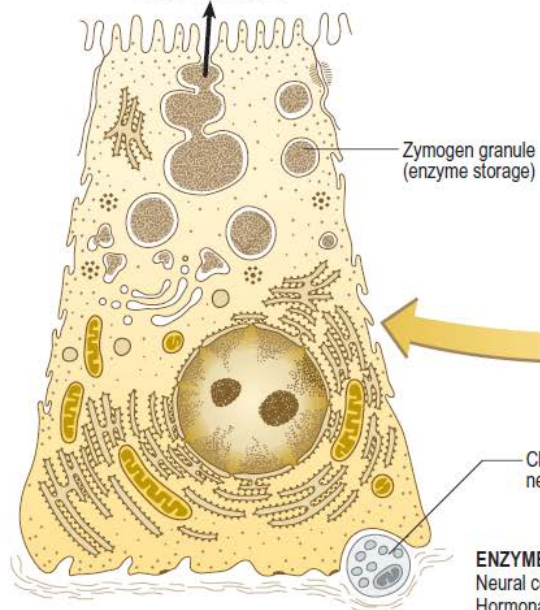


BICARBONATE IONS AND WATER TRANSPORT (Ductal and centro-acinar cells)

Neural control Mainly vagal cholinergic fibres
Hormonal control Mainly secretin (duodenum and jejunum)

Acinar secretion is controlled by duodenal neuroendocrine cell secretion

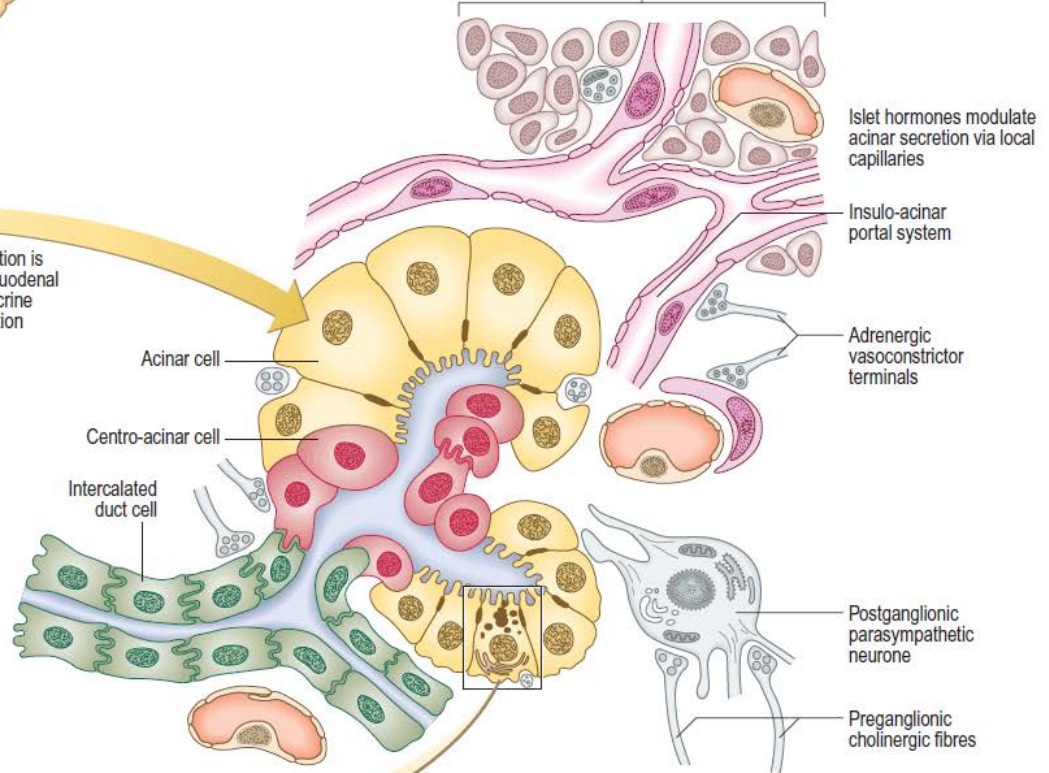
Secretion of granule contents (including proteases, esterase, amylase and lipase)



ENZYME SECRETION (Acinar cells)

Neural control Mainly vagal cholinergic fibres
Hormonal control Mainly duodenal cholecystokinin (CCK)

Pancreatic islet



Islet hormones modulate acinar secretion via local capillaries

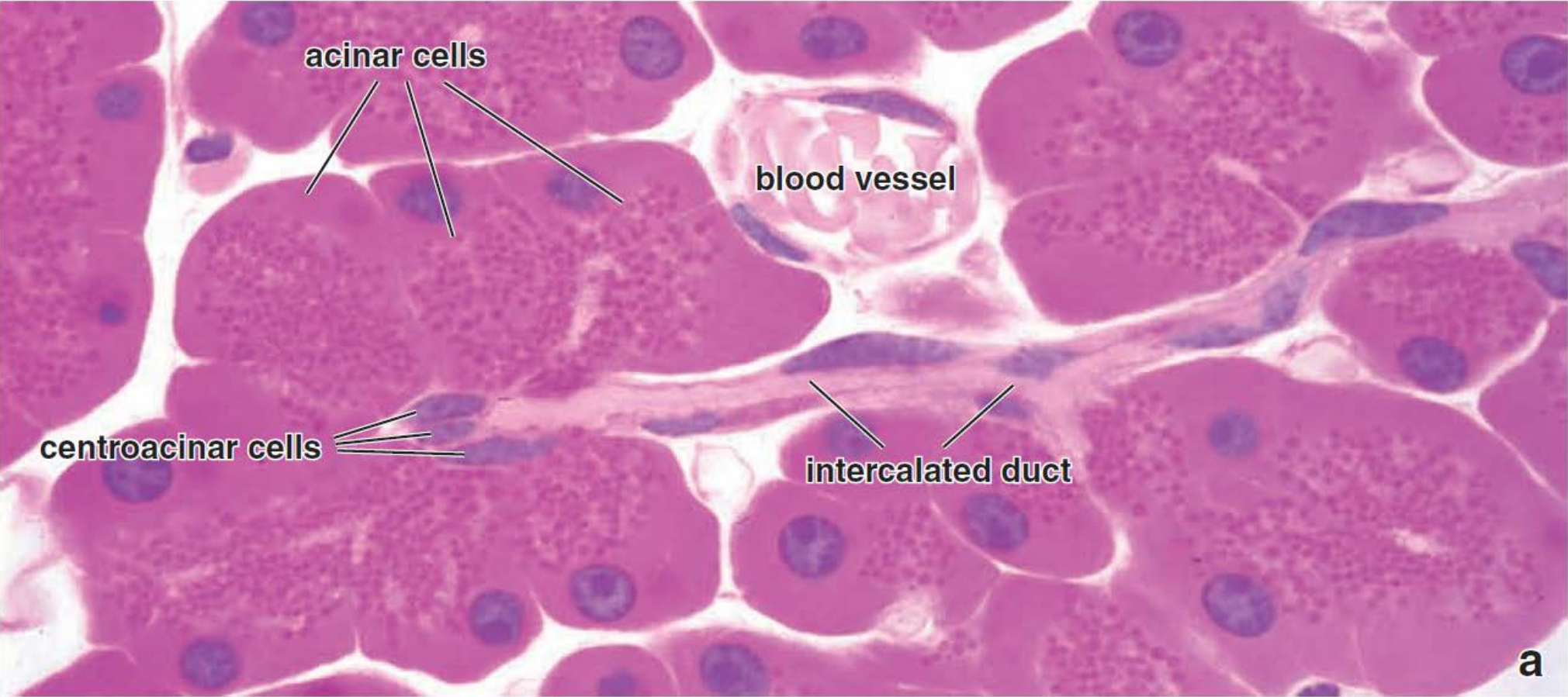
Insulo-acinar portal system

Adrenergic vasoconstrictor terminals

Postganglionic parasympathetic neurone

Preganglionic cholinergic fibres

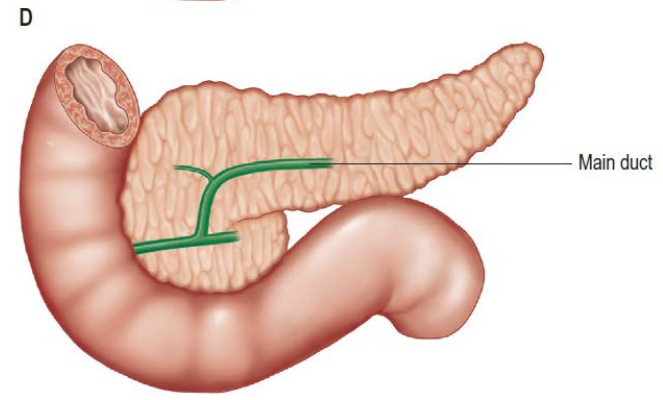
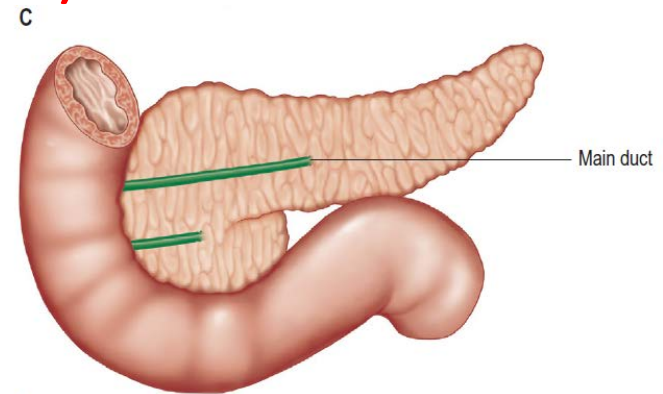
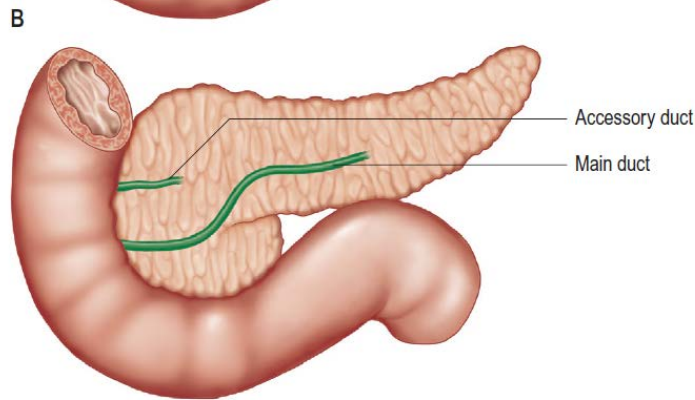
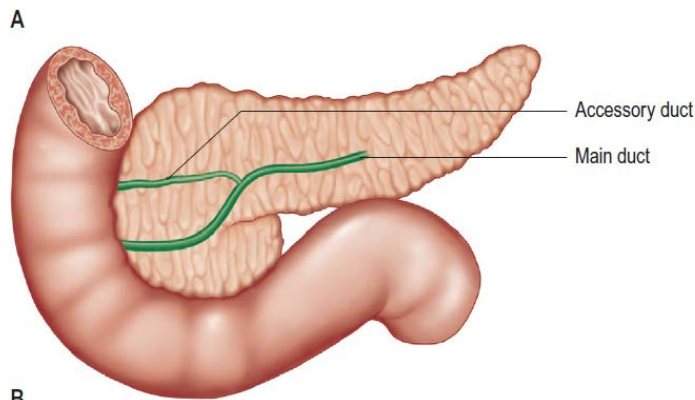
Microstructure of the Exocrine Pancreas



Microstructure of the Exocrine Pancreas

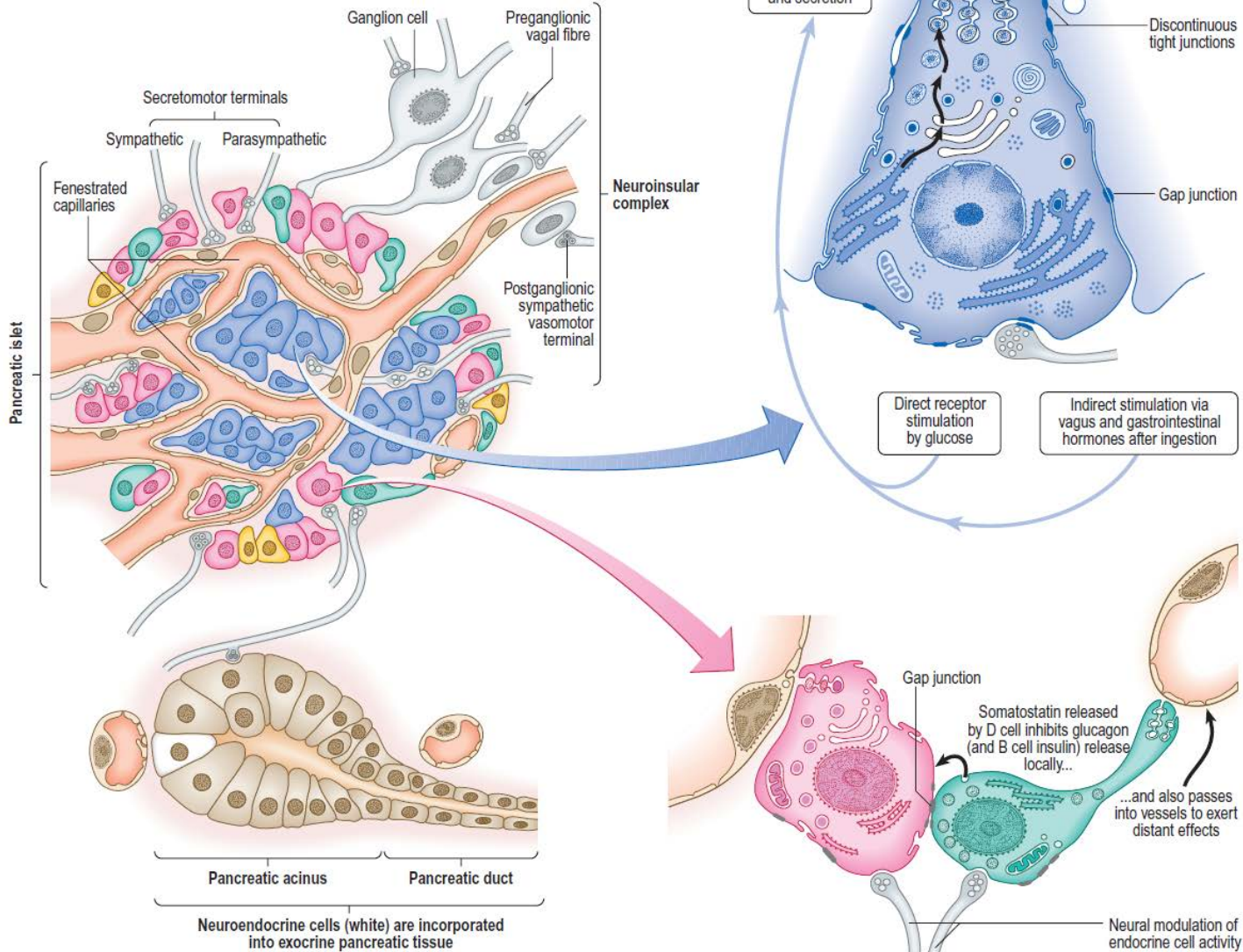
Duct system

- **Intercalated ducts** are short and drain into **intralobular collecting ducts**.
- Intralobular ducts drain into the larger **interlobular ducts**, which are lined with a low columnar epithelium in which enteroendocrine cells and occasional goblet cells may be found.
- The **main pancreatic duct (of Wirsung)**.
- The **accessory (dorsal) pancreatic duct (of Santorini)**.



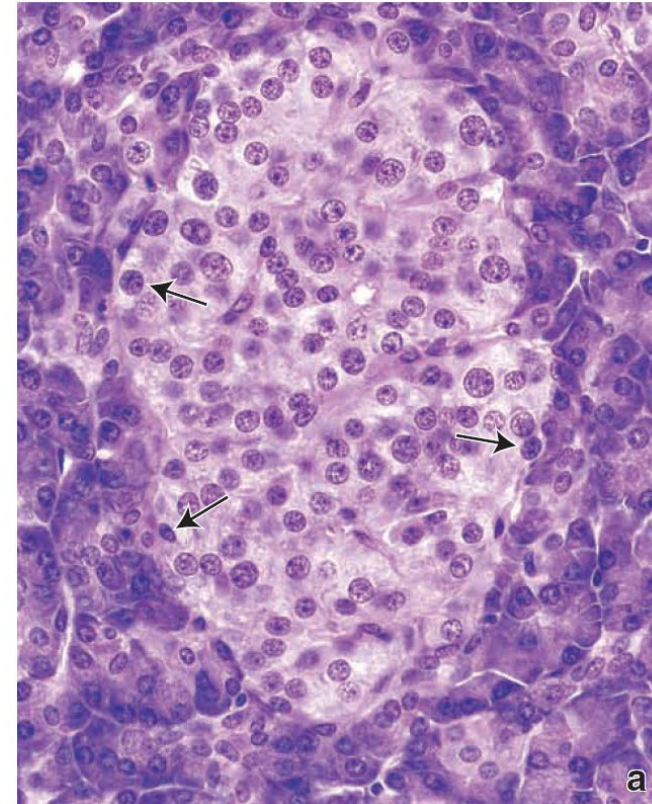
Microstructure of the Endocrine Pancreas

Cell types	Secretion
A (Alpha cells)	Glucagon
B (Beta cells)	Insulin
D (Delta cells)	Somatostatin, gastrin
F cells	Pancreatic polypeptide

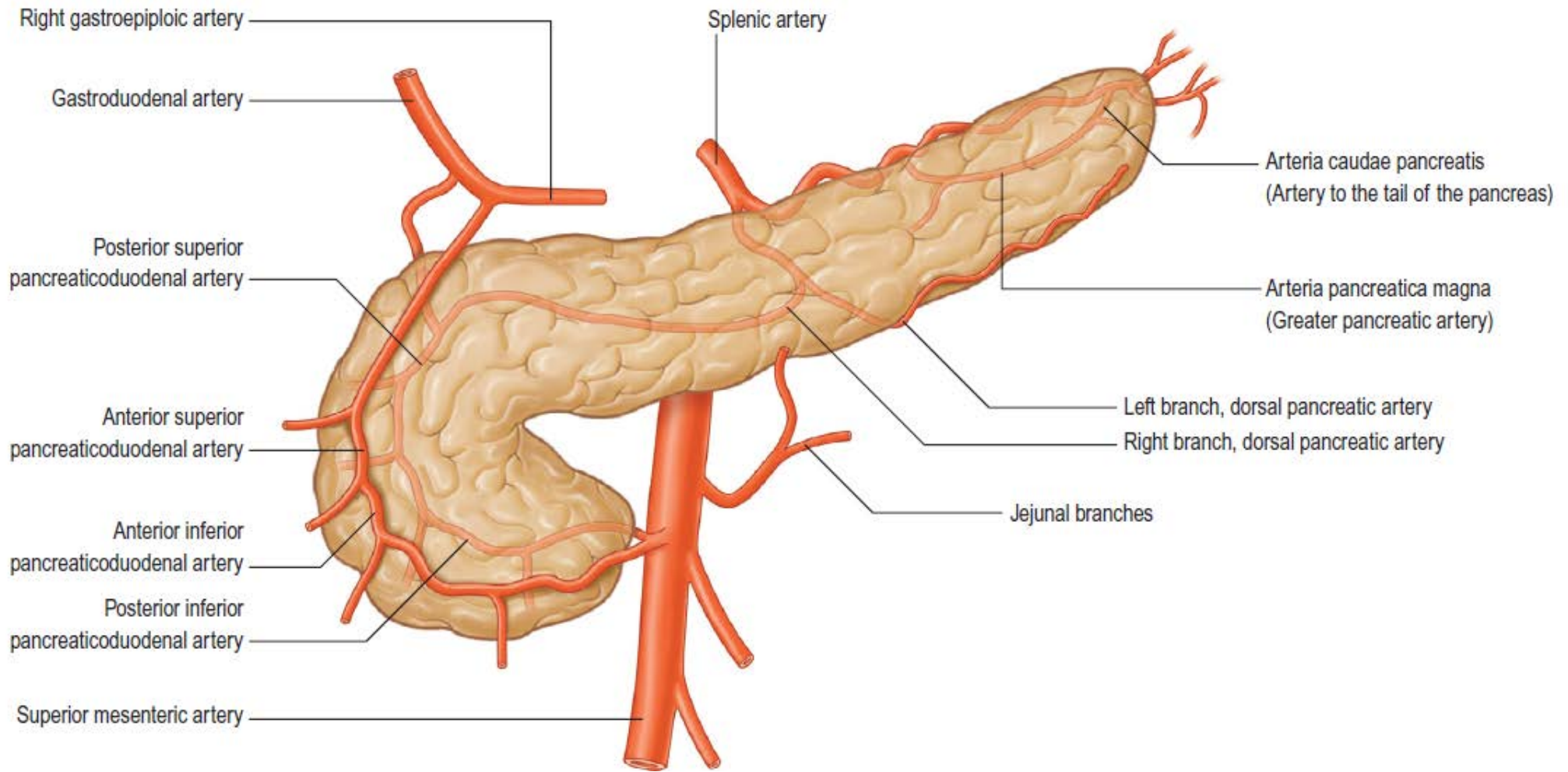


Microstructure of the Endocrine Pancreas

- It is estimated that 1 to 3 million **islets of Langerhans** constitute about 1% to 2% of the volume of the human pancreas but are most numerous in the tail.
- Main cell types:
 - ✓ **B cells secrete insulin (granules of 300 nm)** and constitute about 60% to 70% of the total islet cells and are generally located in its central portion.
 - ✓ **A cells secrete glucagon** and constitute about 15% to 20% of the islet population and are generally located peripherally in the islets.
 - ✓ **D cells secrete somatostatin (granules of 300 – 350 nm)** and constitute about 5% to 10% of the total islet cells tissue and are also located peripherally in the islets.
 - ✓ **Pancreatic polypeptide (PP) or F cells.**
 - ✓ **Epsilon cells secrete ghrelin.**

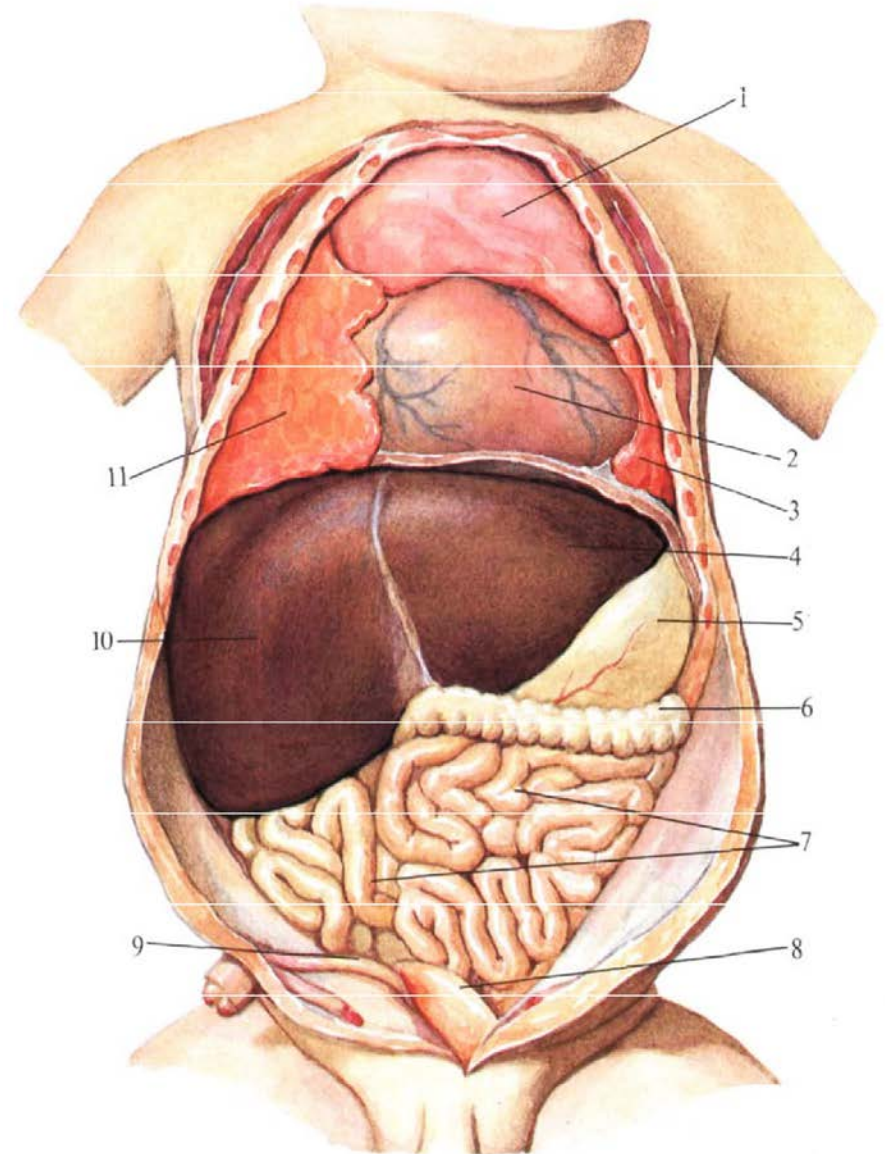


Blood Supply of the Pancreas



Liver

- The **liver, Gr. hepar** is the largest internal organ (gland):
 - ✓ In adults averaging about 1.5 kg or 2% of the body weight.
 - ✓ In infancy it is 4 to 5% of body weight.
 - ✓ Liver filled with blood weights around 2.4 kg in adults.
- The liver has **dual blood supply** from the **hepatic portal vein** (70 to 80 %) and **hepatic artery** (20 to 30 %).

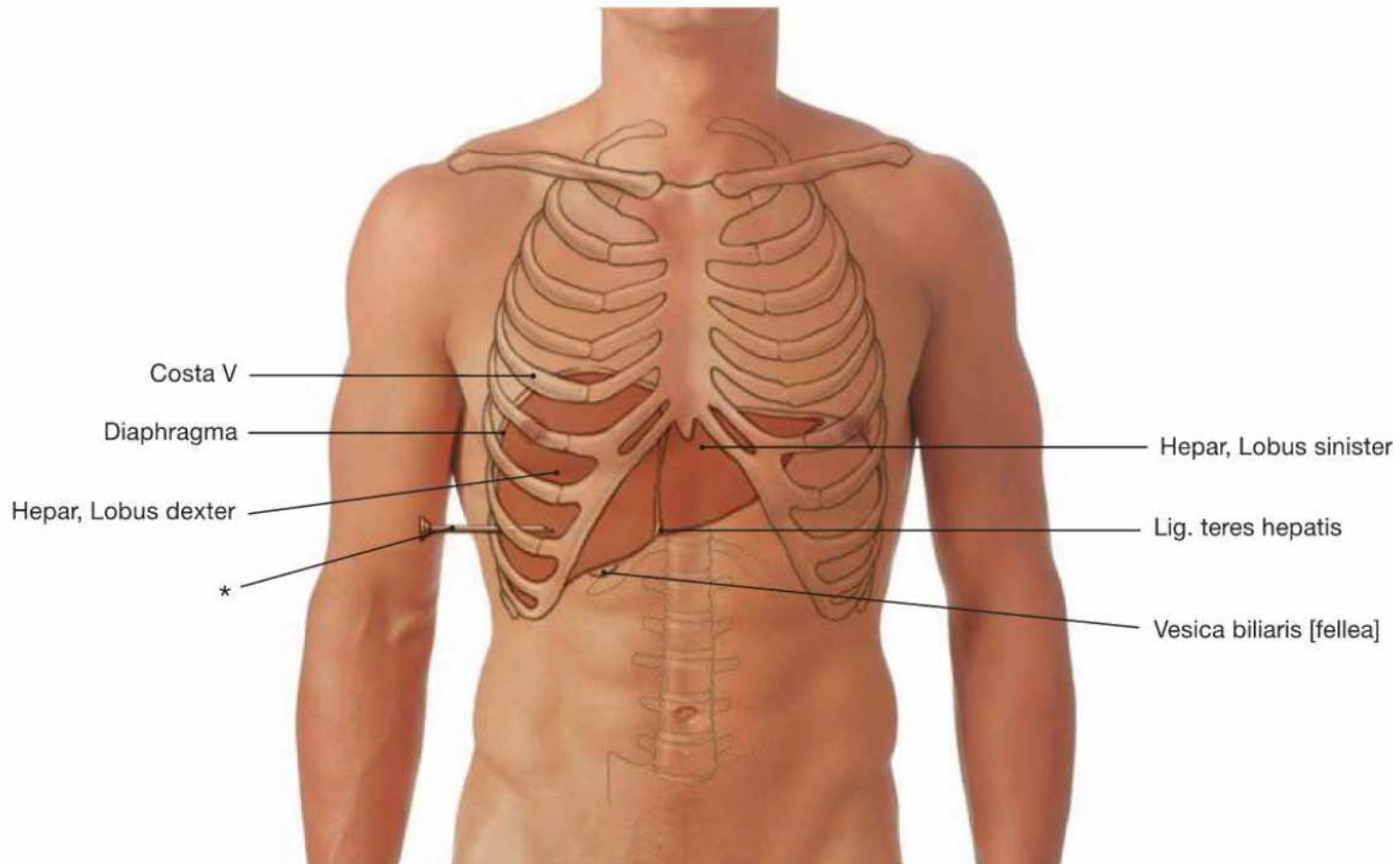


Main Functions of the Liver

- Bile production is an **exocrine function** of the liver.
- The **endocrine-like functions** of the liver are represented by its ability to modify the structure and function of many hormones and biologically active substances – vitamin A, vitamin D, vitamin E, vitamin K.
- The liver produces most of the body's circulating plasma proteins (**synthetic function**) – albumins, lipoproteins, clotting factors, binding proteins, transport proteins.
- **Metabolic functions:**
 - ✓ Carbohydrate metabolism – regulates the blood-sugar level.
 - ✓ Protein metabolism – deamination of amino acids and synthesis of urea.
 - ✓ Lipid metabolism – cholesterol (80%) synthesis and lipogenesis.
- **Detoxification** – xenobiotics, steroid, endogenous metabolites.
- Helps maintain electrolyte and water **homeostasis**.
- **Thermoregulation**.
- **Storage** – glycogen, vitamin B12, vitamin A.

Liver

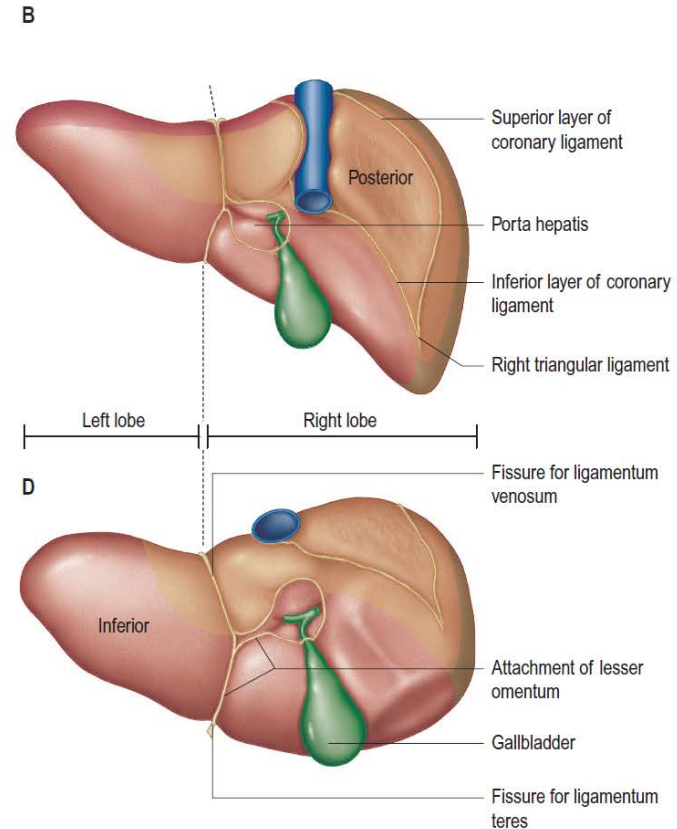
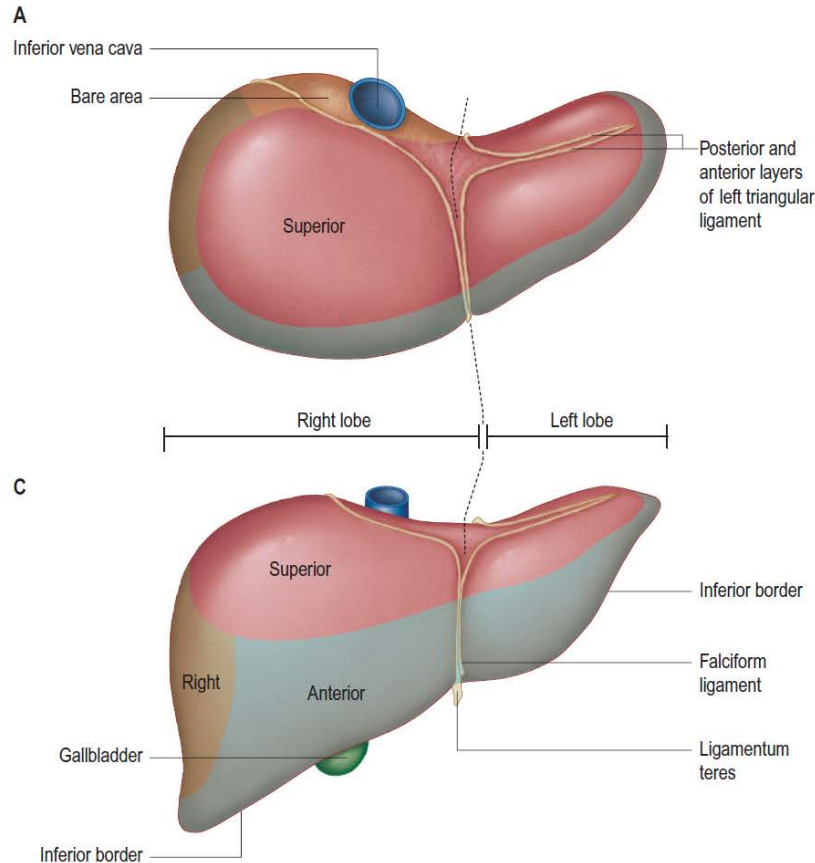
- The liver is located primarily in the **right hypochondrium** (3/4 of it) and **epigastric region**, extending into the **left hypochondrium**.



Liver

External features and relation of the liver

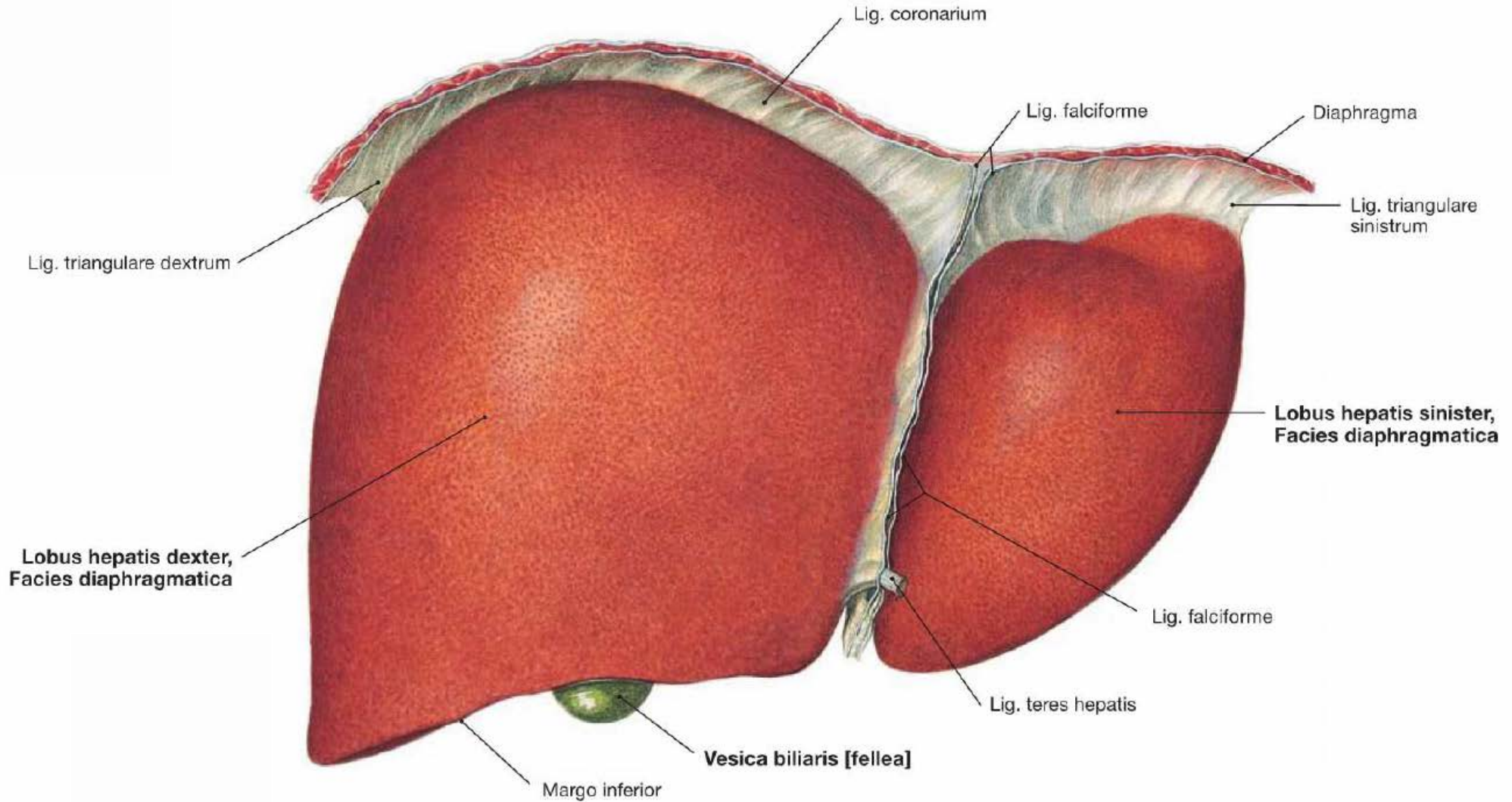
- The liver is usually described as having superior, anterior, right, posterior and inferior surfaces, and has a distinct inferior border.
- It is more appropriate to group the superior, anterior, right and posterior surfaces as the **diaphragmatic surface**, which is mostly separated from the **inferior (visceral) surface** by a narrow inferior border.



Liver

External features and relation of the liver

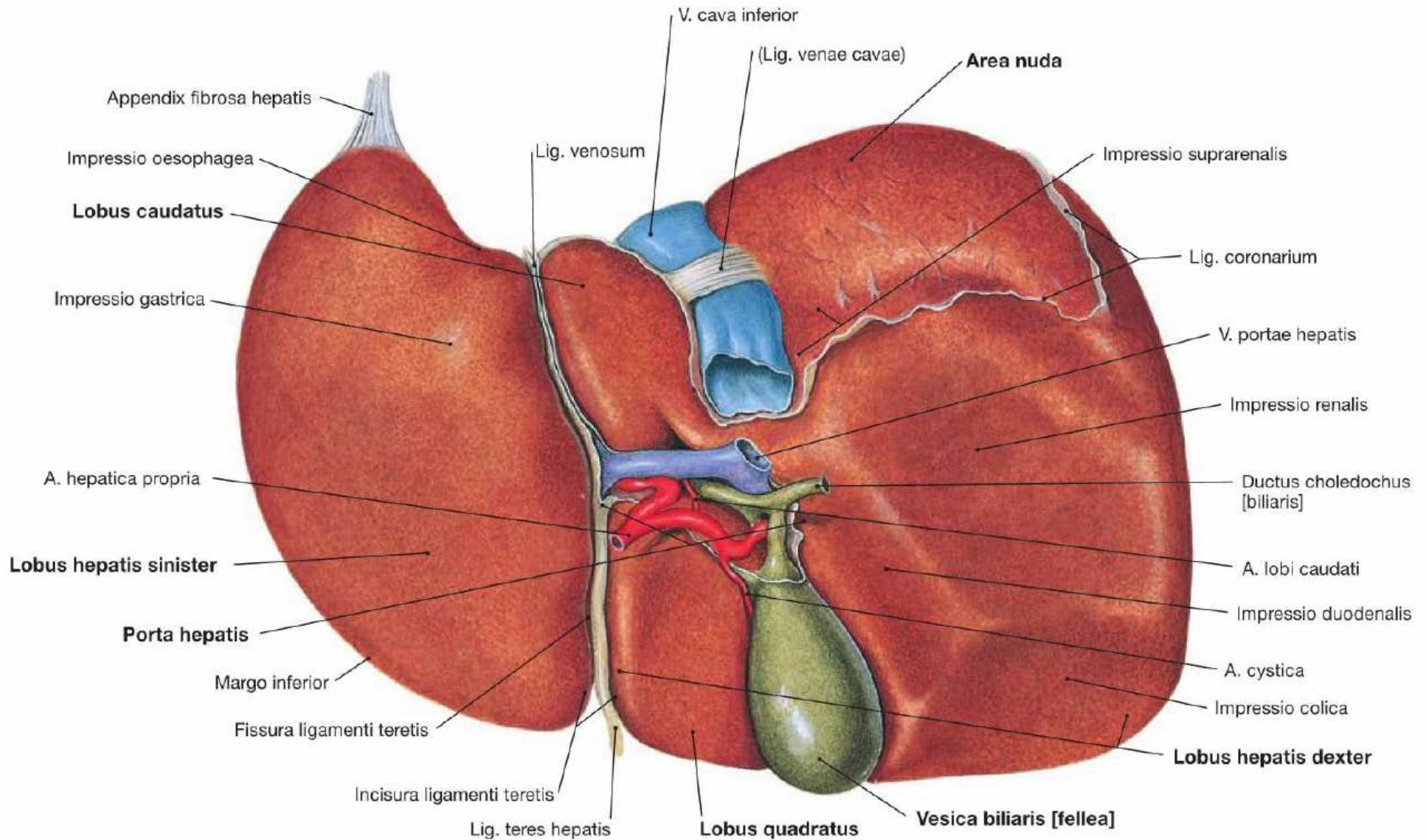
➤ Diaphragmatic surface.



Liver

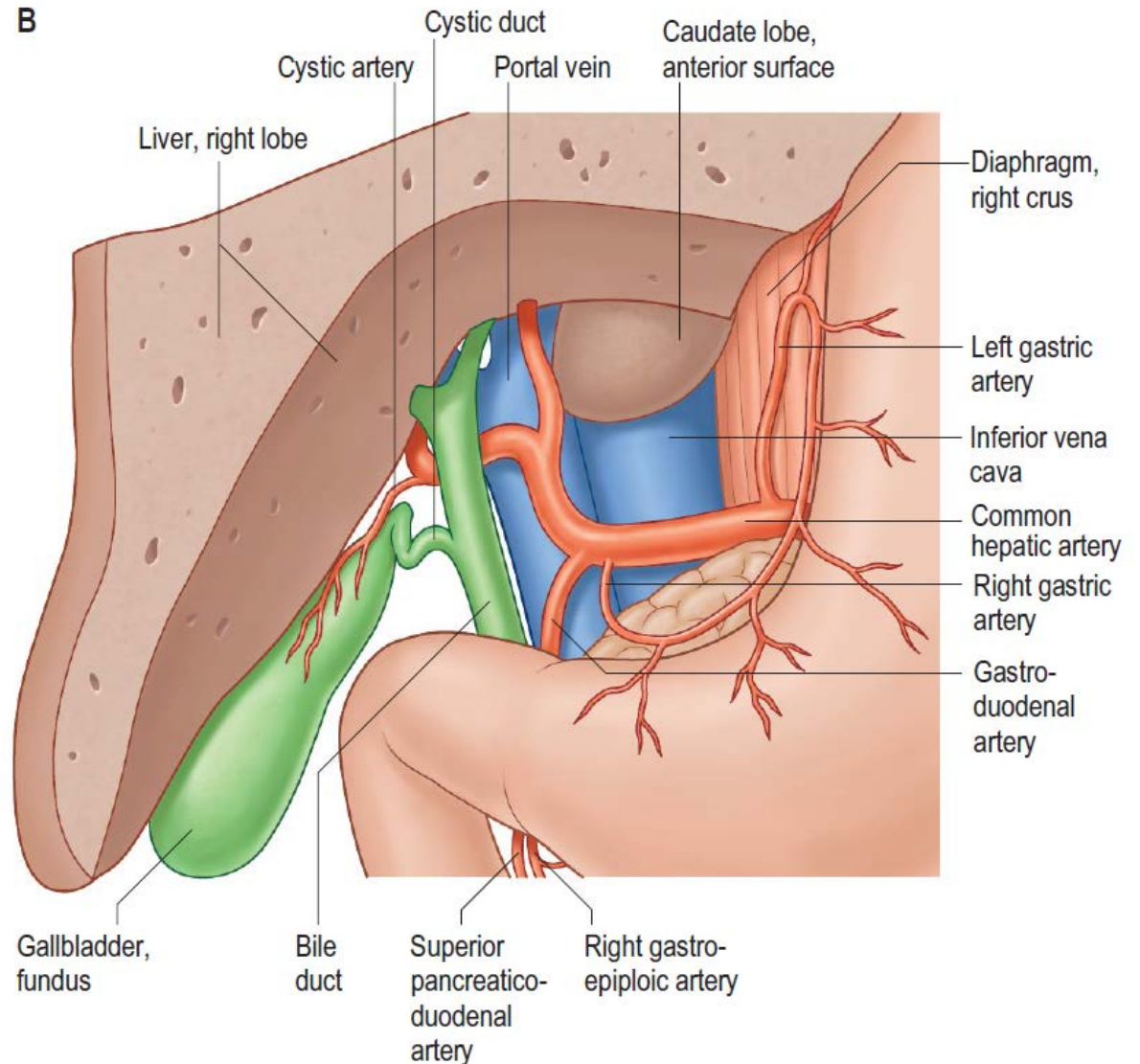
External features and relation of the liver

➤ Inferior (visceral) surface.



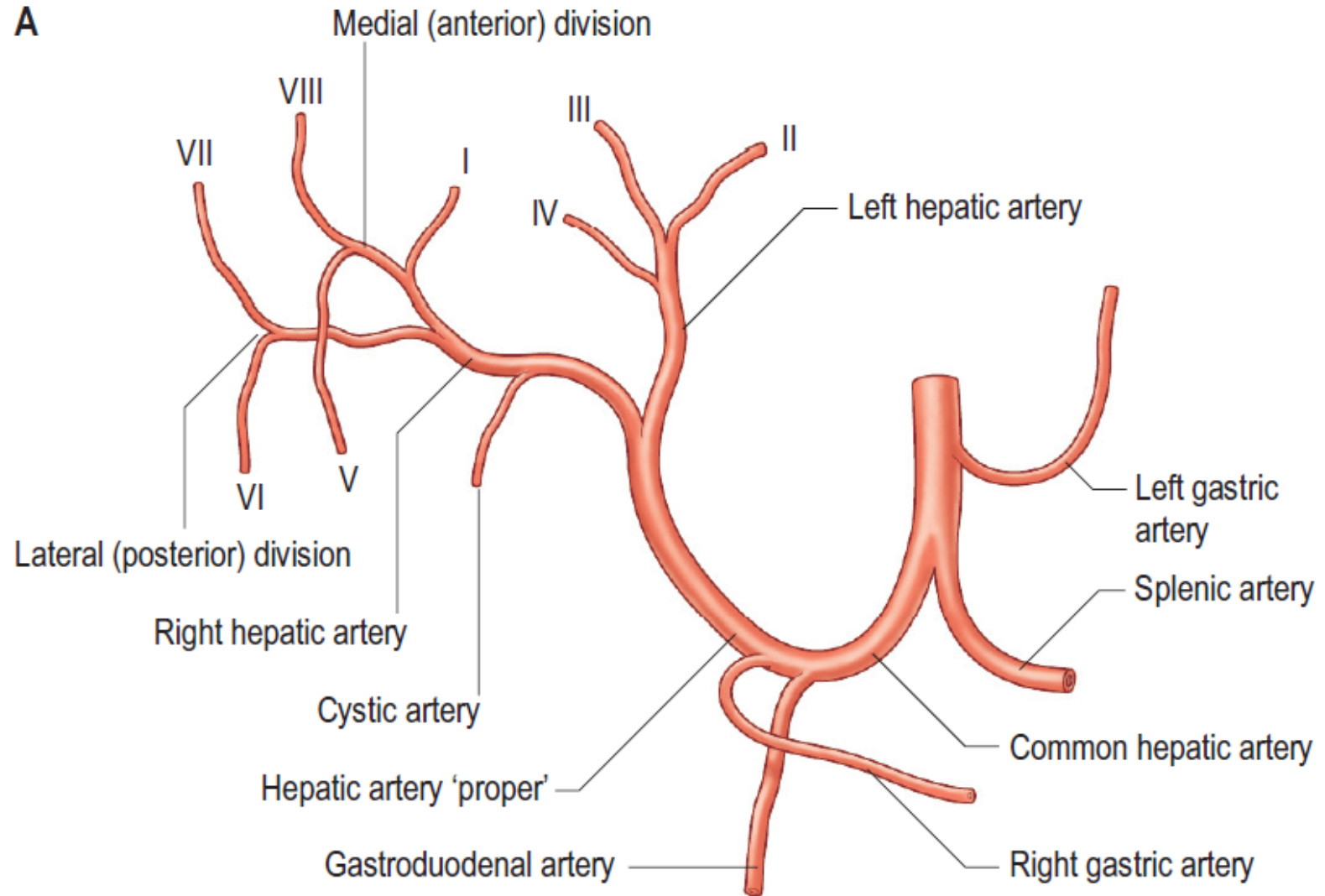
Hepatic Vessels and Segmentation

- The hepatic portal system:
 - ✓ **Portal vein.**
 - ✓ **Hepatic artery proper.**
 - ✓ **Lymphatic vessels.**
- The hepatic veins.



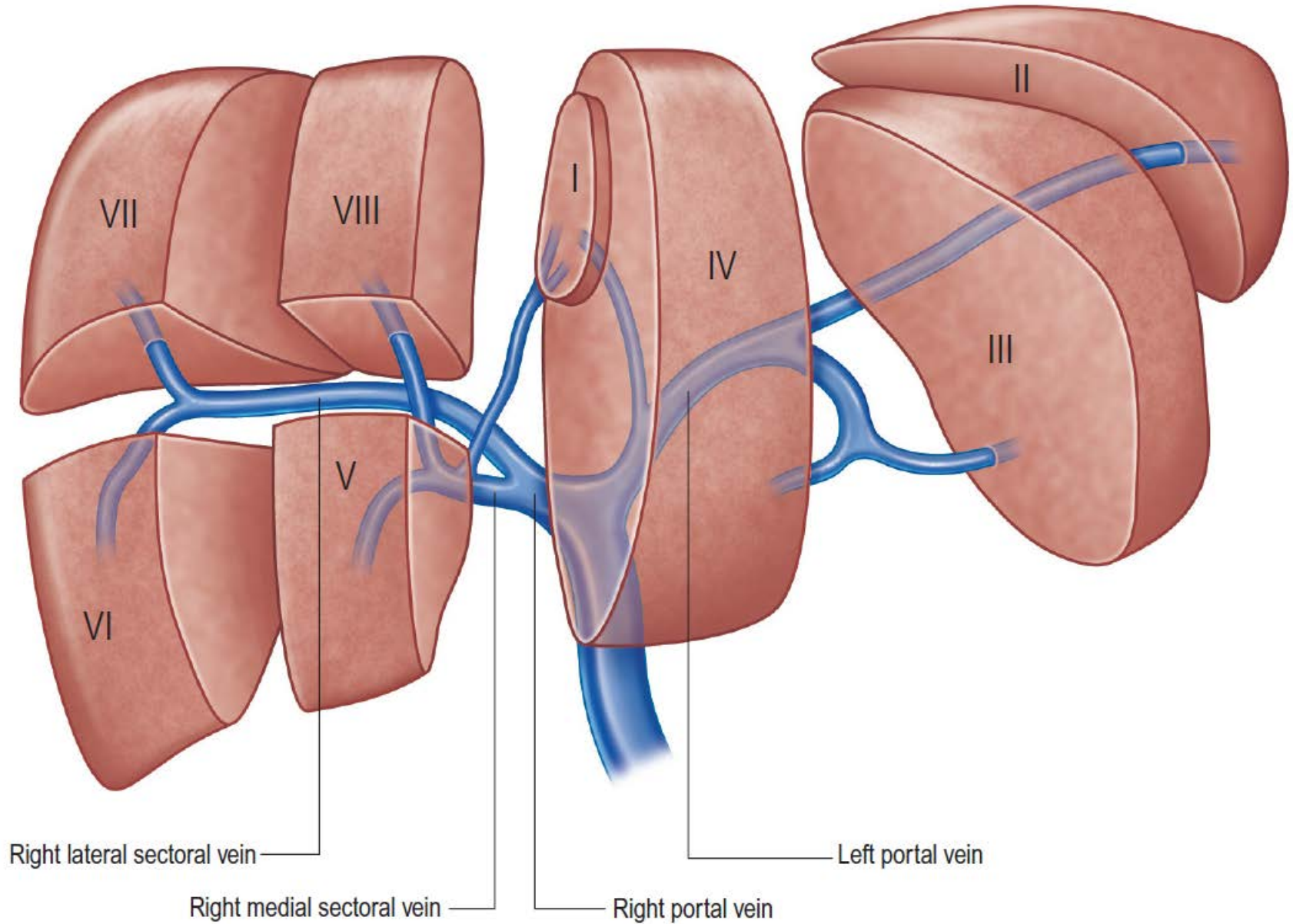
Hepatic Vessels and segmentation

Hepatic artery proper



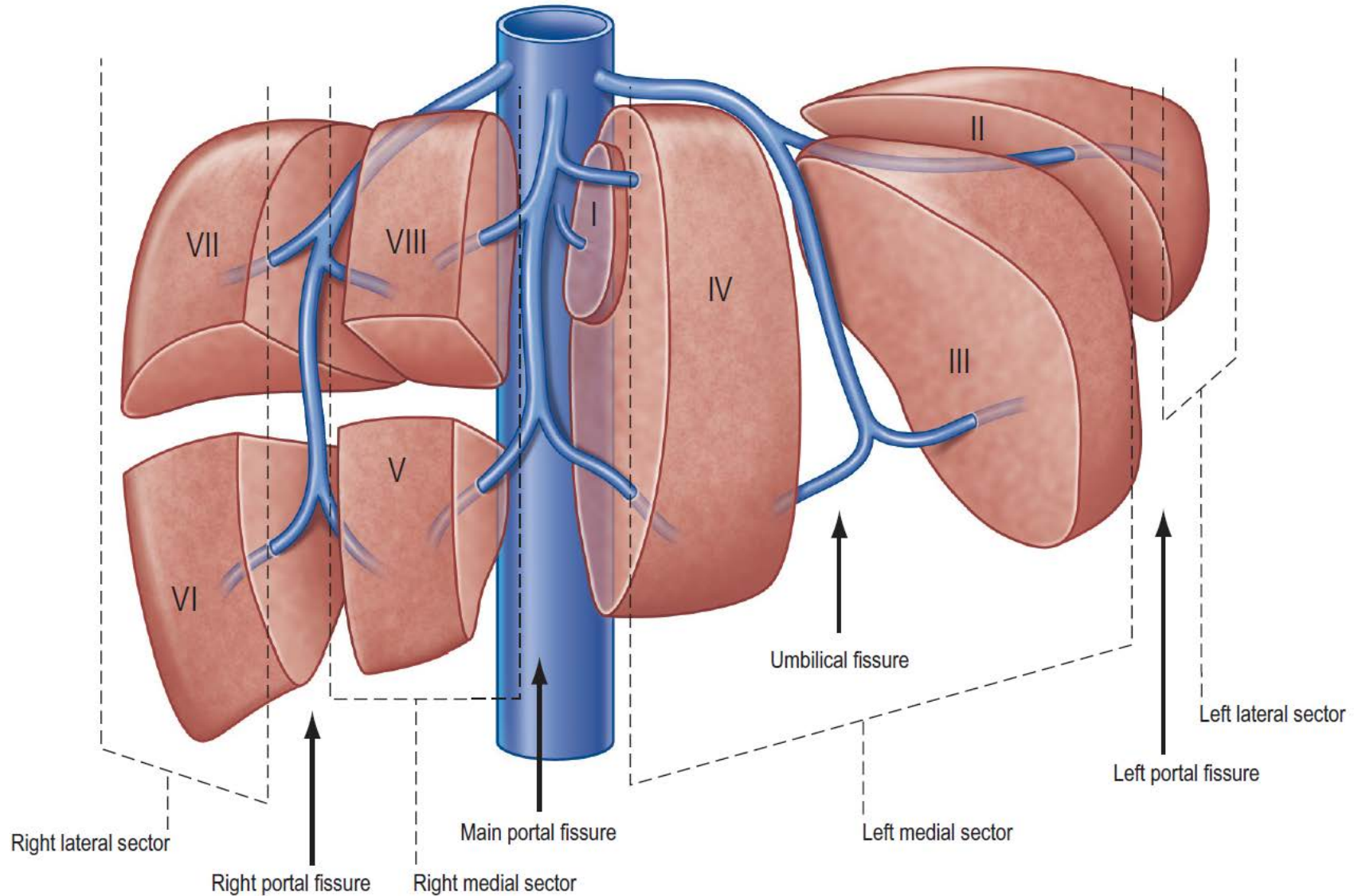
Hepatic Vessels and Segmentation

Portal vein



Hepatic Vessels and Segmentation

Hepatic veins

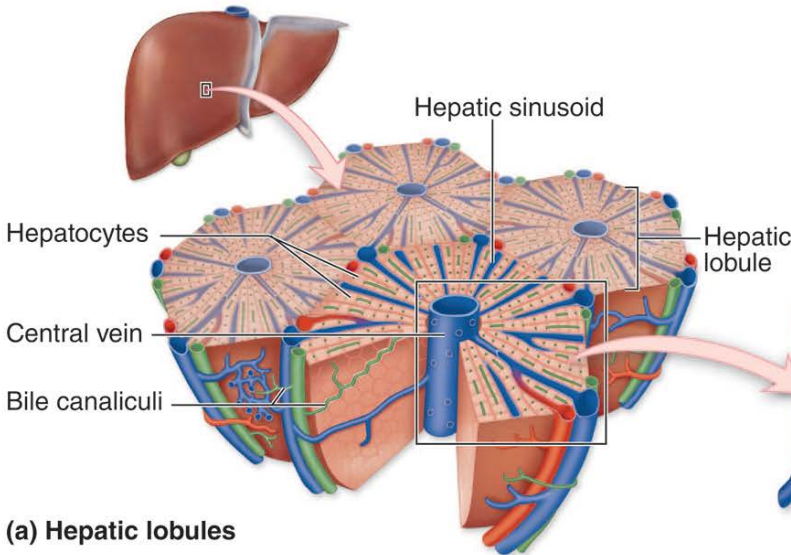


Microstructure of the Liver

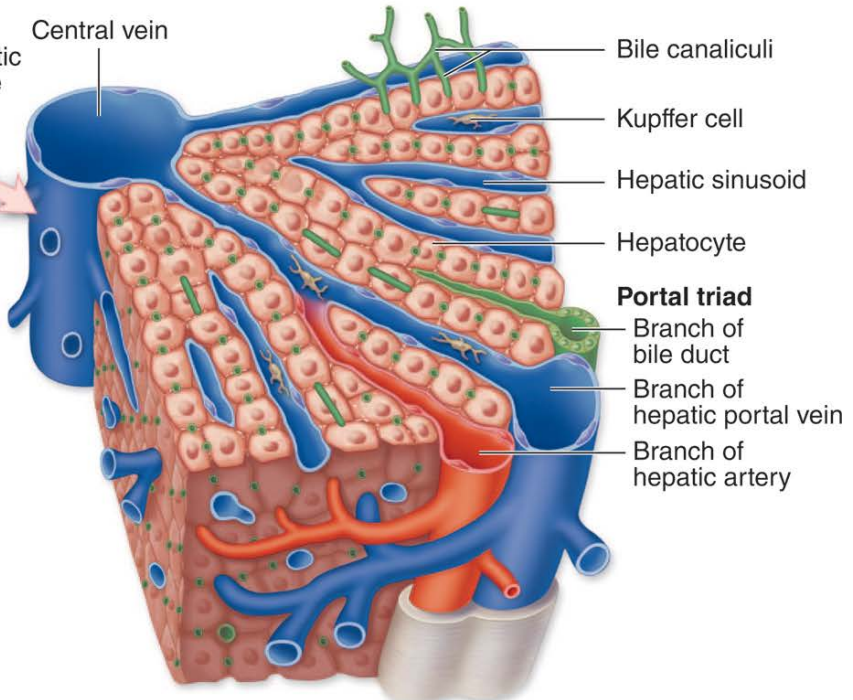
- Most of the surface of the liver is covered by a typical **serosa** (visceral peritoneum).
- Beneath this, and enclosing the whole organ, is a thin (50–100 μm) **capsule of connective tissue (capsule of Glisson)**, from which extensions pass into the liver as **septa** and **trabeculae**.
- Branches of the **hepatic artery**, **hepatic portal vein** and **bile ductules (portal triads)**, run within these connective tissue trabeculae.
- Liver **parenchyma** consists of organized plates of **hepatocytes**, which in the adult are normally one cell thick and are separated by **sinusoidal capillaries**.
- **Sinusoidal capillaries (sinusoids)** are the vascular channels between the plates of hepatocytes.
- **Perisinusoidal spaces (spaces of Disse)** lies between the sinusoidal endothelium and the hepatocytes.

Microstructure of the Liver

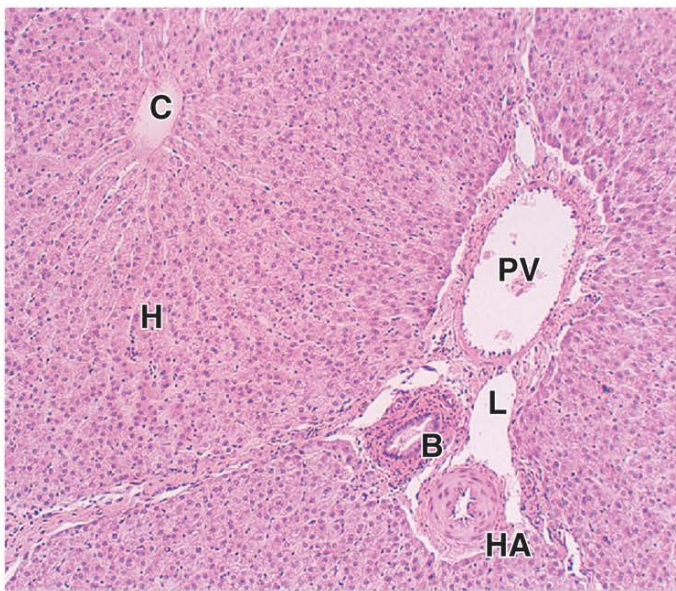
The classic hepatic lobule



(a) Hepatic lobules



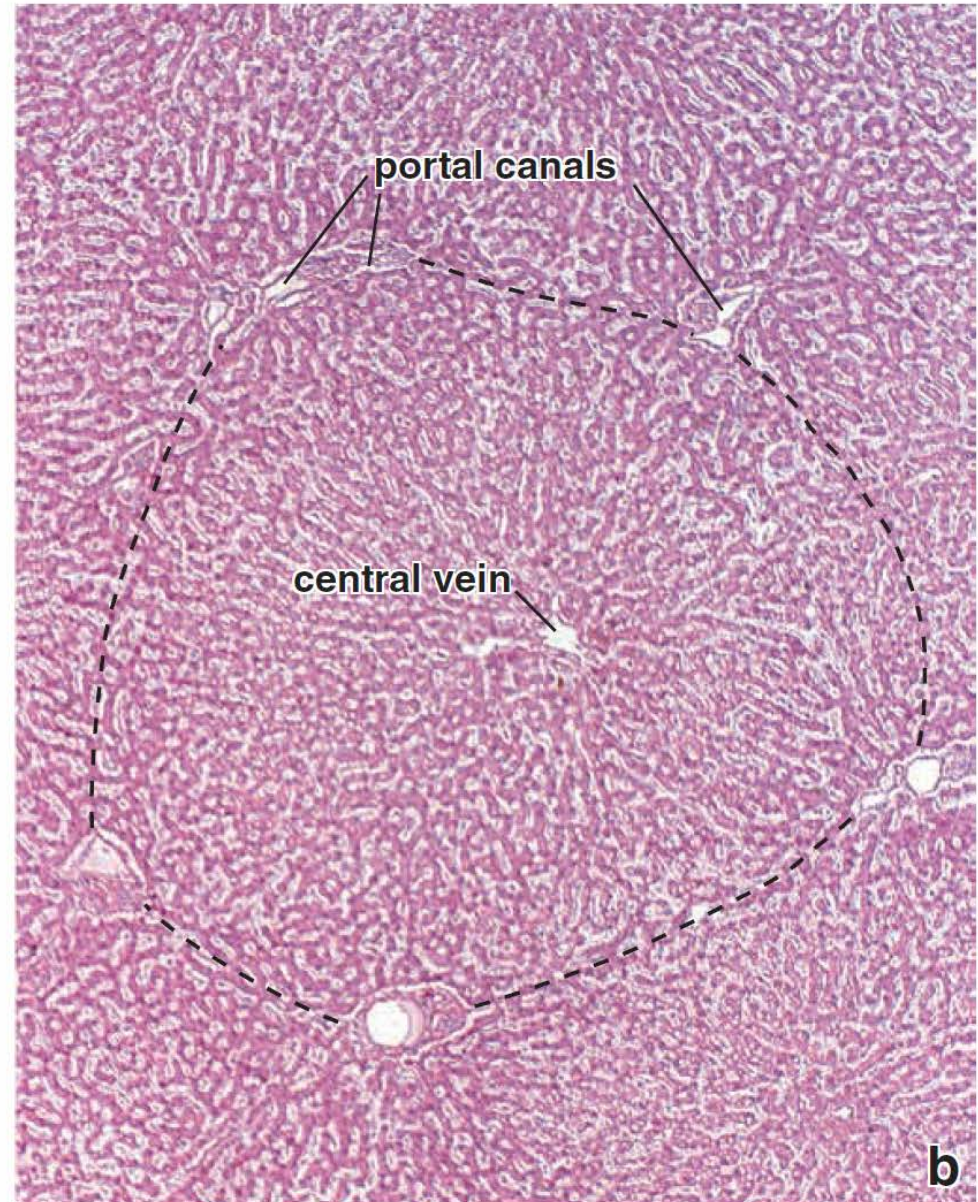
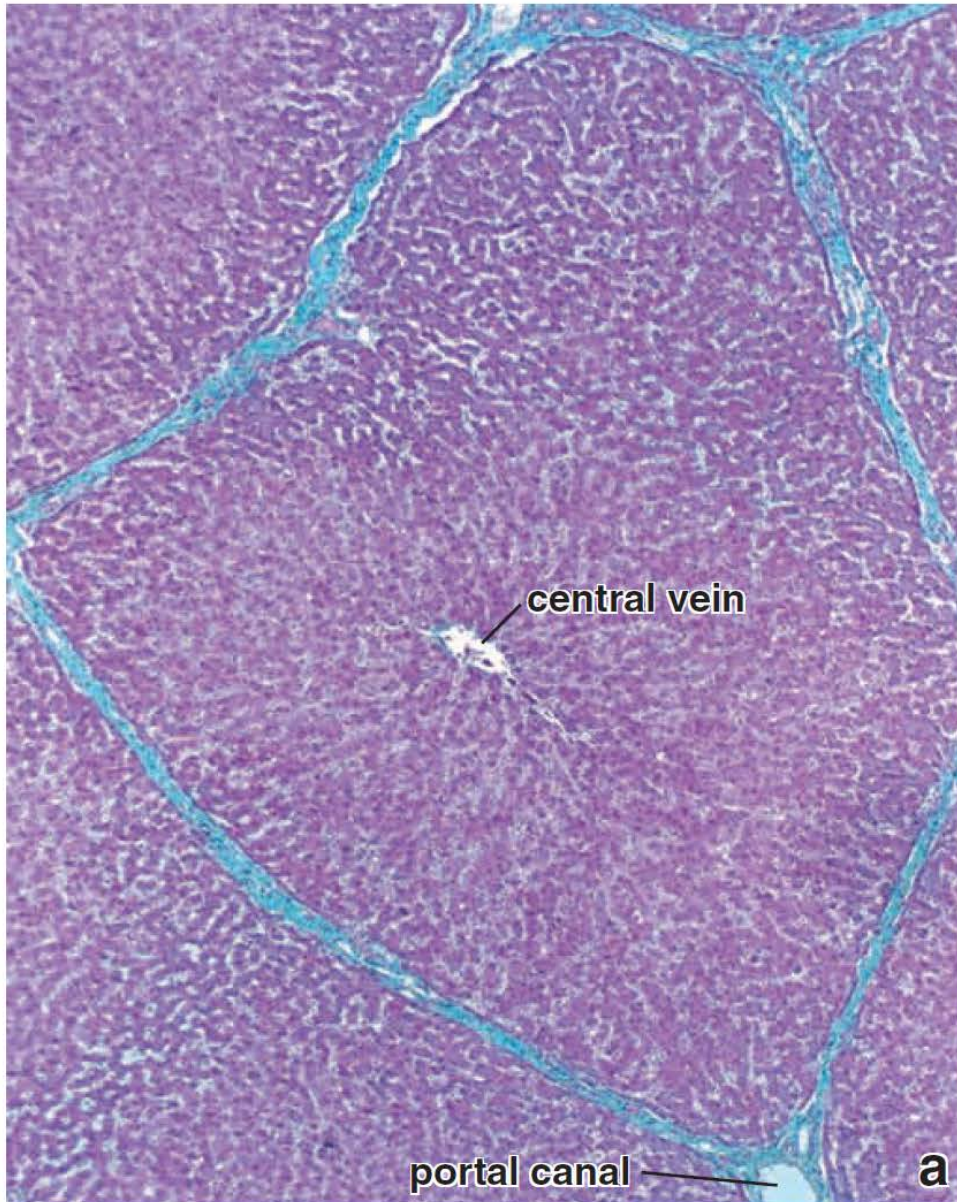
(b) Hepatocytes and sinusoids



(c) Portal triad and hepatic lobule

Microstructure of the Liver

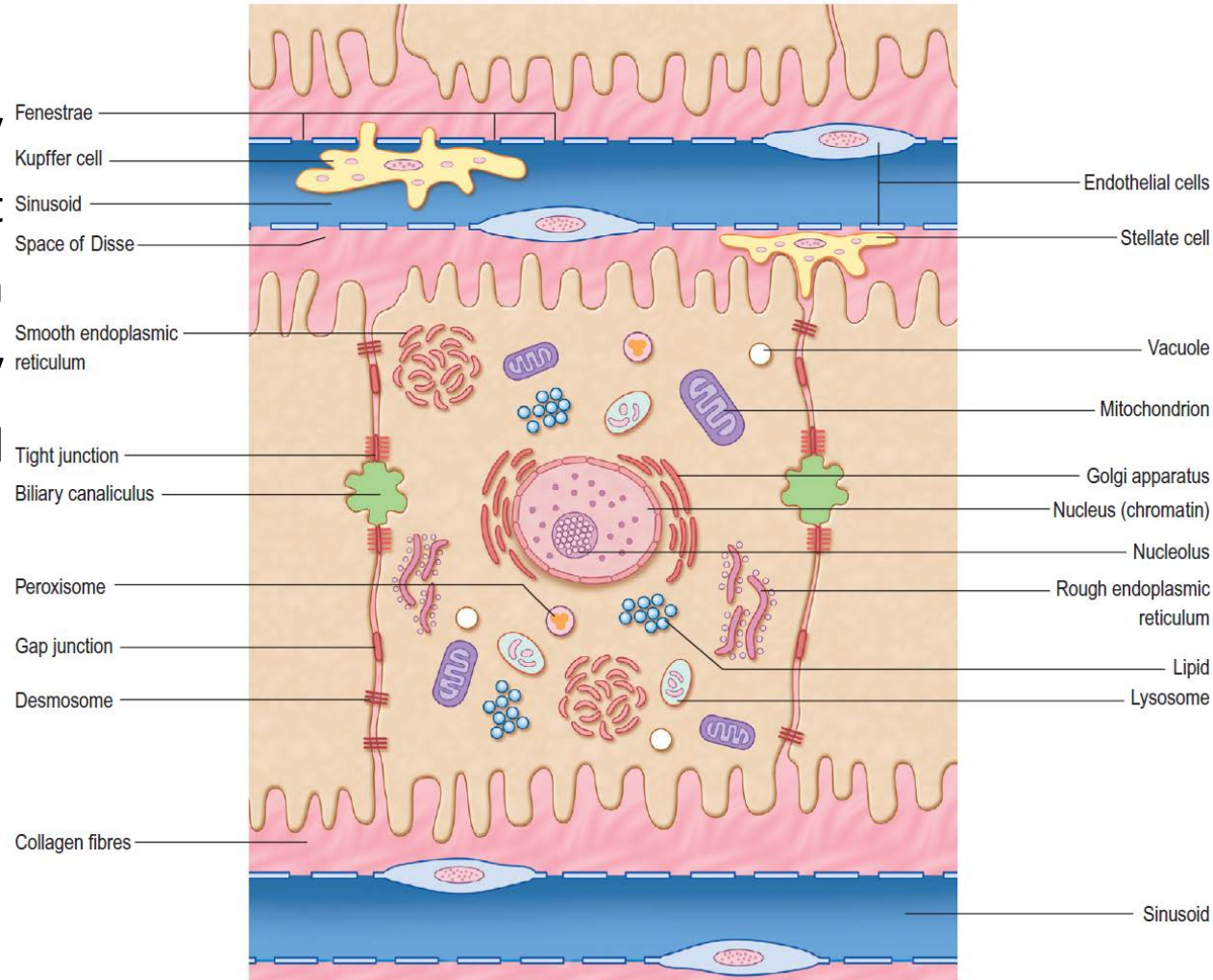
The classic hepatic lobule



Microstructure of the Liver

Hepatocytes

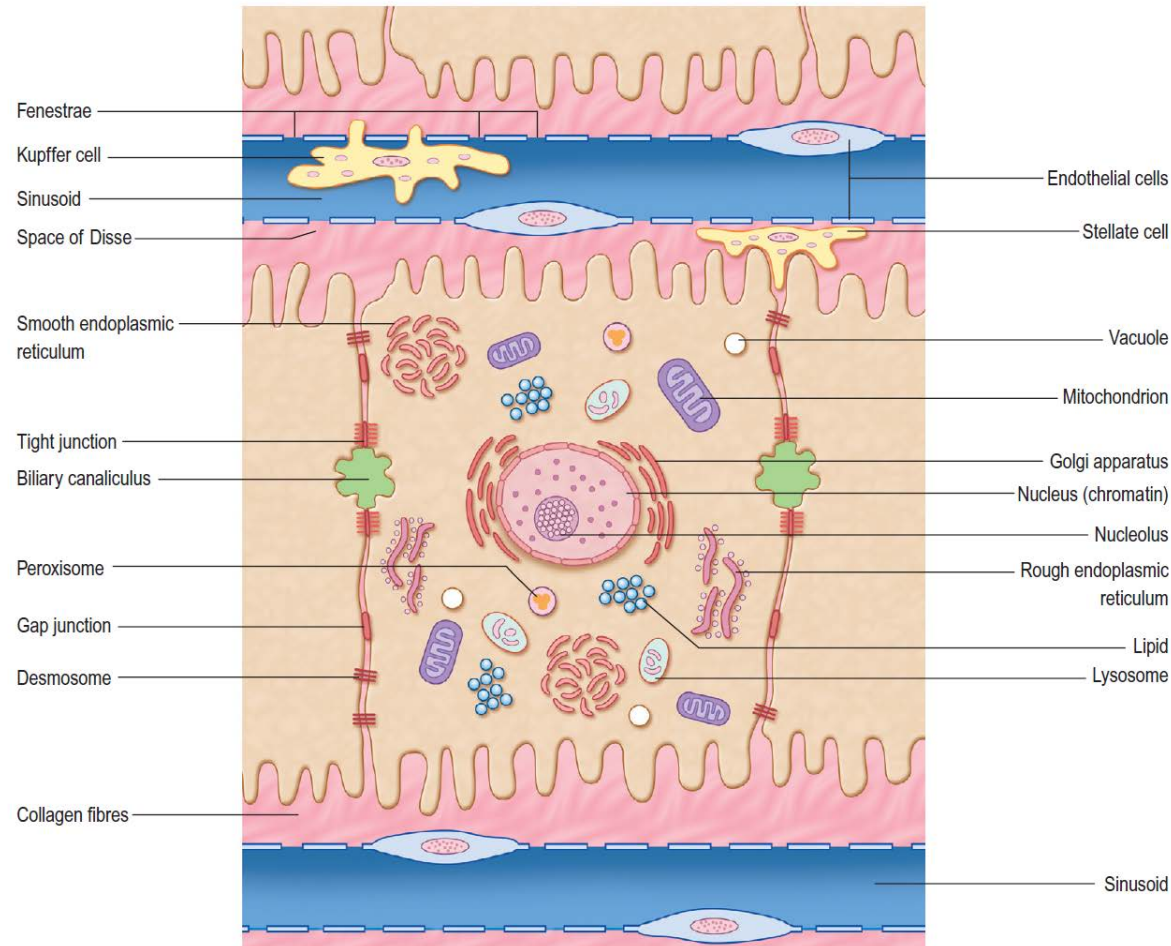
- About 80% of the liver volume and 60% of its cellular population.
- They are polyhedral, with 5-12 sides, and measure 20-30 μm across. Their nuclei are round, euchromatic and often tetraploid, polyploid or multiple, with two or more in each cell.
- Their cytoplasm typically contains a considerable amount of rough and smooth endoplasmic reticulum, many mitochondria, lysosomes and well-developed Golgi apparatus.



Microstructure of the Liver

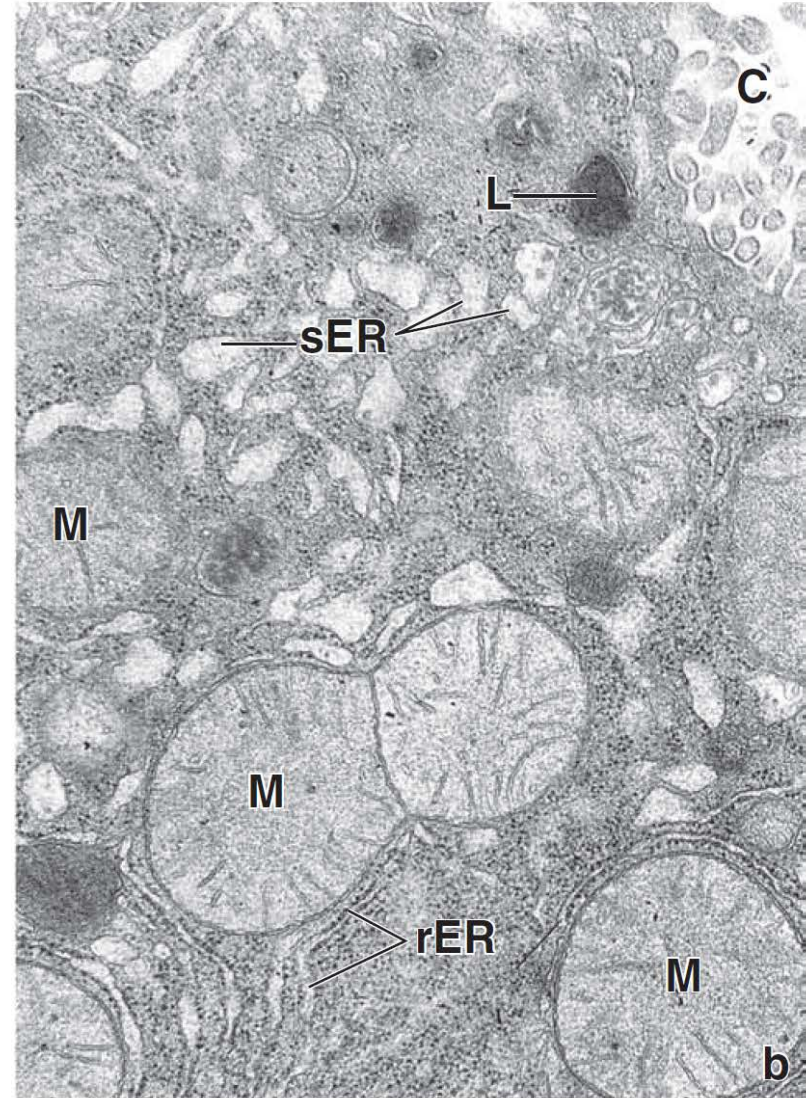
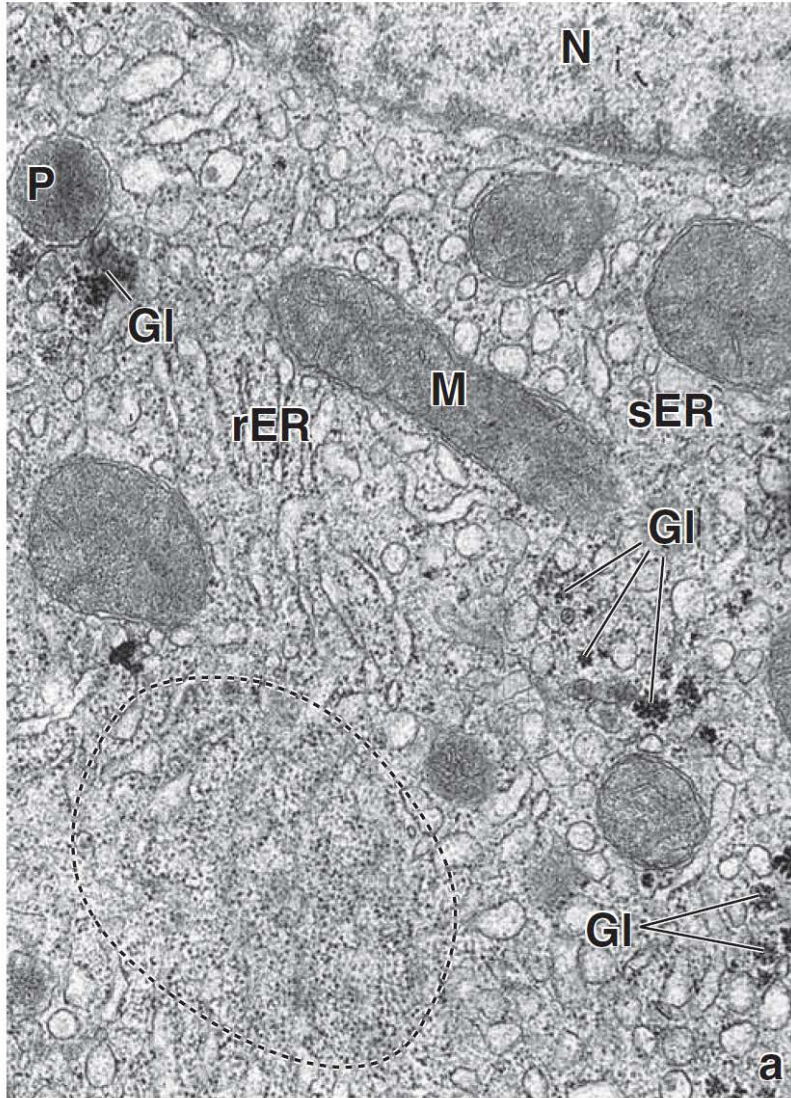
Hepatocytes

- Numerous large peroxisomes.
- The surfaces of hepatocytes facing the sinusoids exhibit numerous microvilli, approximately 0.5 μm long.
- Glycogen granules and lipid vacuoles are usually prominent.
- Lateral plasma membranes of adjacent hepatocytes form the bile canaliculi, which are specialized regions of intercellular space formed by apposing grooves in hepatocyte plasma membranes, sealed from extraneous interstitial space by tight junctions.



Microstructure of the Liver

Hepatocytes

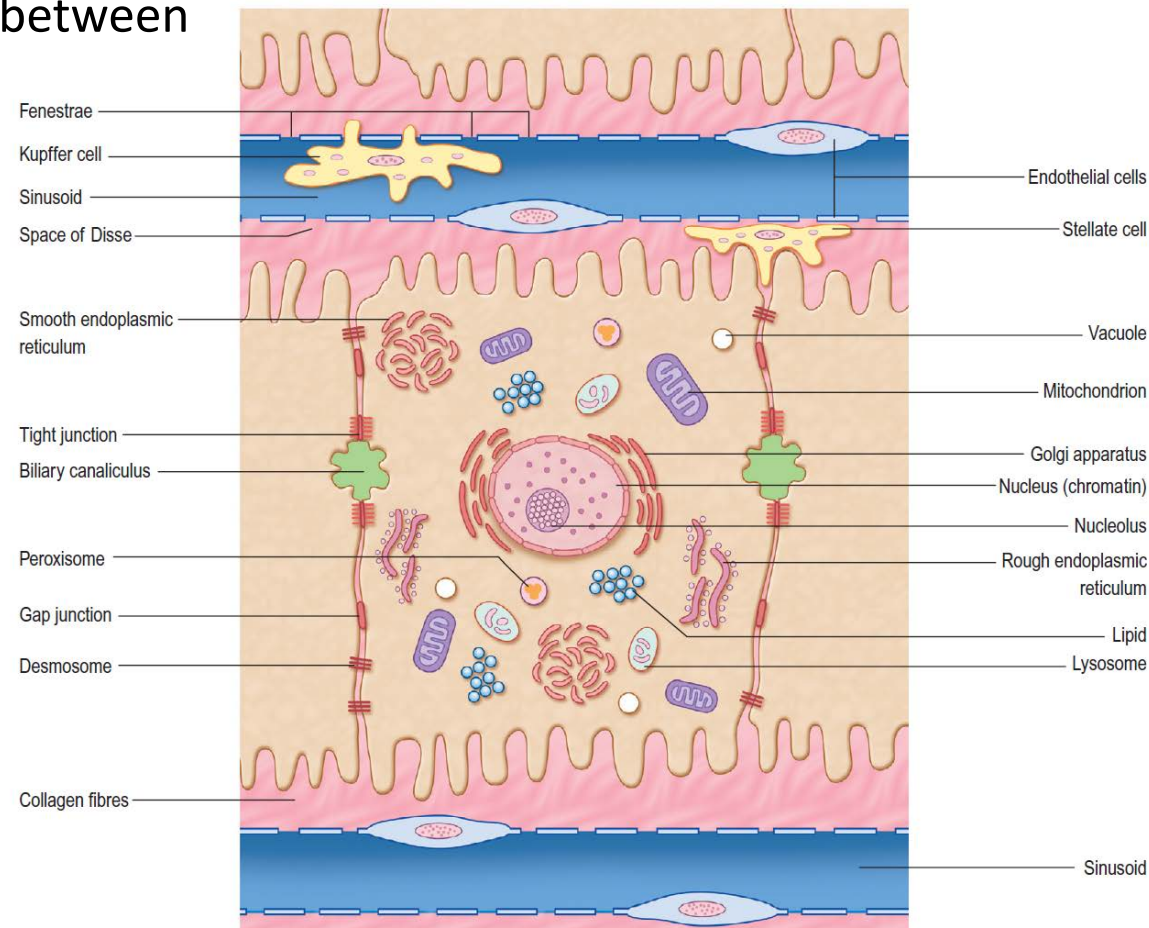


Electron micrographs of a hepatocyte.

Microstructure of the Liver

Sinusoids and perisinusoidal space of Disse

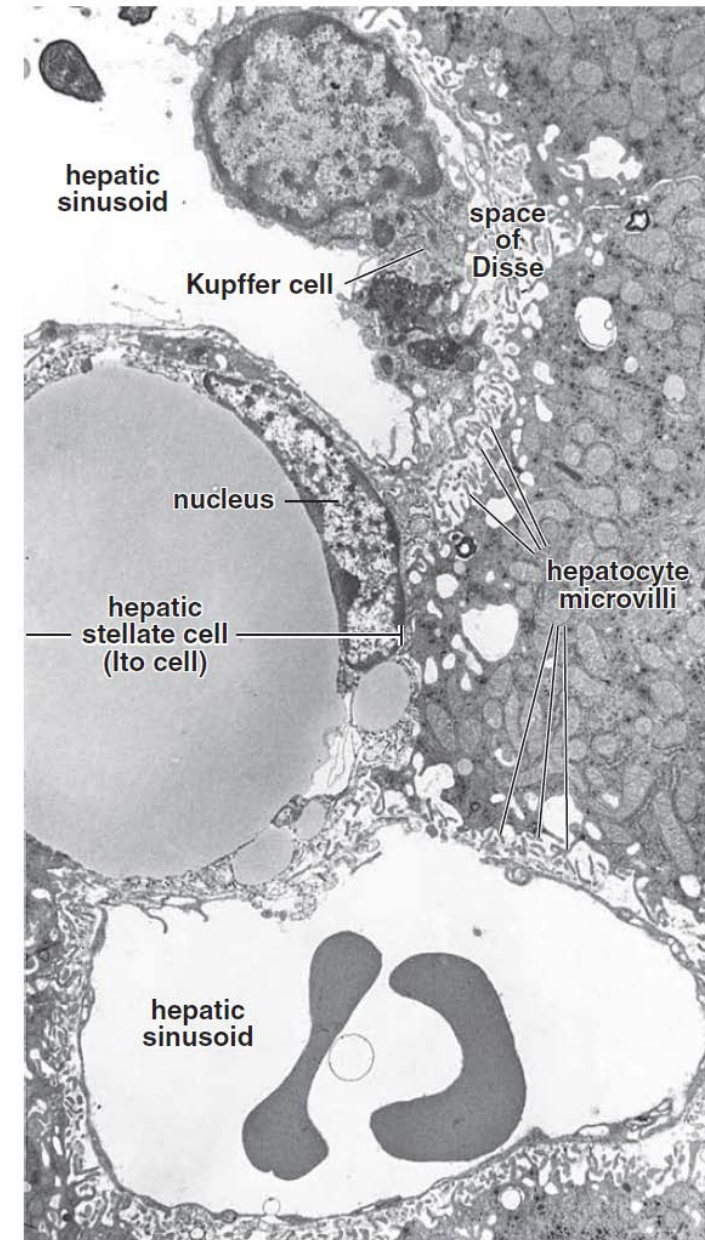
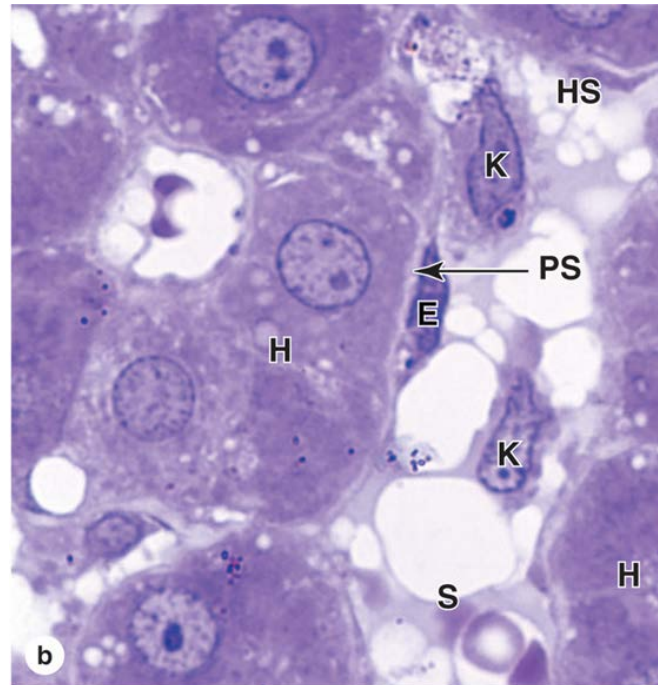
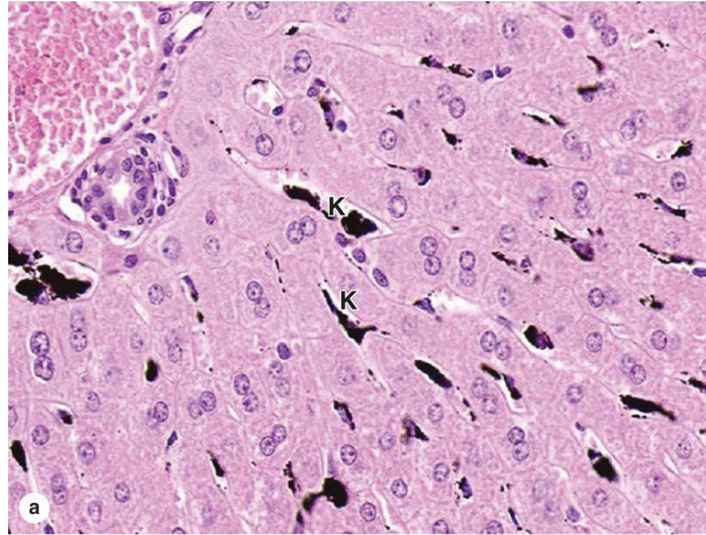
- Hepatic sinusoids are lined with a thin **discontinuous endothelium**.
 - ✓ Basal lamina that is absent over large areas.
 - ✓ **Large fenestrae**, without diaphragms, are present within the endothelial cells.
 - ✓ Large gaps are present between neighboring endothelial cells.
- Hepatic sinusoids differ from other sinusoids in that a second cell type, the **stellate sinusoidal macrophage (Kupffer cell)** is a regular part of the vessel lining.
- Kupffer cells belong to the mononuclear phagocytotic system.



Microstructure of the Liver

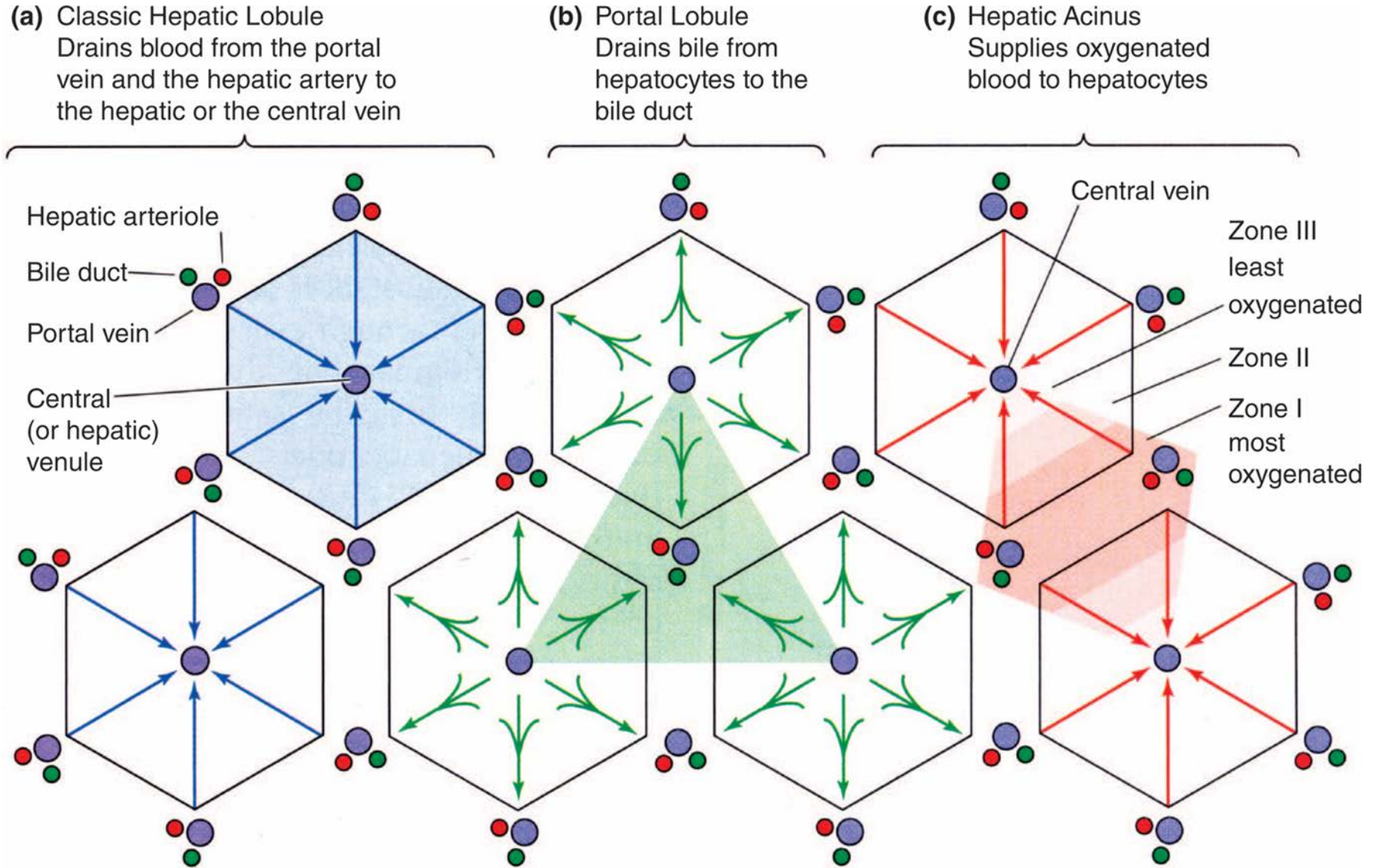
Sinusoids

- **Kupffer cells.**
- **Hepatic stellate cells of Ito** in the perisinusoidal space.



Structure-function Relationships in Liver

There are three ways to describe the structure of the liver in terms of a functional unit: the **classic lobule**, the **portal lobule** and **the liver acinus**.

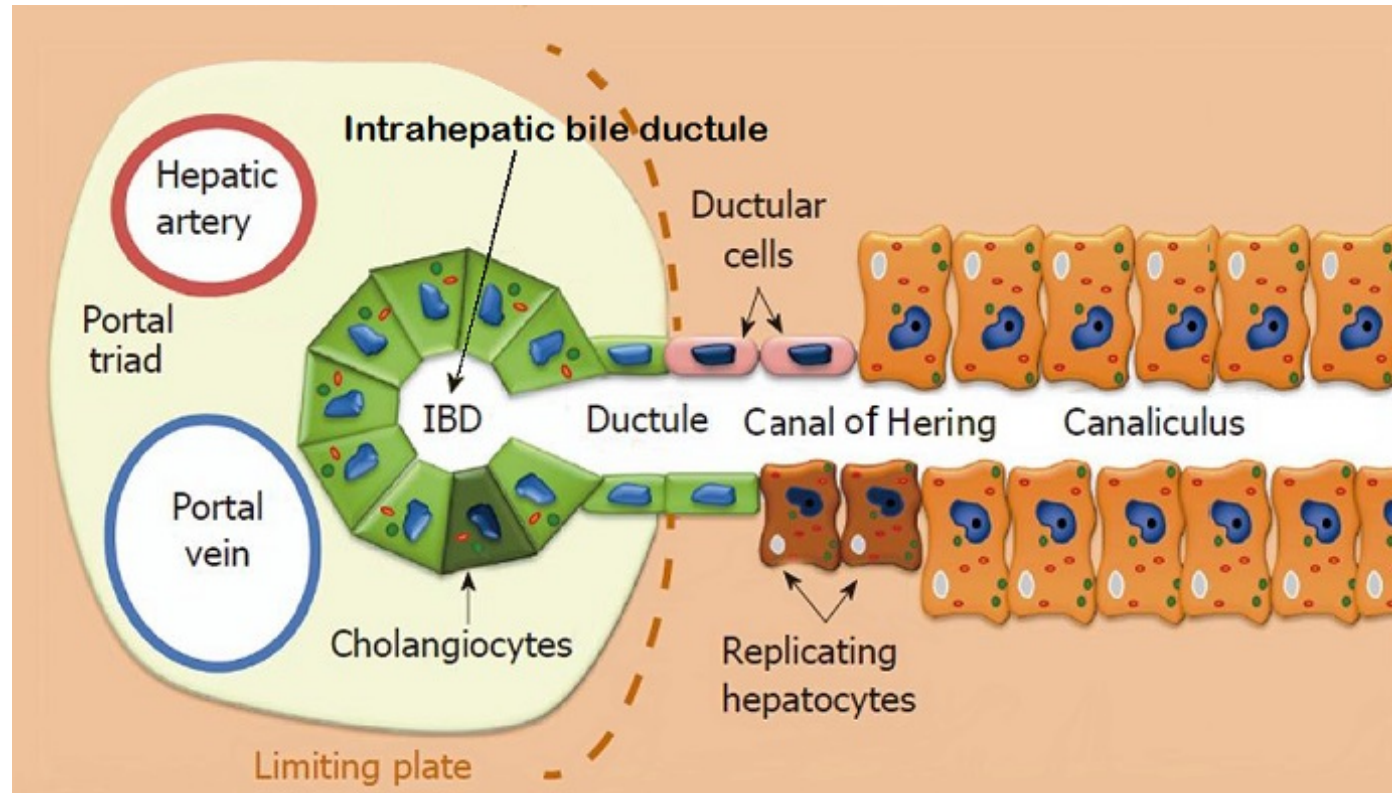


Biliary Tree

- The biliary tree is the three-dimensional system of channels of increasing diameter that bile flows through from the hepatocytes to the gallbladder and then to the intestine.

Intrahepatic bile ducts

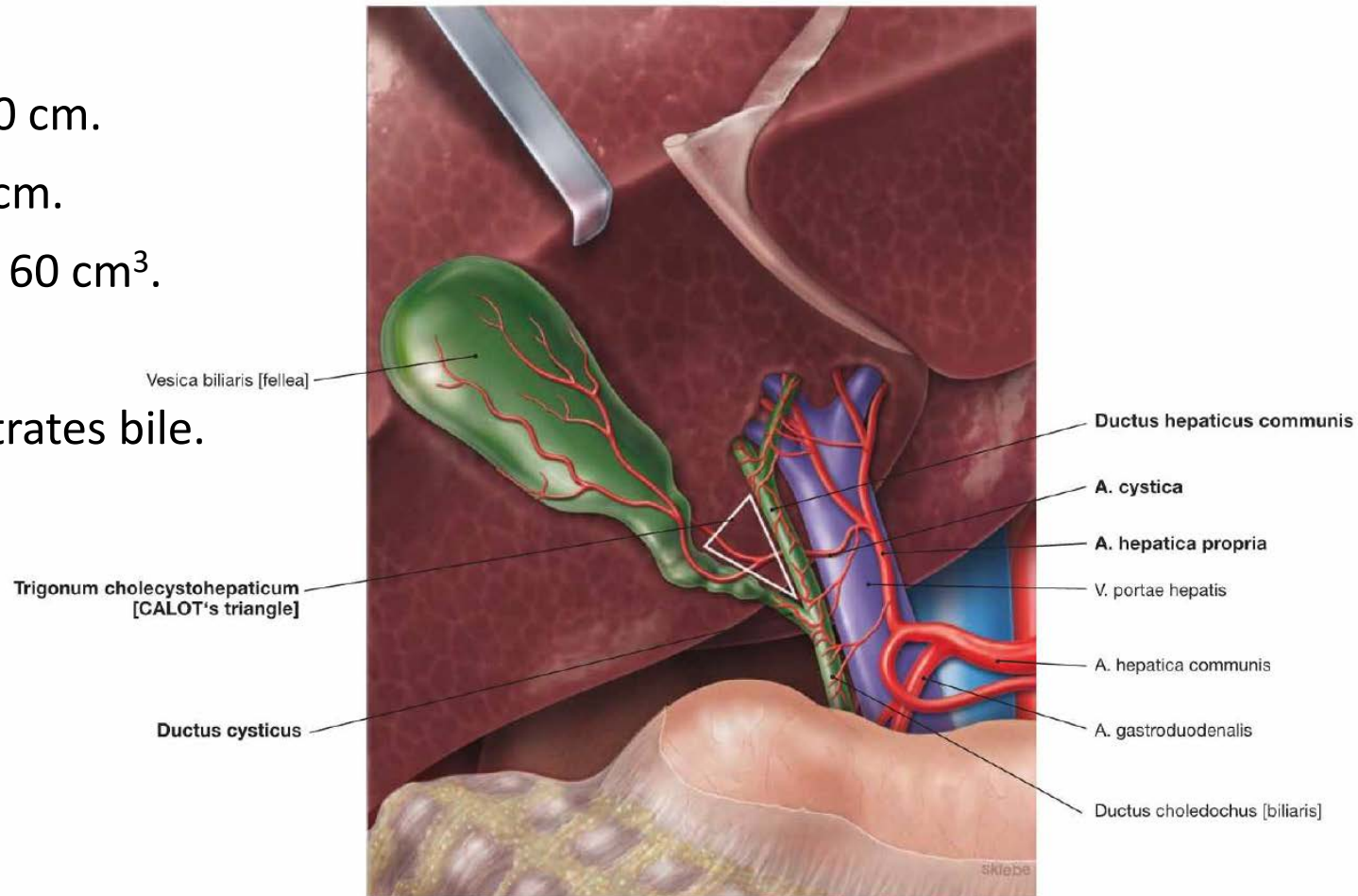
1. **Bile canaliculi** with diameter of 0.5 μm (in the hepatic lobule).
2. **Canals of Hering** – lined partially with hepatocytes and cuboidal **cholangiocytes** (still in the hepatic lobule) with diameter of 1 to 1.5 μm .
3. **Interlobular bile ducts.**
4. **Right hepatic duct.**
5. **Left hepatic duct.**



Gall Bladder

External features and relations

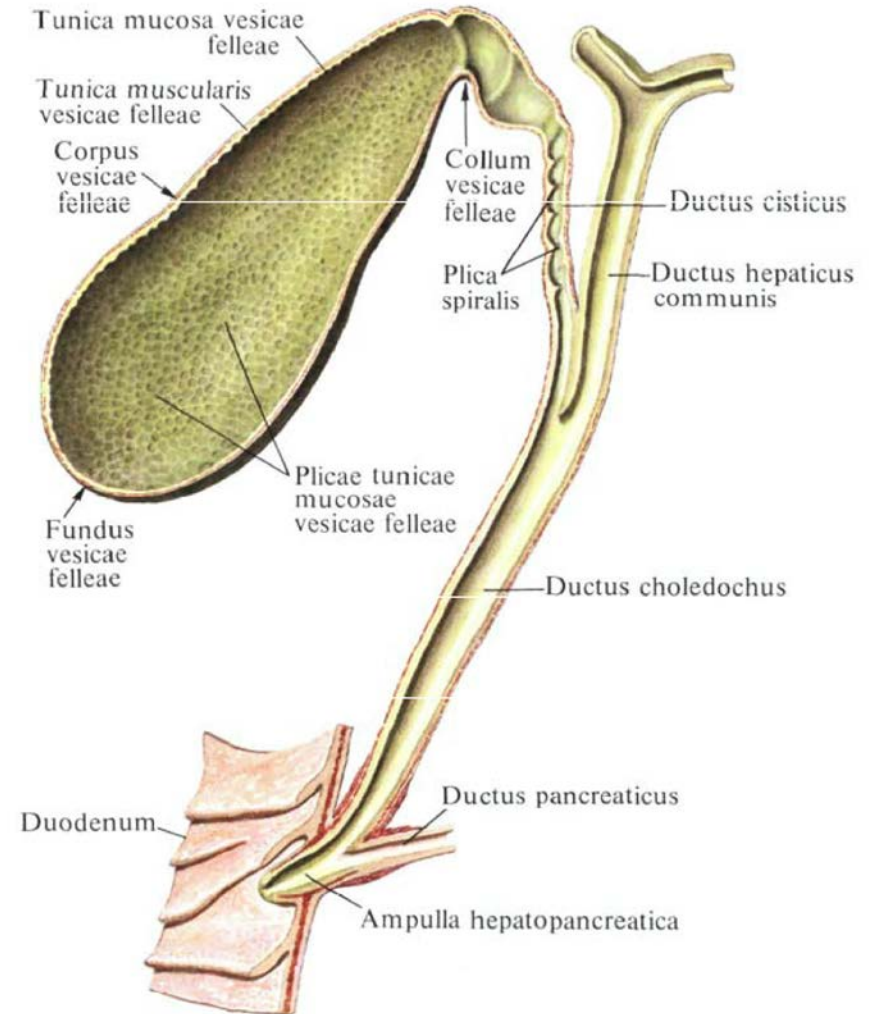
- The gall bladder, Lat. vesica biliaris (fellea) is a pear-shaped sac lying on the visceral surface of the right lobe of the liver in a fossa (gallbladder fossa, Lat. fossa vesicae biliaris) between the right and quadrate lobes.
- Size:
 - ✓ Length from 8 to 10 cm.
 - ✓ Width from 3 to 4 cm.
 - ✓ Volume from 40 to 60 cm³.
- Function:
 - ✓ Stores and concentrates bile.



Gall Bladder

External features and relations

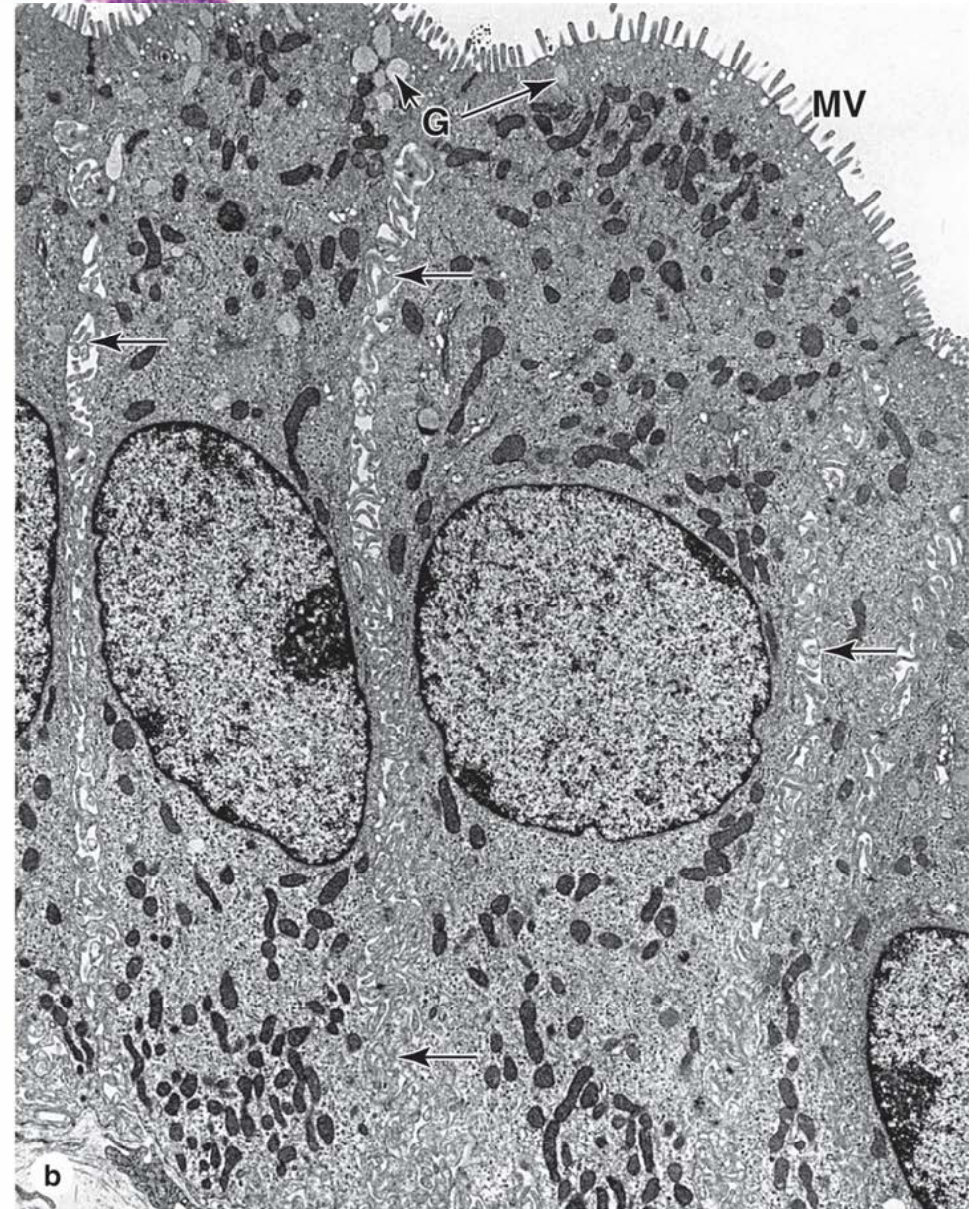
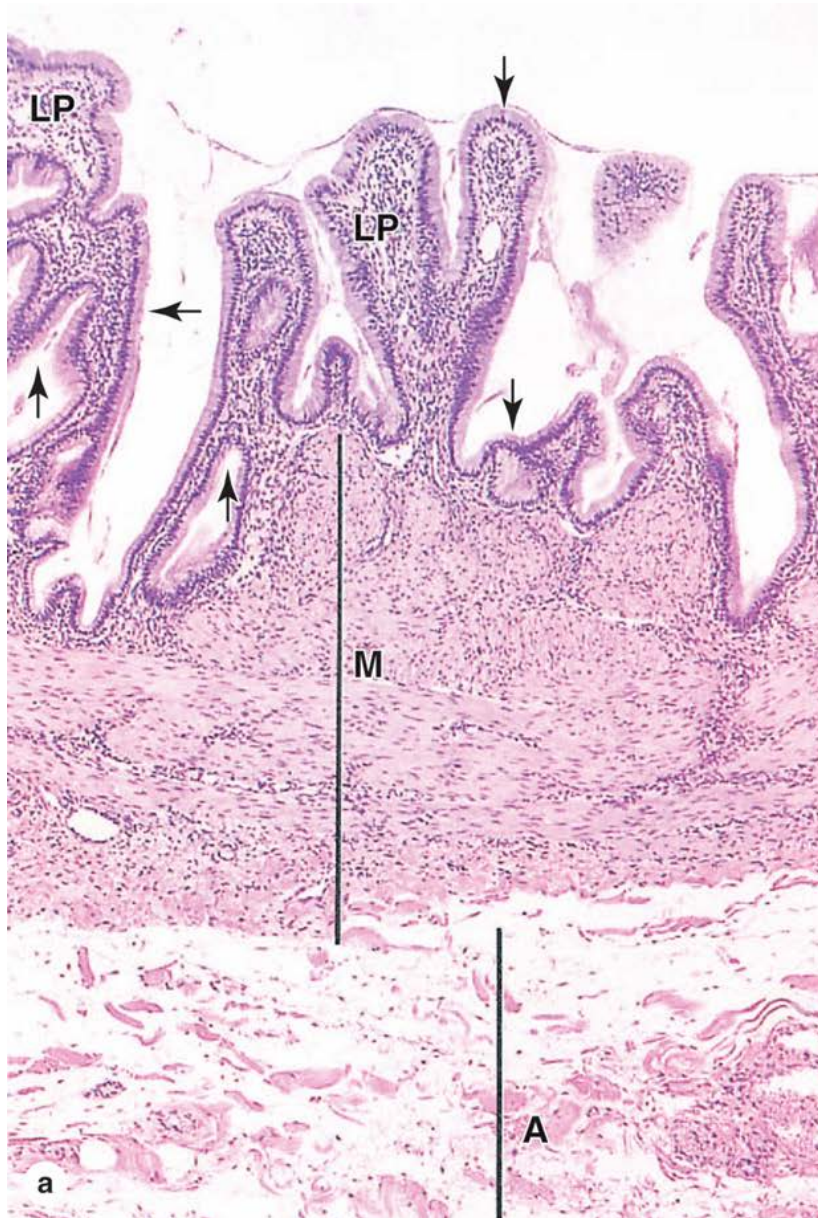
- It is divided into:
 - ✓ **Fundus**, Lat. fundus vesicae biliaris – a rounded end which may project from the inferior border of the liver.
 - ✓ **Body**, Lat. corpus vesicae biliaris – a major part in the biliary fossa which may be against the transverse colon and the superior part of the duodenum.
 - ✓ **Neck**, Lat. collum vesicae biliaris – a narrow part with mucosal folds forming the spiral fold.
- **Cystic duct** – 3-4 cm long
 - ✓ **Spiral valve**.



Microstructure of the Gall Bladder

- I. **Mucosa** – forms numerous deep mucosal folds.
 1. **Epithelium** – simple columnar epithelium.
 2. **Lamina propria** – rich in fenestrated capillaries and small venules, there are no lymphatic vessels. Very cellular, contains many lymphocytes and plasma cells.
 - ✓ **Mucin-secreting glands.**
 3. **Muscularis mucosae** – **absent.**
- II. **Submucosa** – **absent.**
- III. **Muscularis externa.**
 - ✓ Helical smooth muscle cells.
 - ✓ Numerous collagen and elastic fibers.
 - ✓ Rokitansky-Aschoff sinuses – deep diverticula of the mucosa.
- IV. **Adventitia (serosa).**

Microstructure of the Gall Bladder



Biliary Tree

Extrahaepatic bile ducts

1. **Common hepatic duct**, Lat. ductus hepaticus communis.

✓ 4-5 cm long in lig. hepatoduodenale.

2. **Cystic duct**, Lat. ductus cysticus – 3 cm.

✓ Spiral valve of Heister.

3. **Common bile duct**, Lat. ductus choledochus – 7-8 cm.

✓ Supraduodenal part.

✓ Retroduodenopancreatic.

✓ Intraparietal.

4. **Hepatopancreatic ampulla of Vater.**

