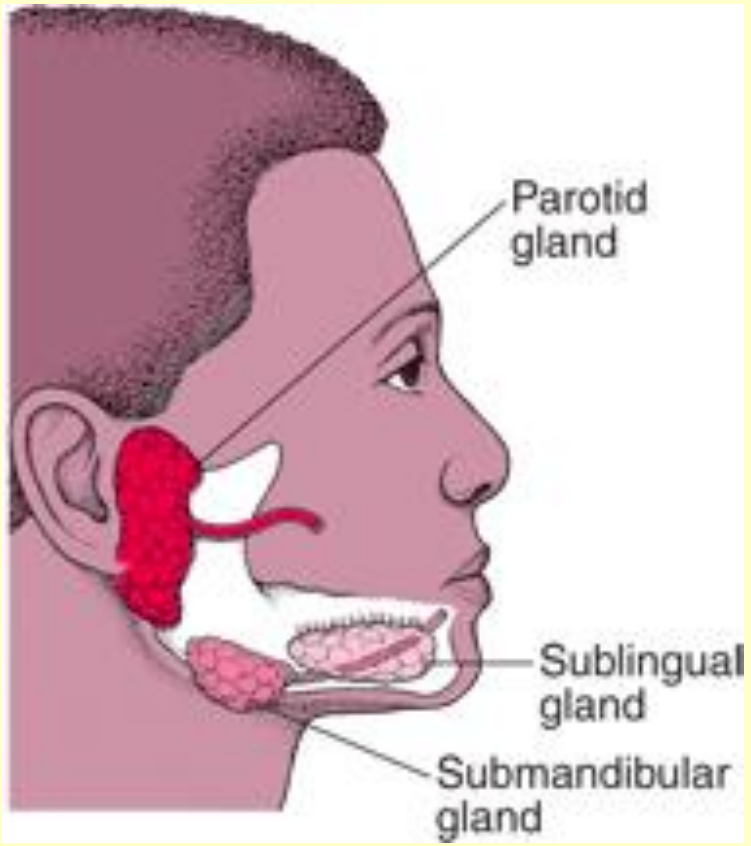
Digestive System
Part 3, Glands

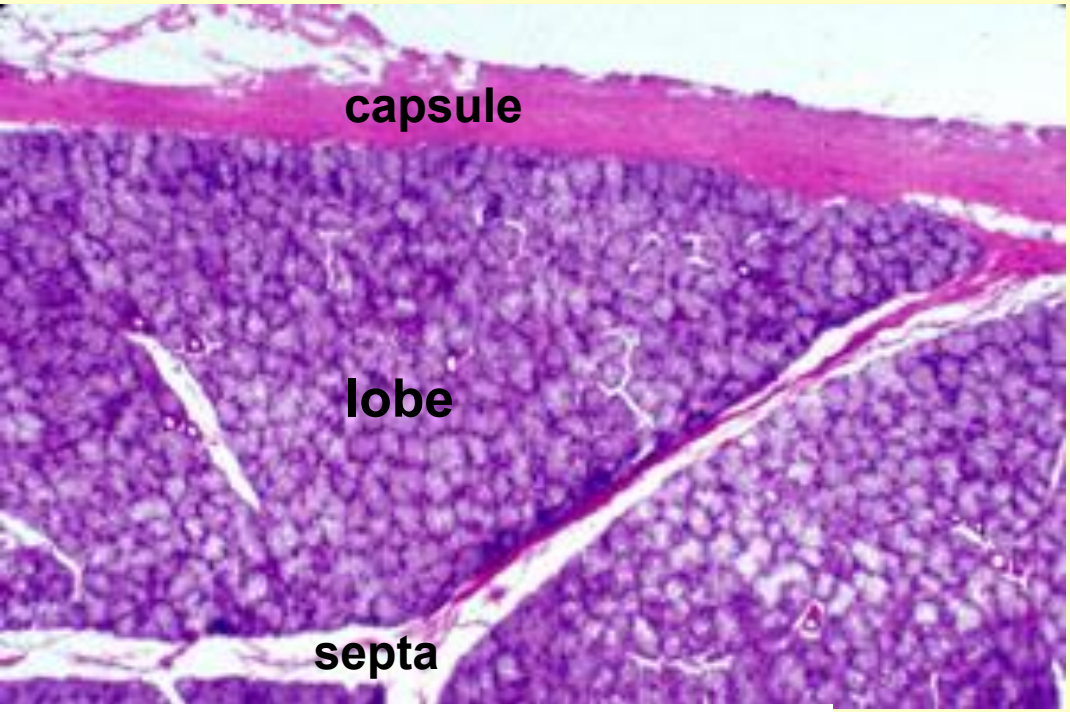
Salivary Glands - exocrine glands (with ducts) - produce **saliva:**

- facilitates the process of tasting food, initiates of **digestion** and permits of deglutition (swallowing)
- protects the body by secreting the antibacterial agents (**lysozyme** and **IgA**)

The major salivary glands:

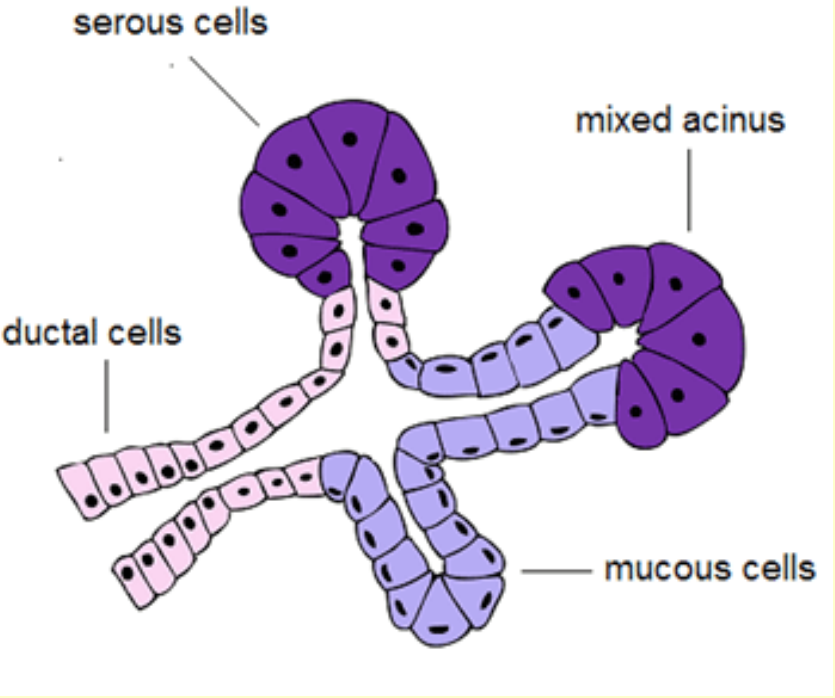
- **Parotid gland**
- **Sublingual gland**
- **Submandibular gland**





Major salivary glands

- connective tissue **capsule**
- septa - **lobes** and **lobules**

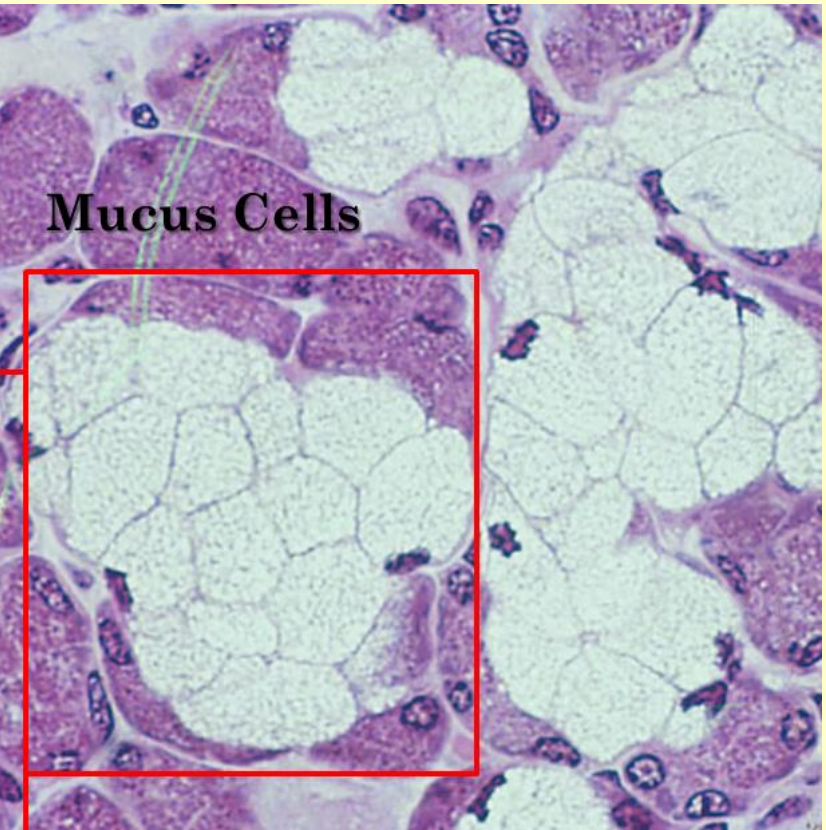


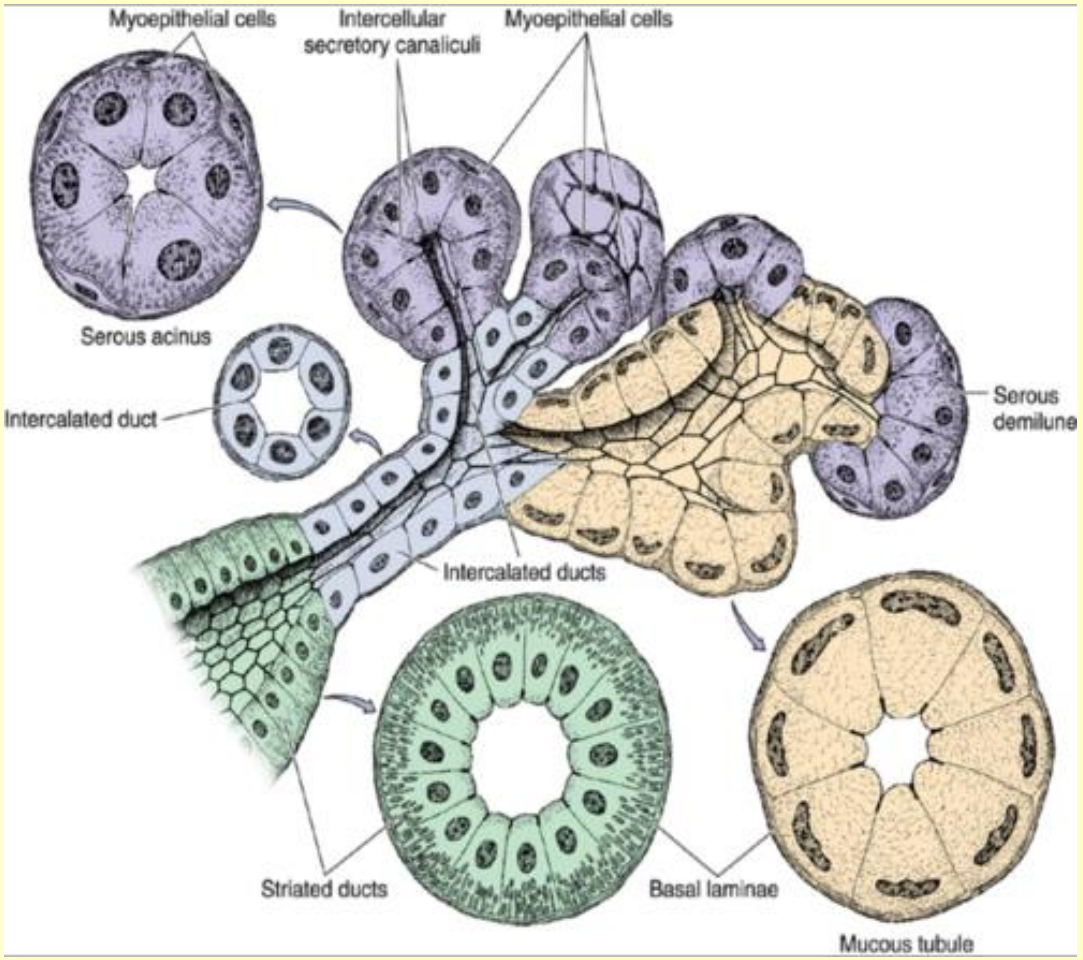
Major salivary glands - tubuloalveolar glands

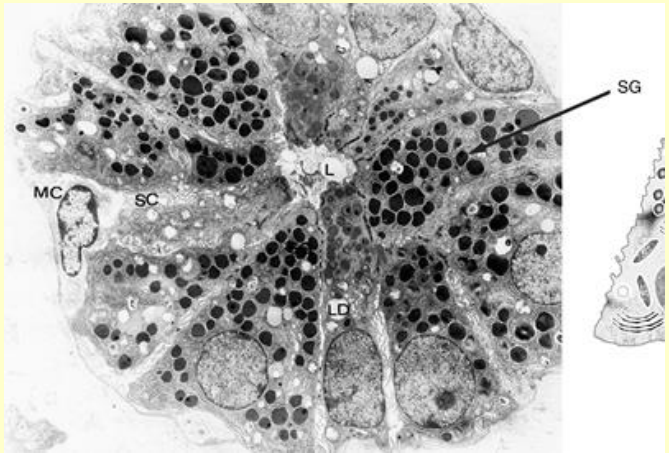
- **secretory** portion - **serous** and/or **mucous** secretory cells - **acini** (alveoli) or **tubules**
- **duct** portion

Mucous cells

- nuclei basally located and **flattened**
- apical region - abundant **secretory granules**

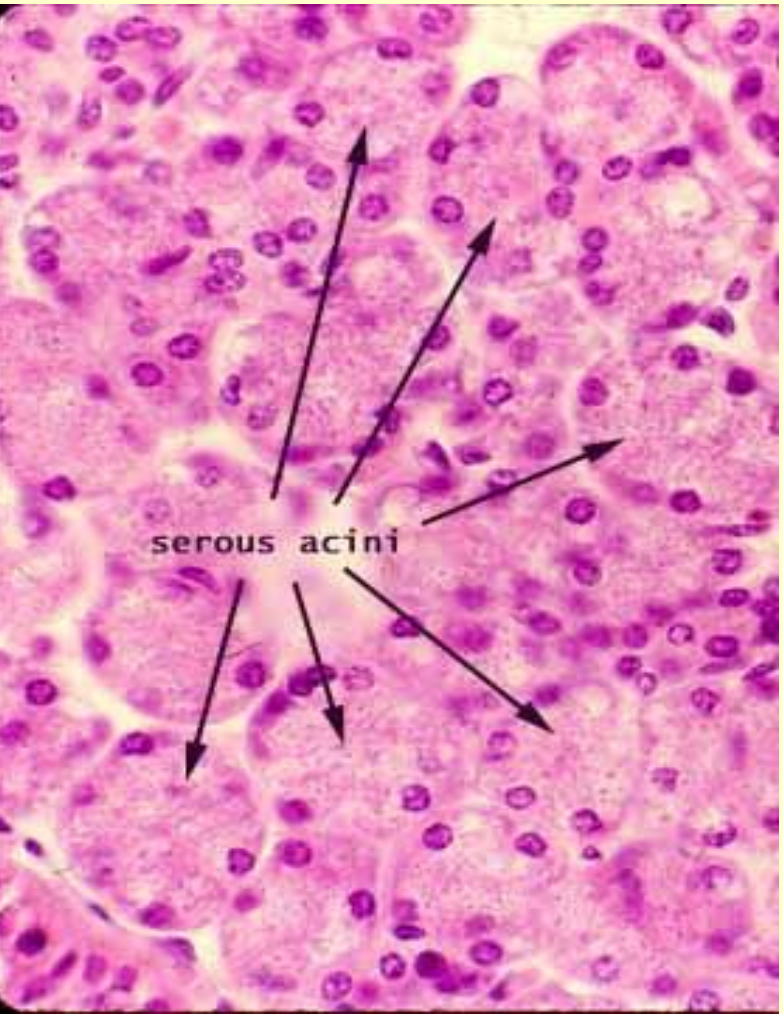


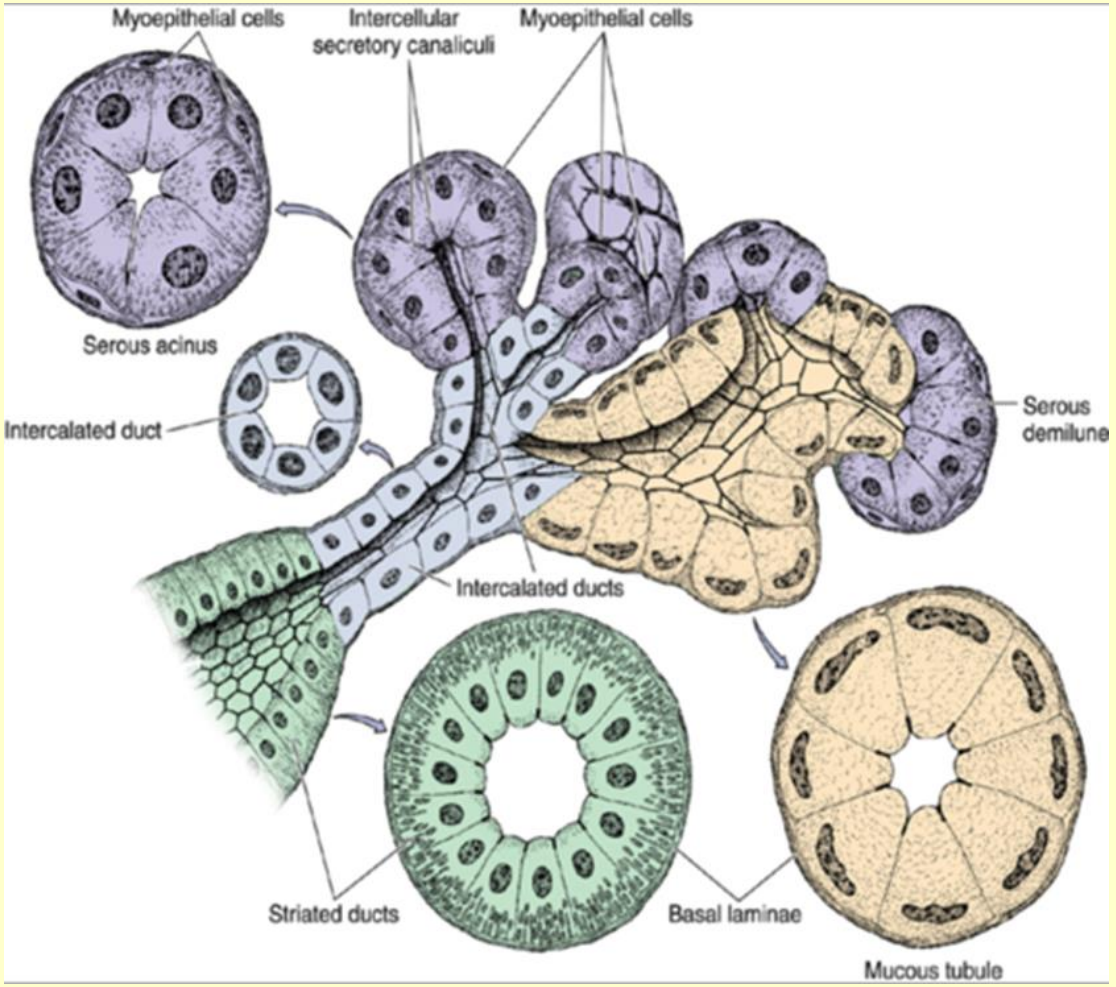




Serous cells

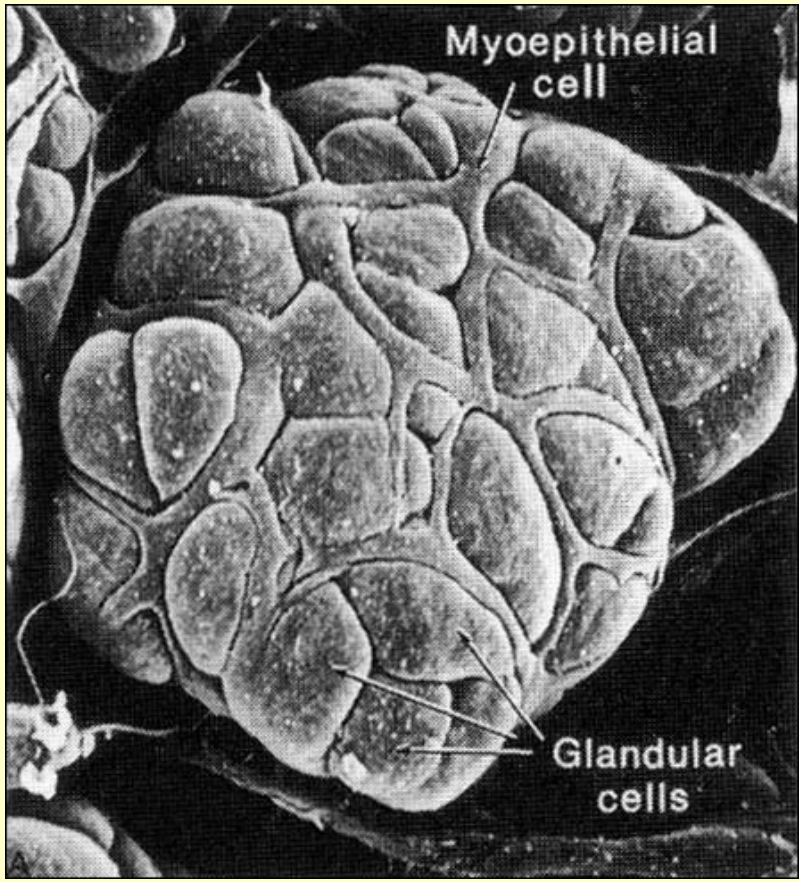
- single, **round**, basally (centrally) located nuclei

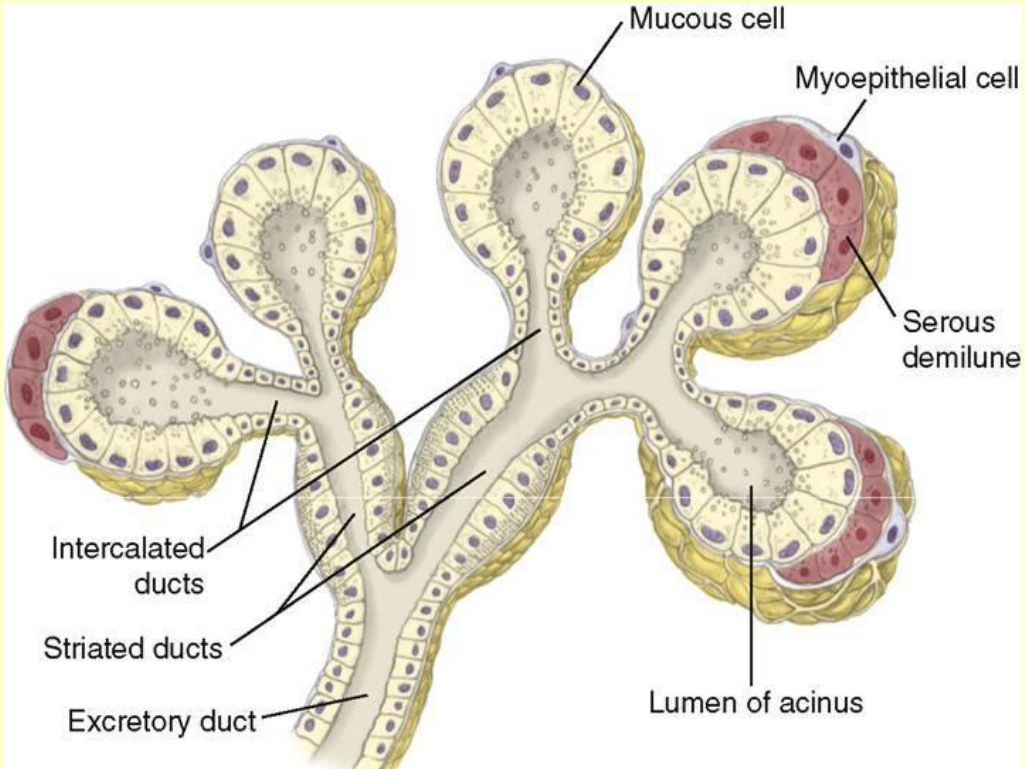




Myoepithelial cells (basket cells)

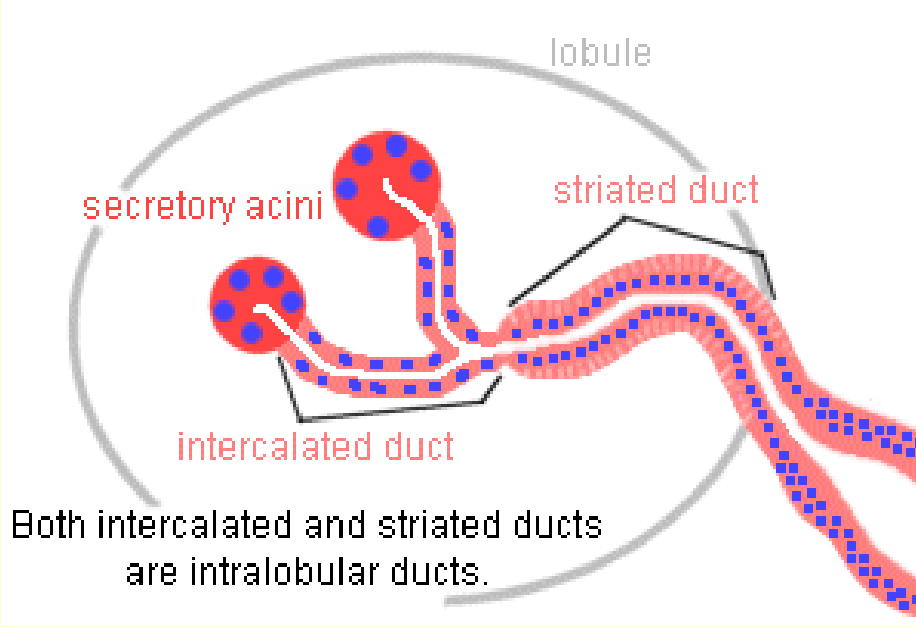
- long processes (actin and myosin) - envelope the acinus
- contraction - releasing the secretion from the acinus into the duct of the gland

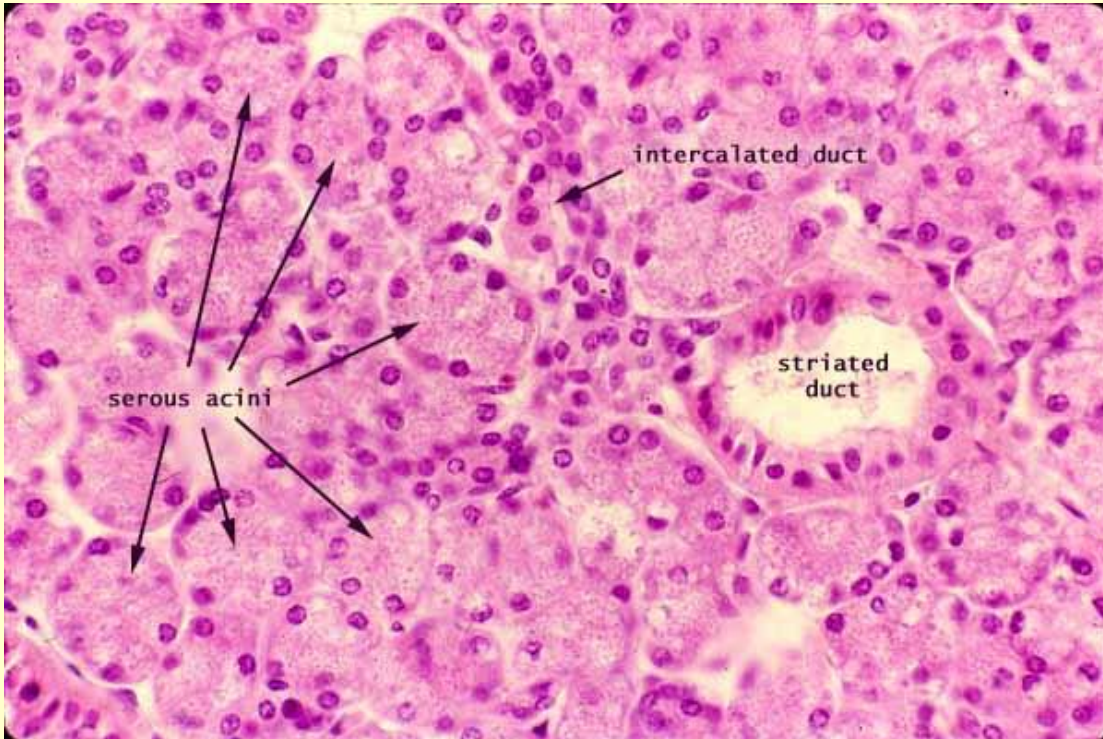




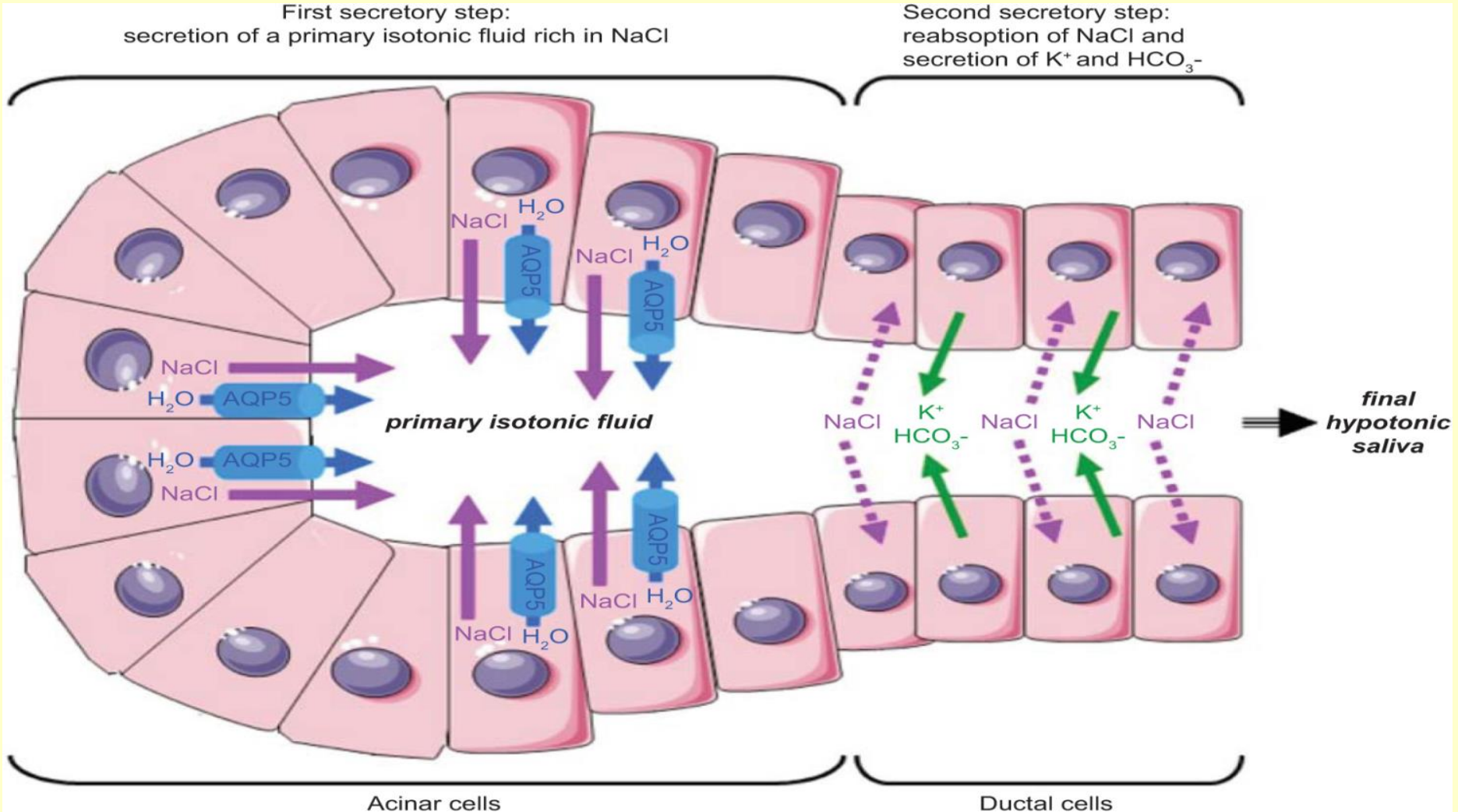
Ducts of salivary glands

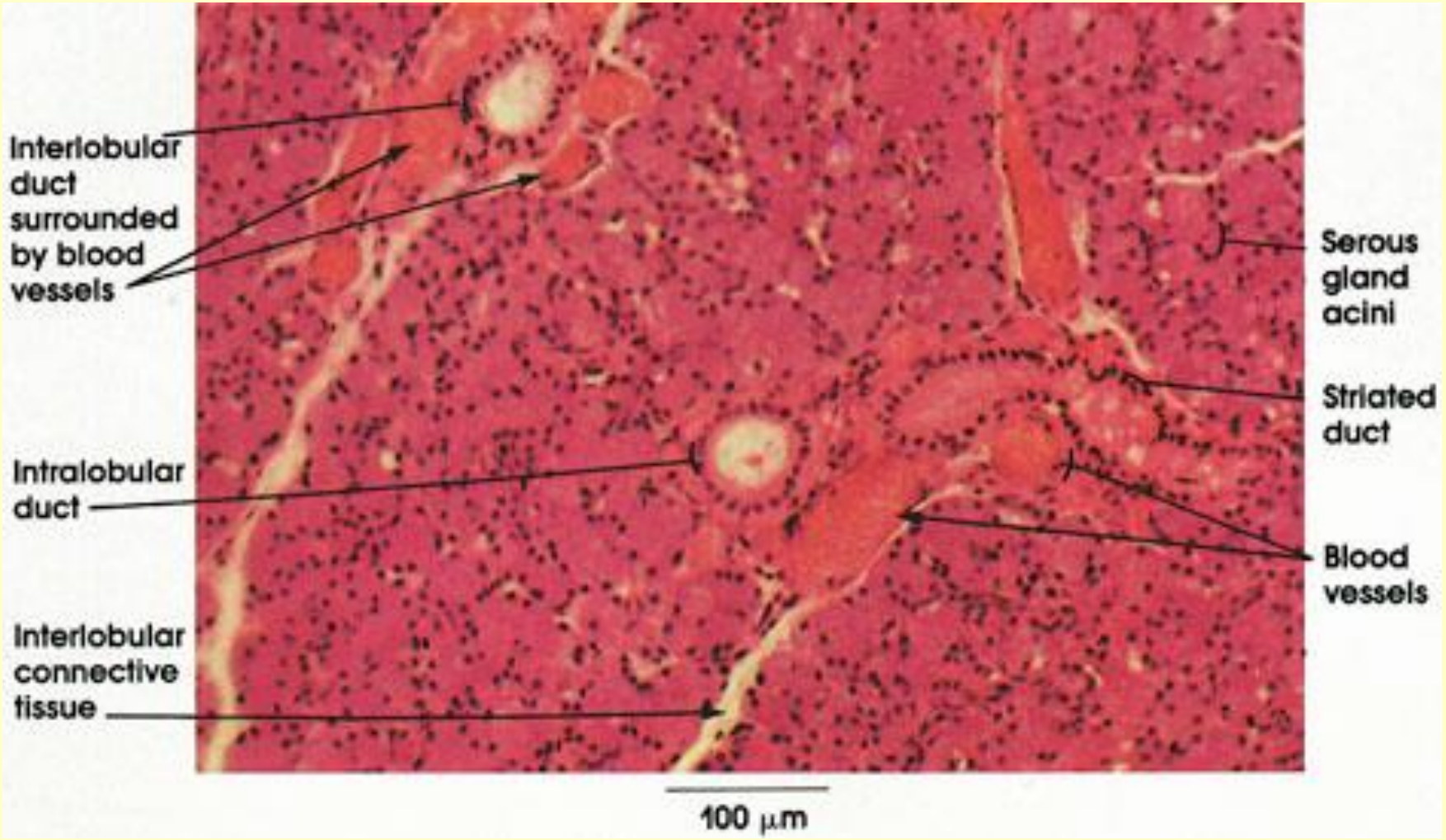
- **intercalated ducts** (attached to the acini) – **simple cuboidal epithelium (**myoepithelial cells)
- **striated ducts**





- **primary saliva** (isotonic)**-** modified by cells of striated ducts – **secondary saliva (**hypotonic - sodium and chloride ions removed, potassium and bicarbonate ions enter)





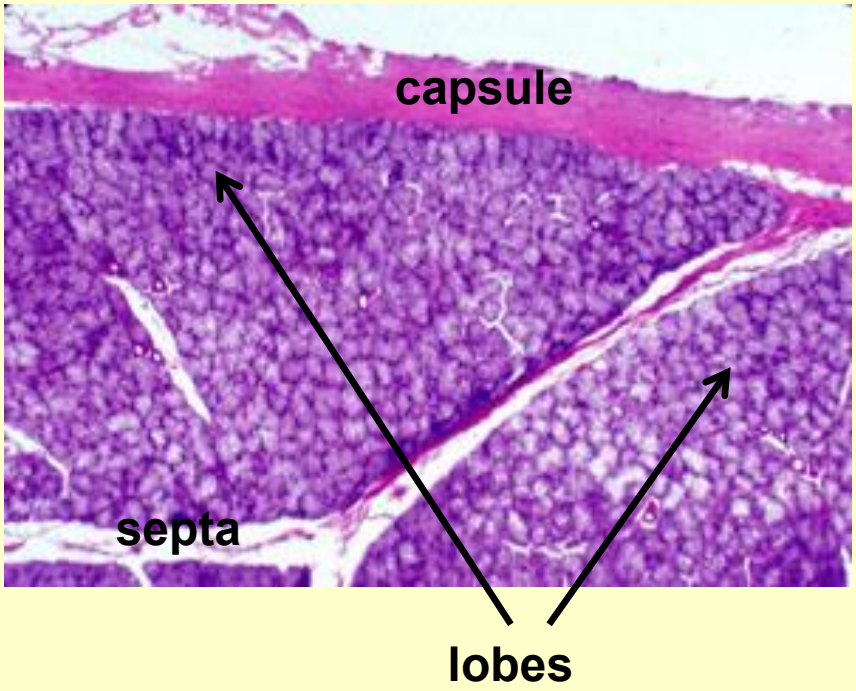
- Intralobular ducts

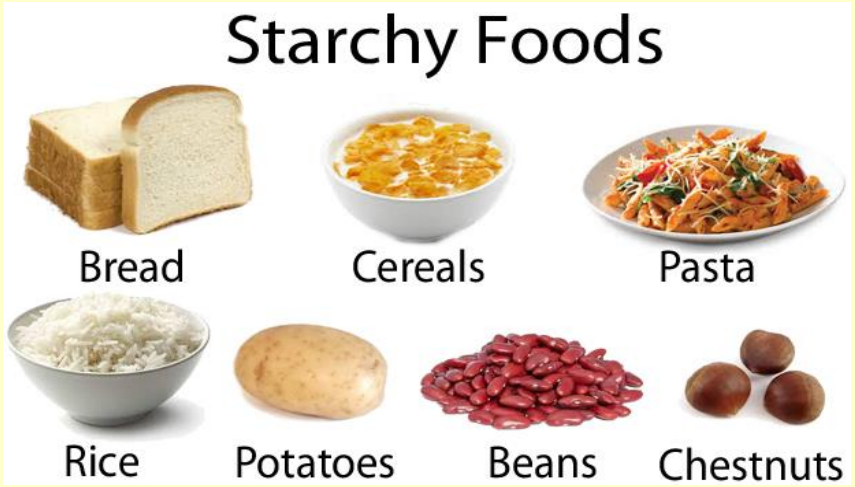
- Interlobular ducts

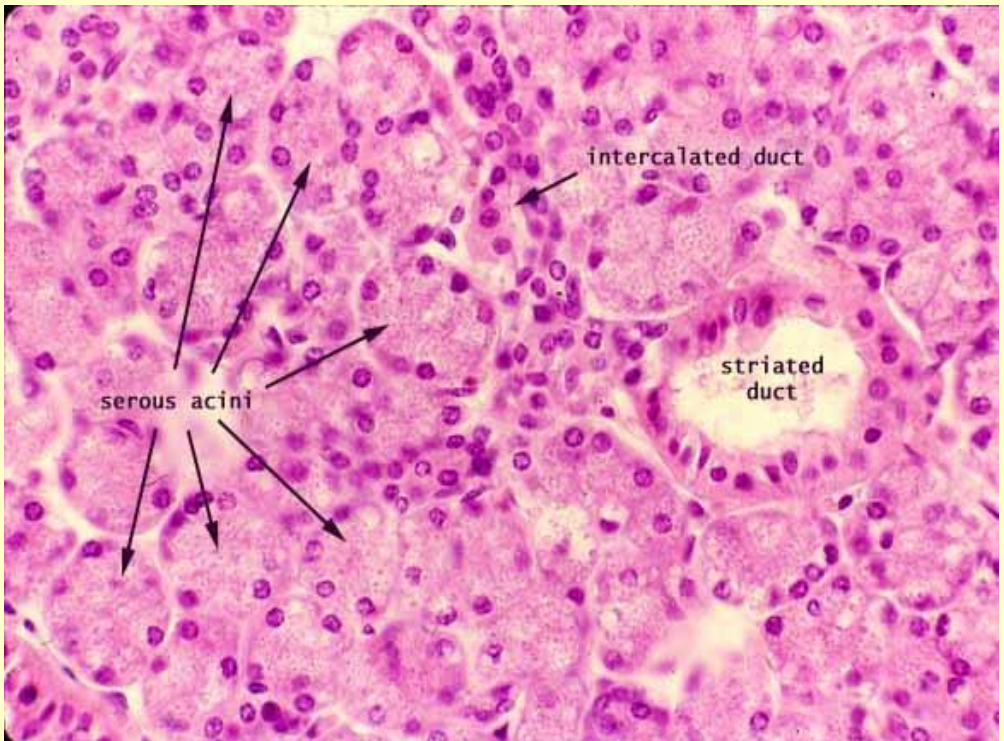
- Terminal (principal) duct delivers the saliva into the oral cavity

Parotid gland - the largest

- produces only about **30%** of the saliva
- capsule - septa - **lobes**
- **mainly serous salivary gland**
- **salivary amylase – ptyalin** (digestion of starch)

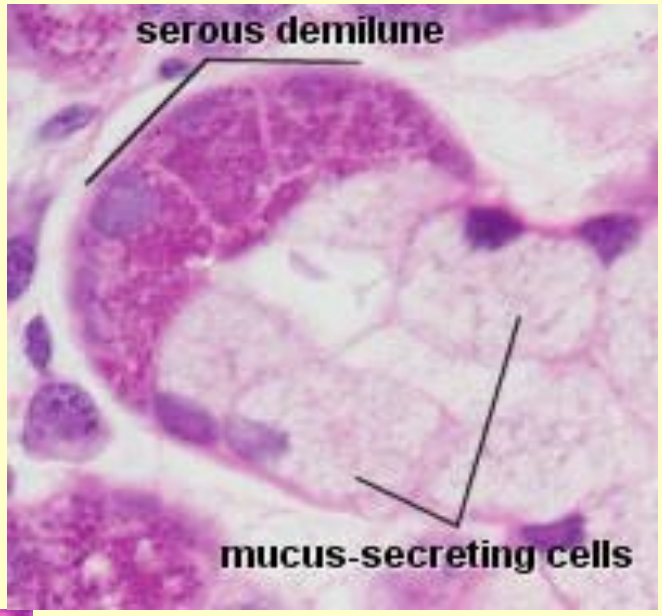


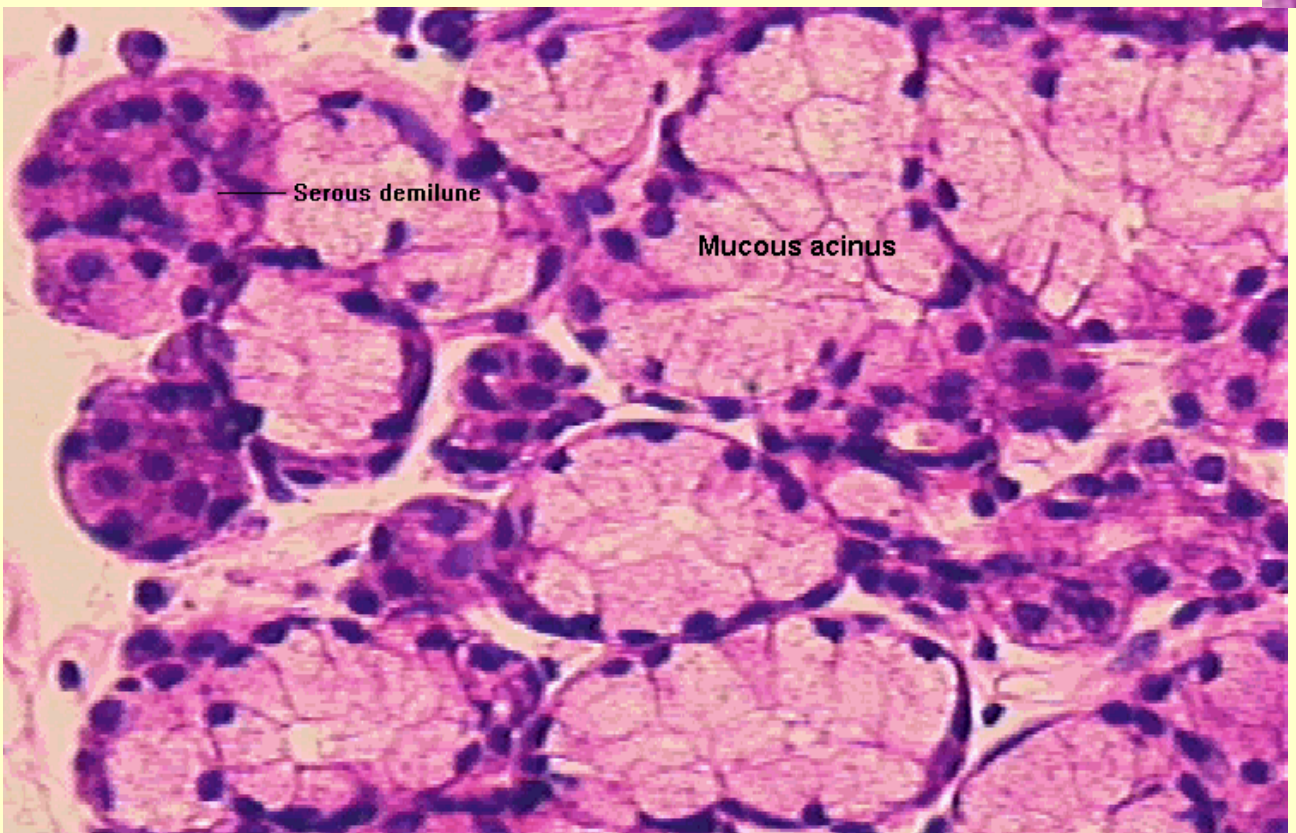




Sublingual gland - the smallest

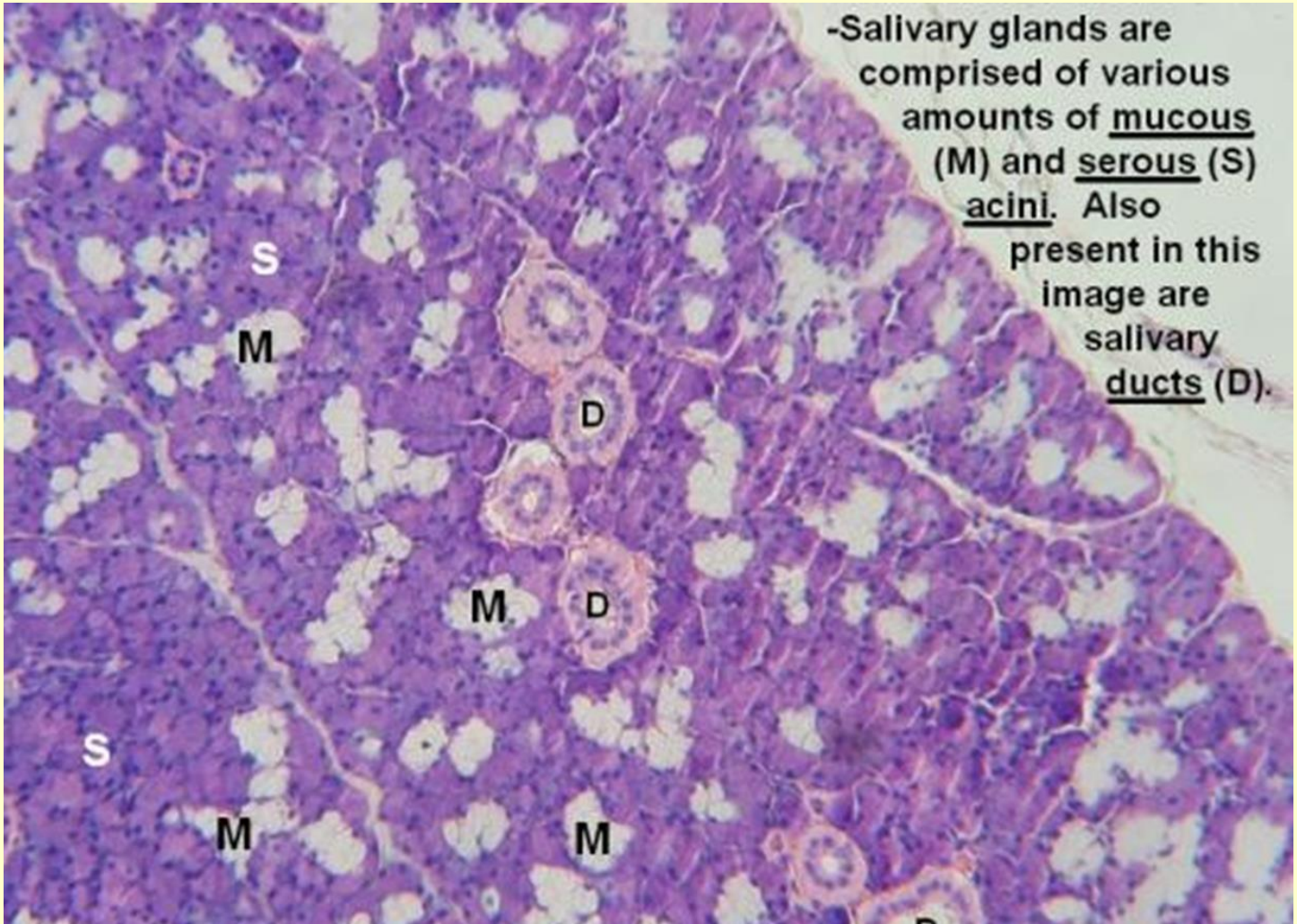
- mostly - **mucous acini** with **serous demilunes** (small cluster of serous cells)
- **mixed (**but mostly mucous) **saliva**.



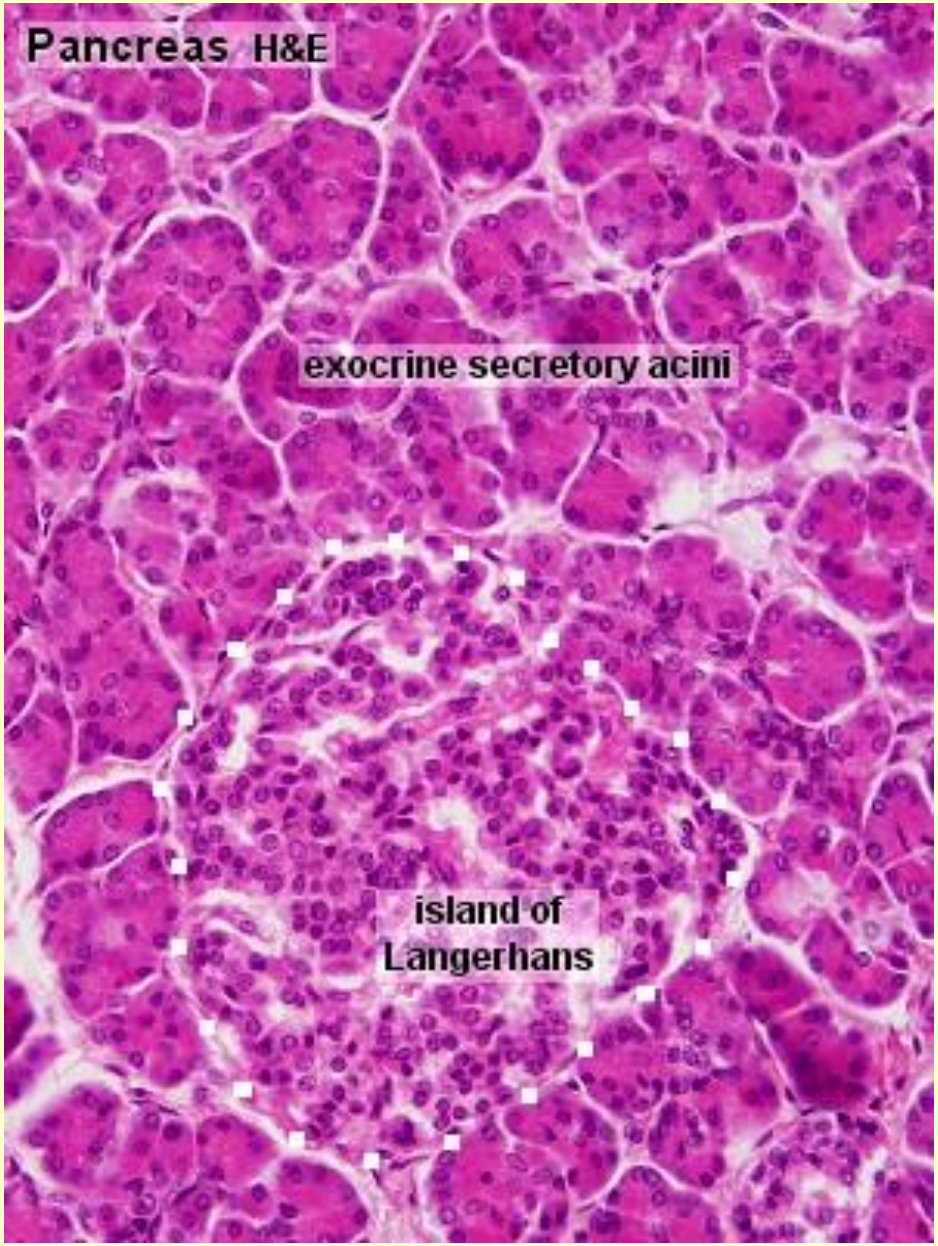


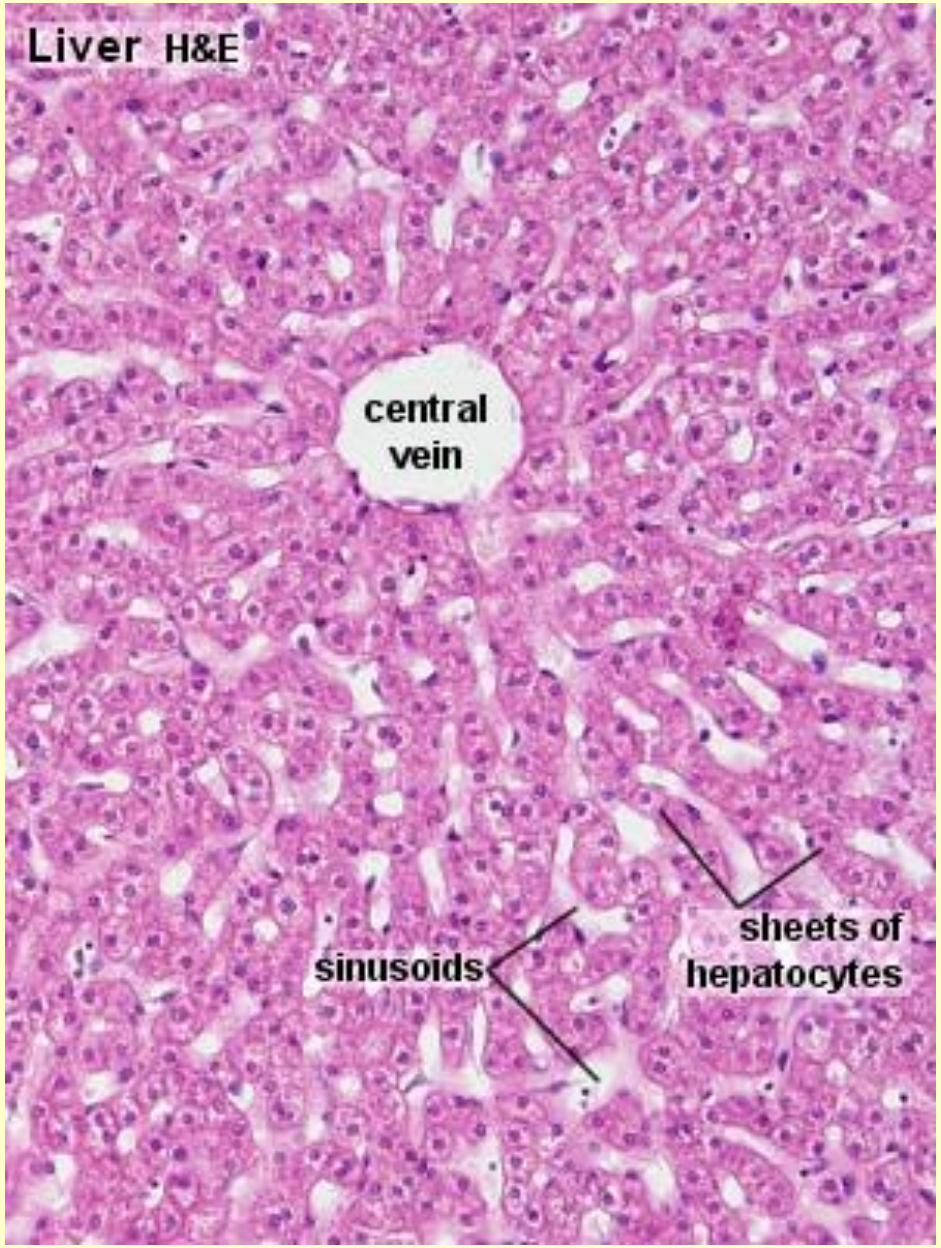
Submandibular gland

- produces **60%** of the total salivary output
- either **serous** or **mucous** cells but **80 -90%** of the acini produce **serous saliva**



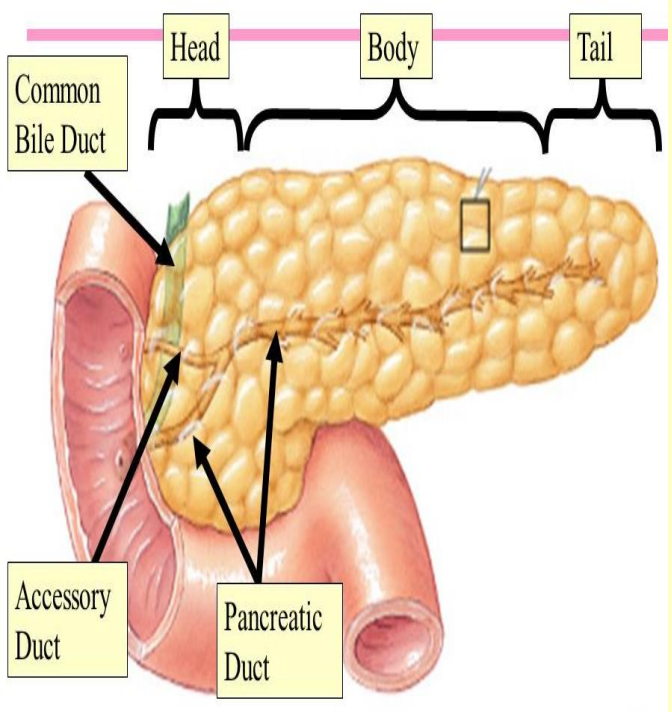
DIGESTIVE SYSTEM – LIVER AND PANCREASE

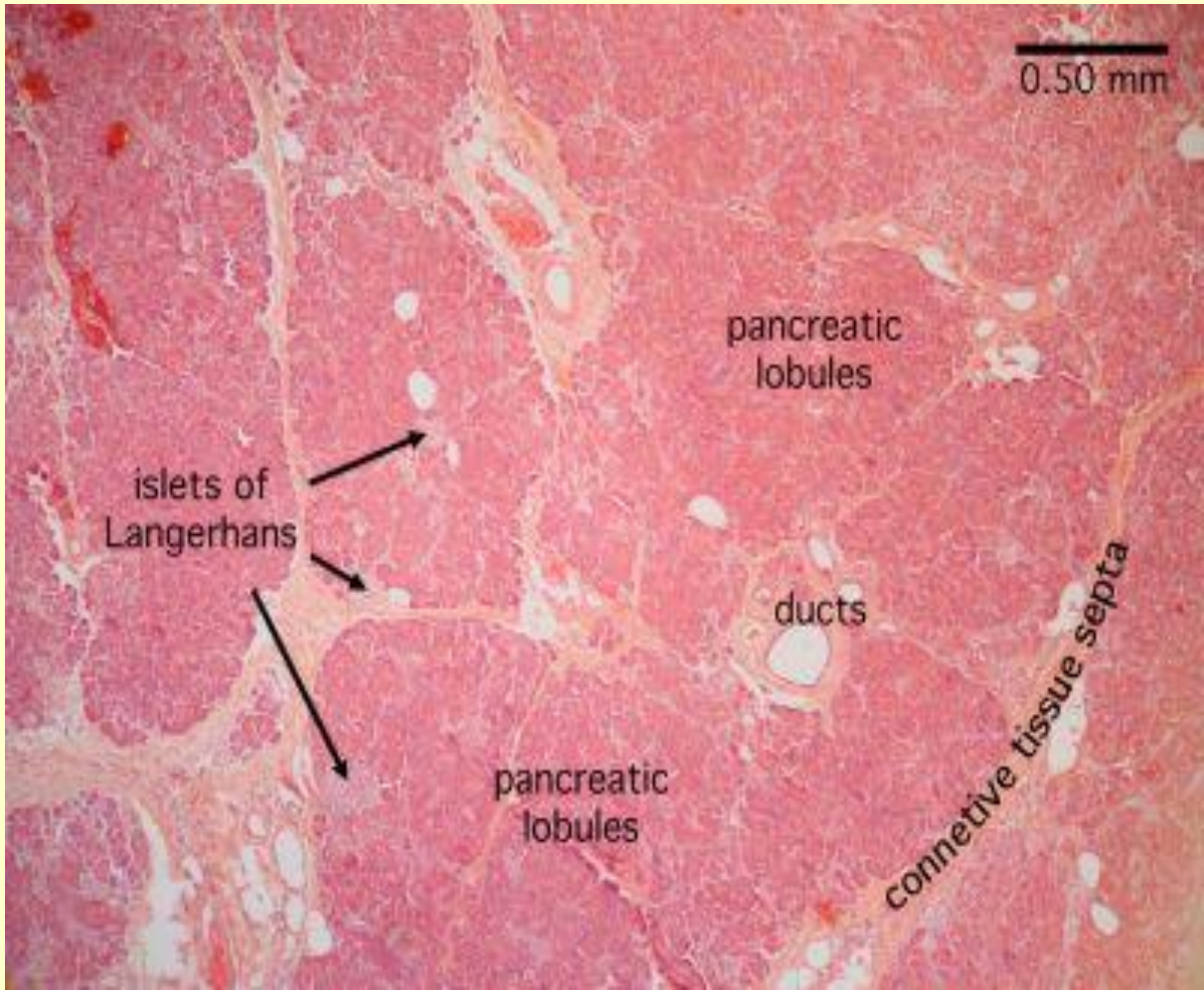


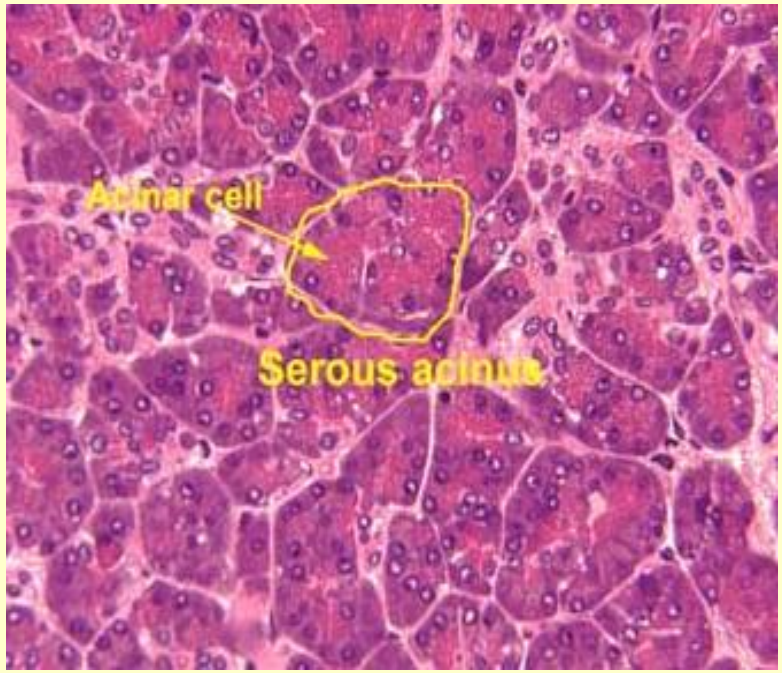


Pancreas - head, body, tail

- connective tissue capsule - septa - lobules
- **exocrine gland - digestive juices** and **endocrine gland – hormones (islets of Langerhans)**

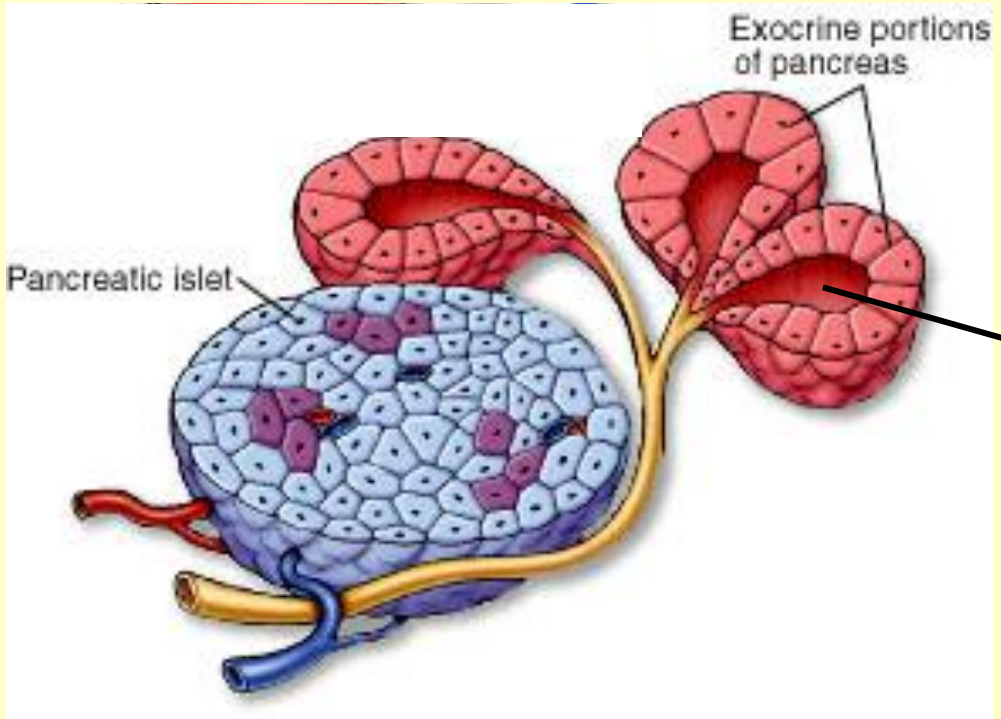


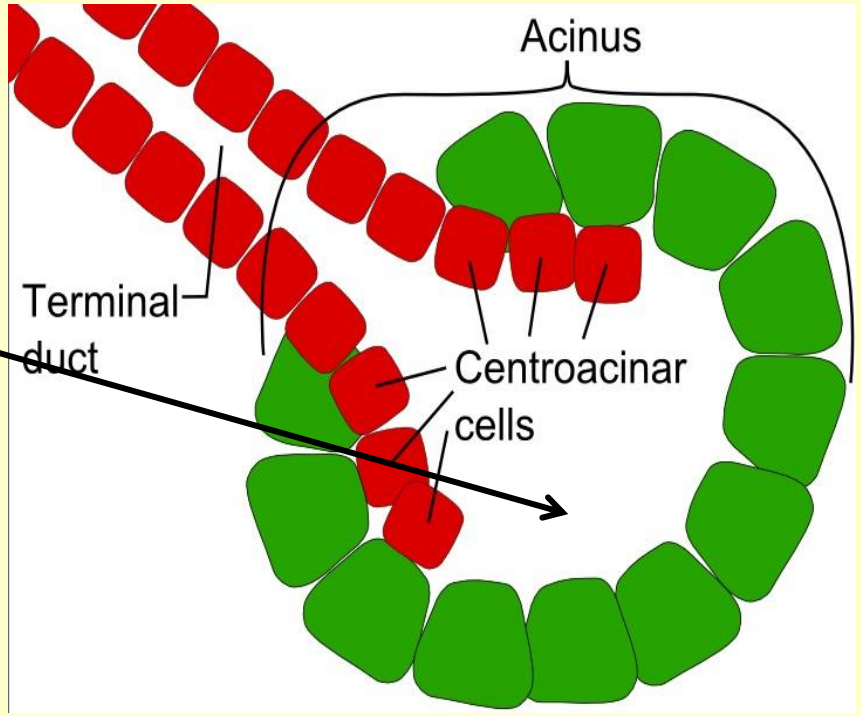




Exocrine pancreas- compound tubuloacinar gland

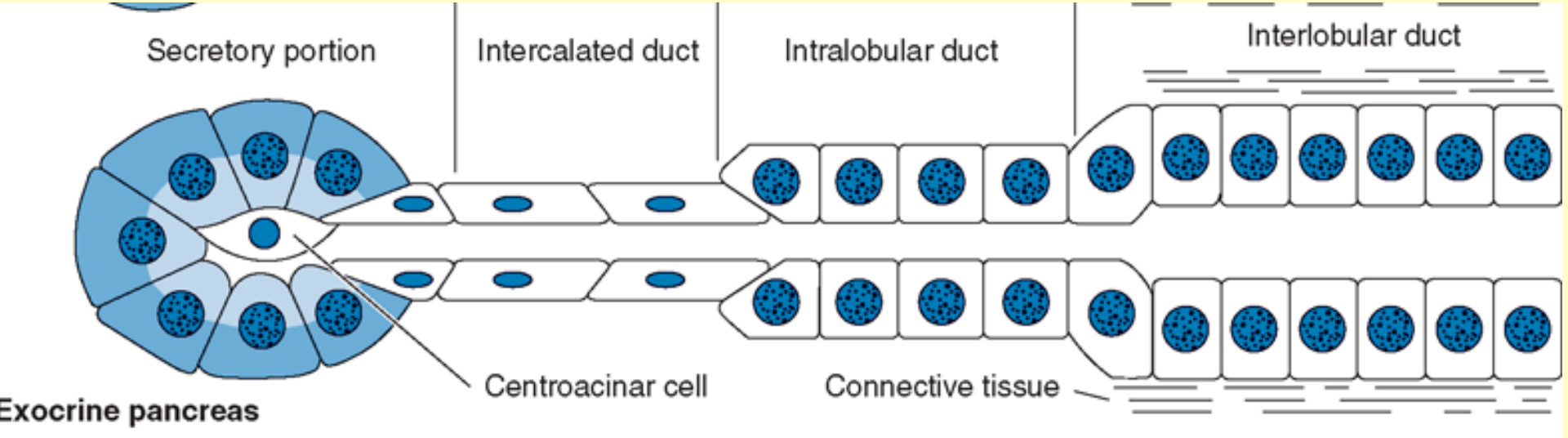
- **acini** – in lumen **centroacinar cells**, the beginning of the **duct system**.
- **acinar cells - digestive enzymes**

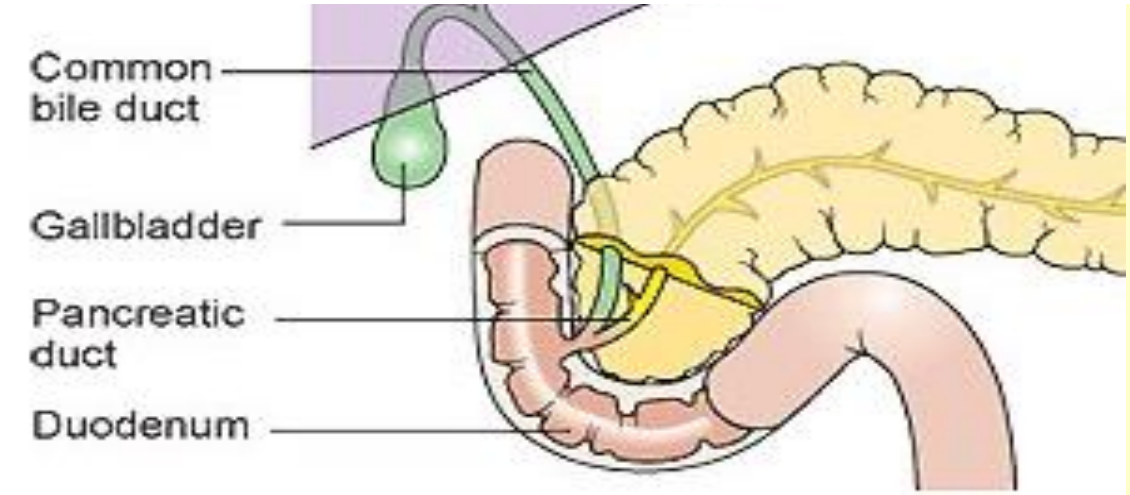




The duct system of pancreas

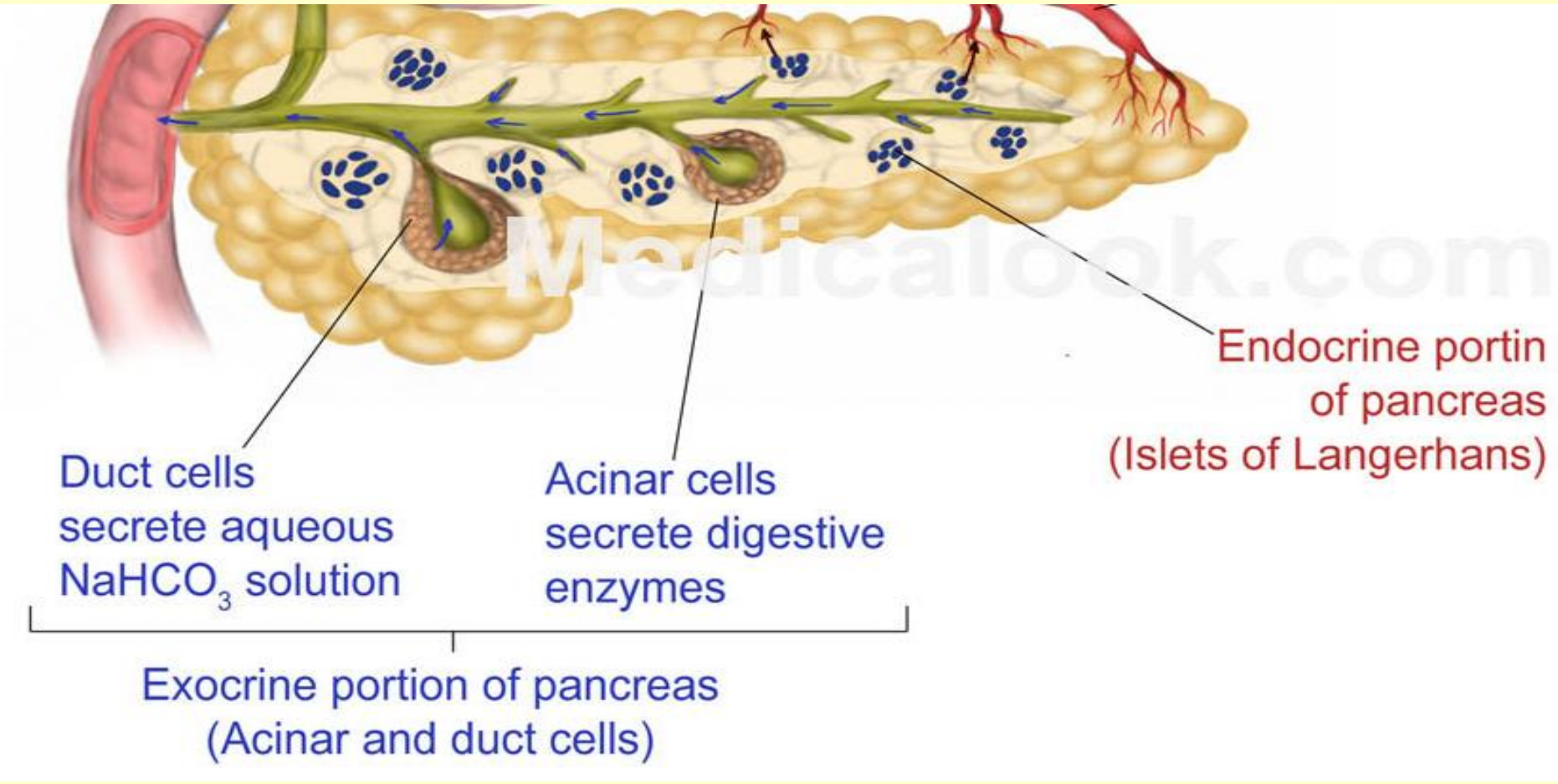
- centroacinar cells - intercalated ducts - intralobular ducts - interlobular ducts
- main pancreatic duct (to the duodenum)





Exocrine pancreas – function

- **acinar cells - digestive enzymes**
- **centroacinar cells, intercalated duct cells - carbonic anhydrase activity - bicarbonate - rich** solution (neutralizes gastric acid)



exocrine pancreas – acinar cells – enzymes

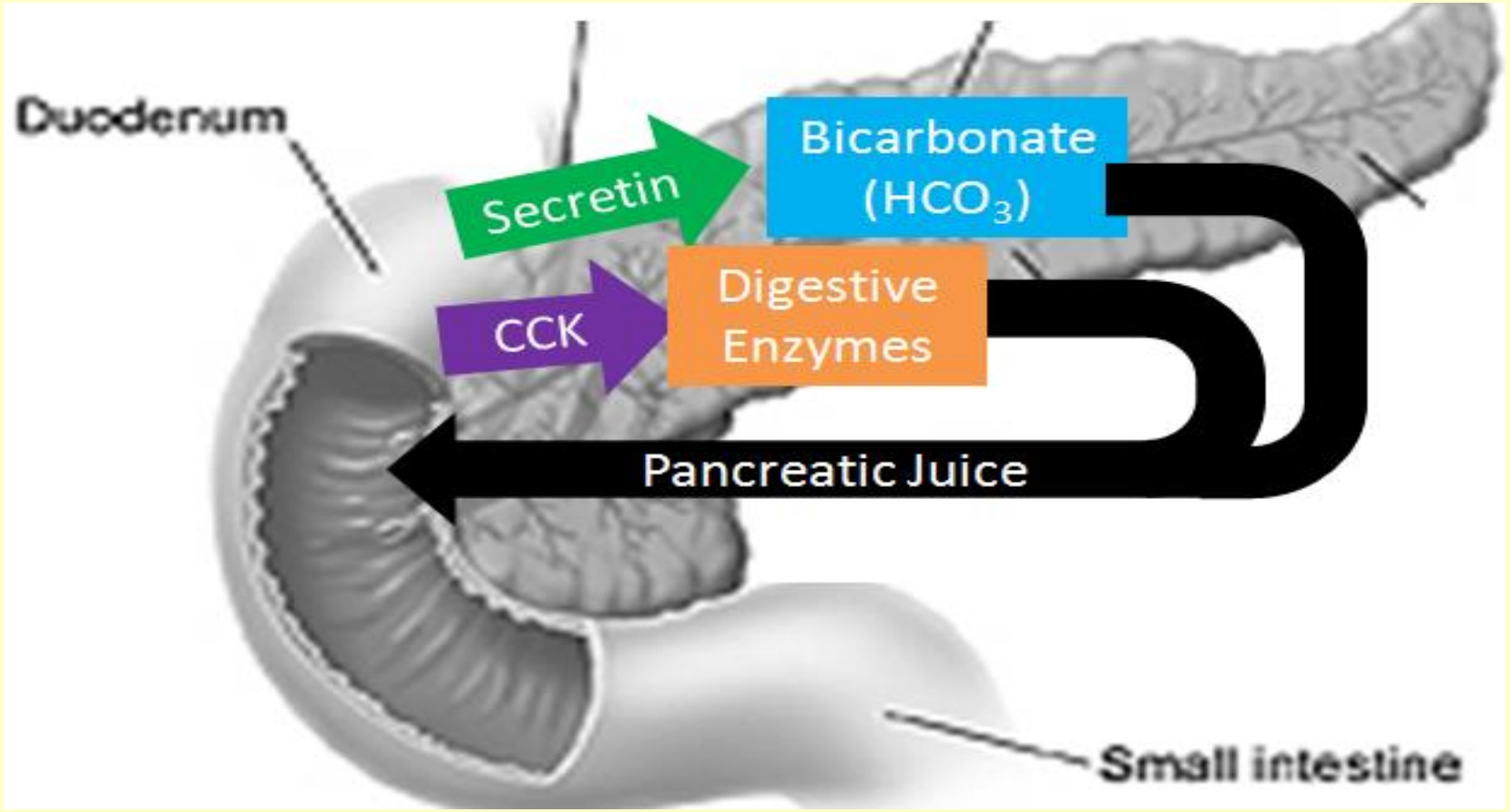
Pancreatic amylase	Starch → Maltose
Lipase	Fats → Fatty acids and glycerol
Nuclease	Nucleic acids → Nucleotides
Trypsin	Proteins → Peptides; zymogen activation
Chymotrypsin	Proteins → Peptides
Carboxypeptidase	Peptides → Shorter peptides and amino acids

Proteases - secreted in inactive form

- **Trypsinogen** - activated to **trypsin** by brush border enzyme **enteropeptidase**
- **Procarboxypeptidase** and **chymotrypsinogen** - activated by trypsin

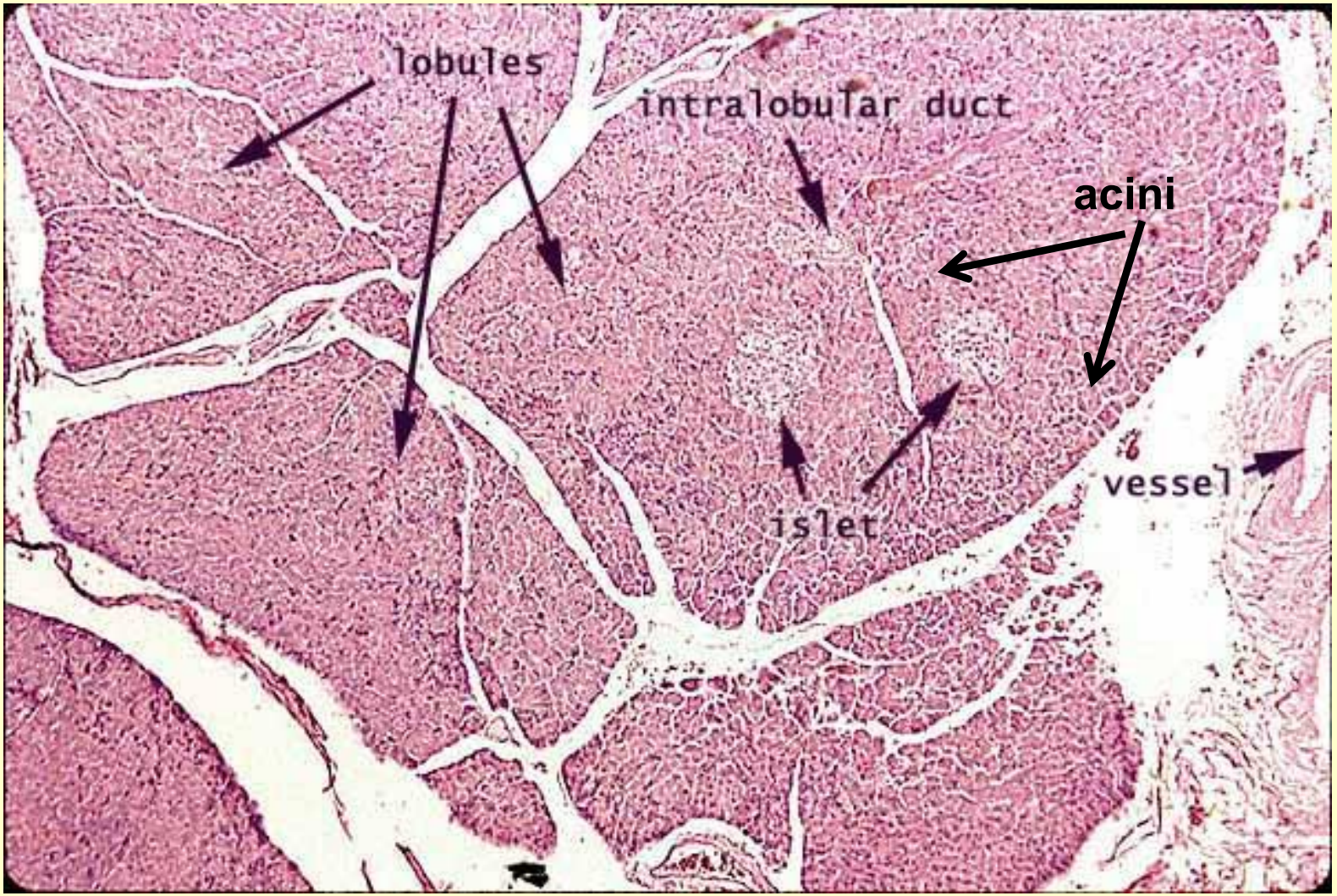
secretin and **cholecystokinin** - DNES cells

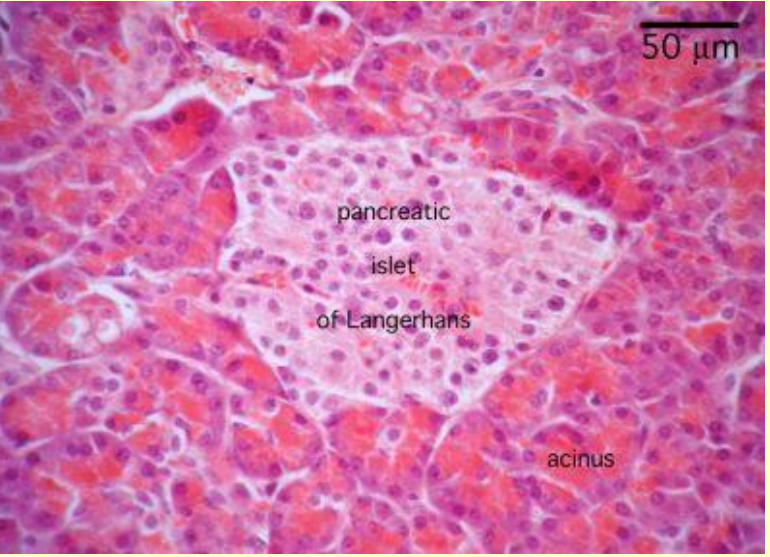
- **Cholecystokinin (CCK) - I** cells - the secretion of **enzyme-rich pancreatic juice**
- **Secretin - S** cells - secretion of **bicarbonate-rich pancreatic juice**



Endocrine pancreas

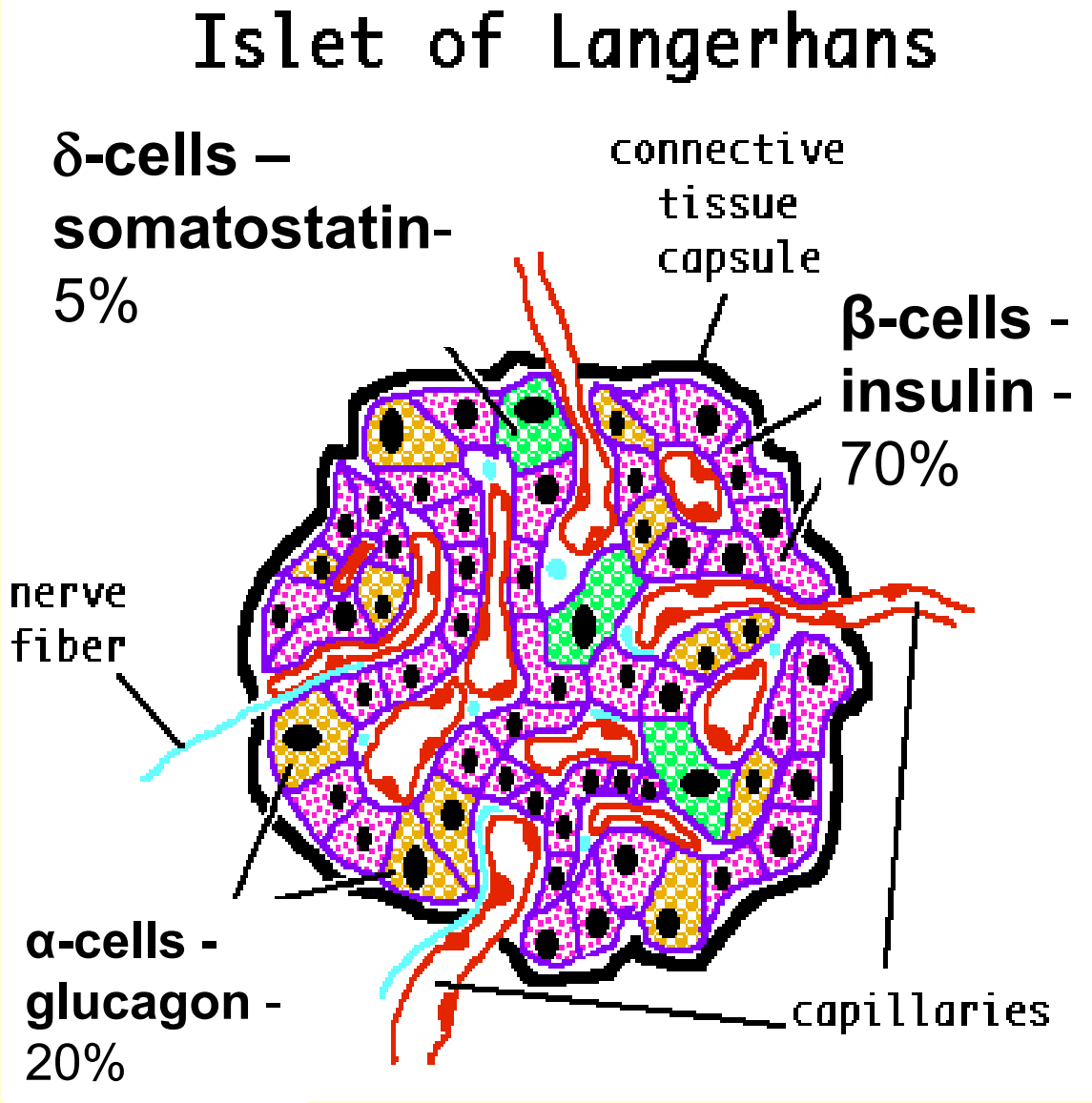
- **islets of Langerhans**
- islets are scattered among the acini





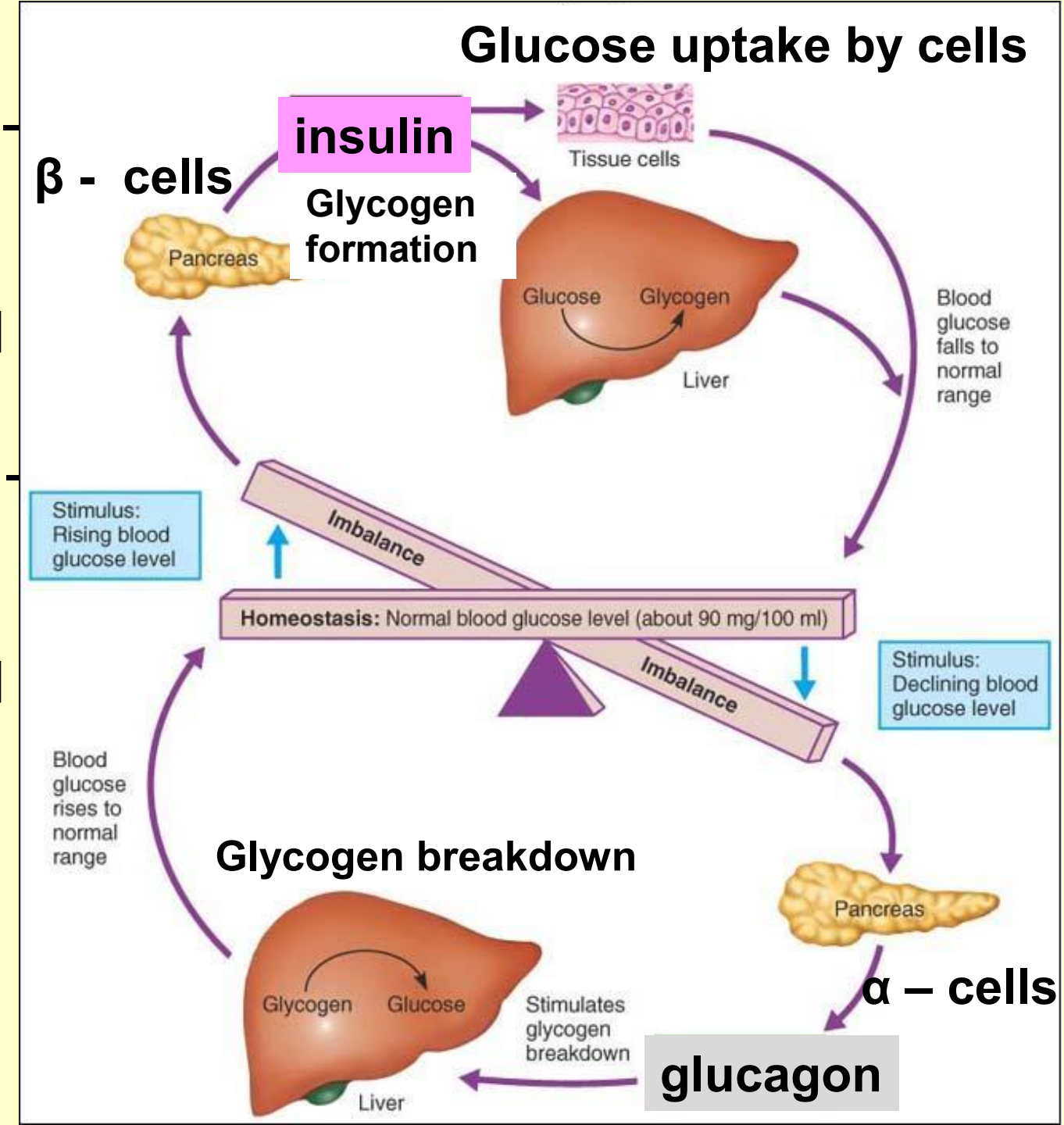
Cells of islets of Langerhans:

- α – cells
- β - cells
- δ - cells
- PP – cells
- G – cells

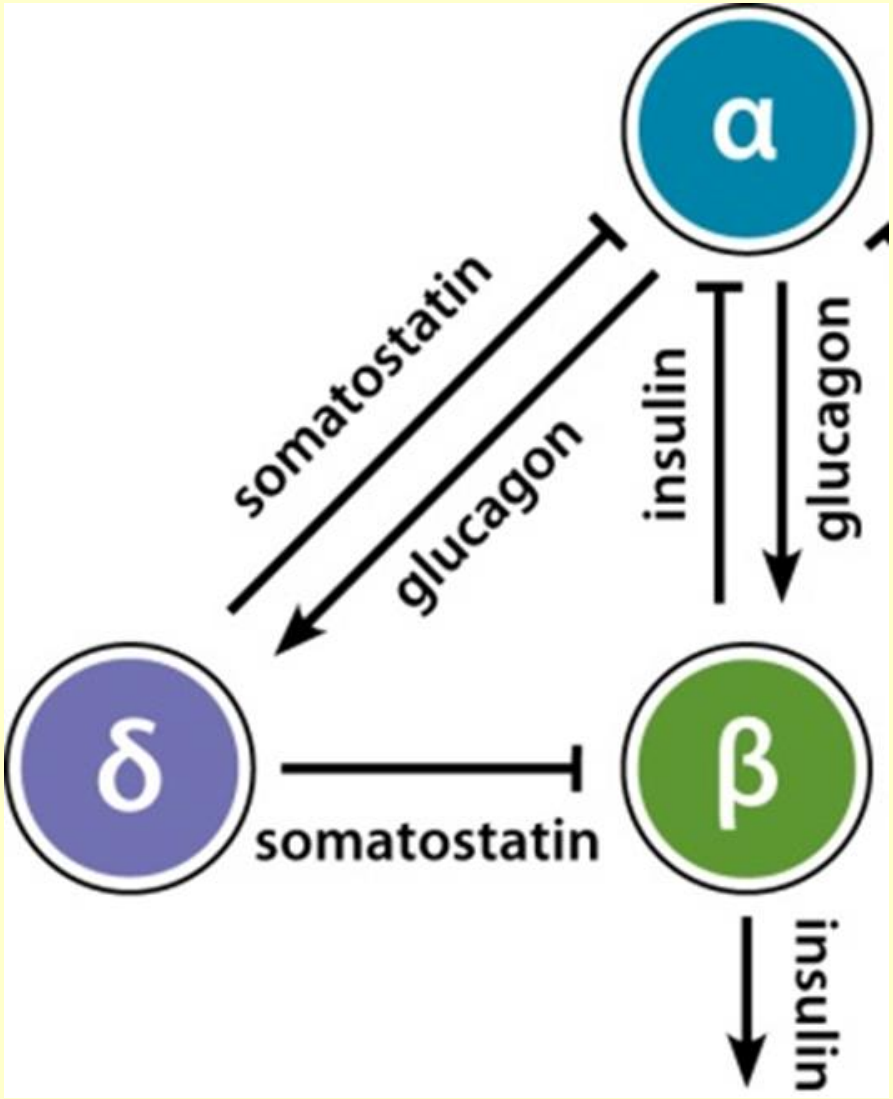


α – cells (20%) - **glucagon** - increases glucose in blood

β - cells (70%) - **insulin** - decreases glucose in blood



δ **(D, D_1) cells (**5%)
D - **somatostatin** - inhibits α and β cells, reduces contraction of smooth muscles of alimentary canal and gallbladder, inhibits HCl production

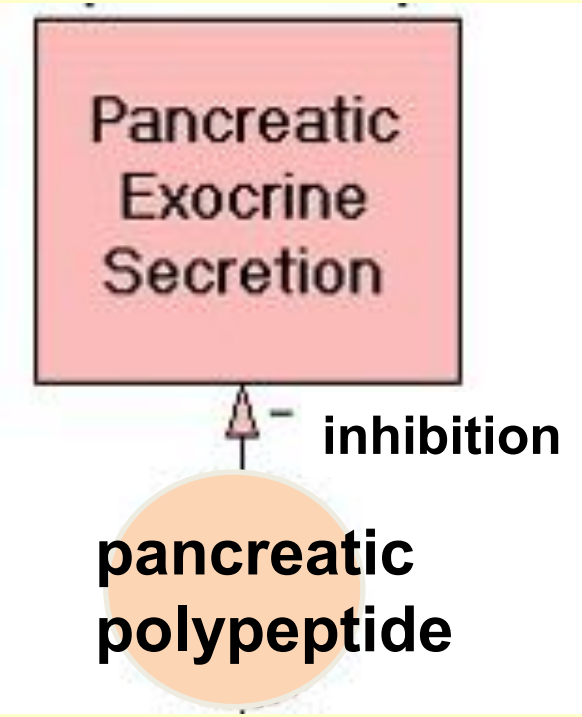


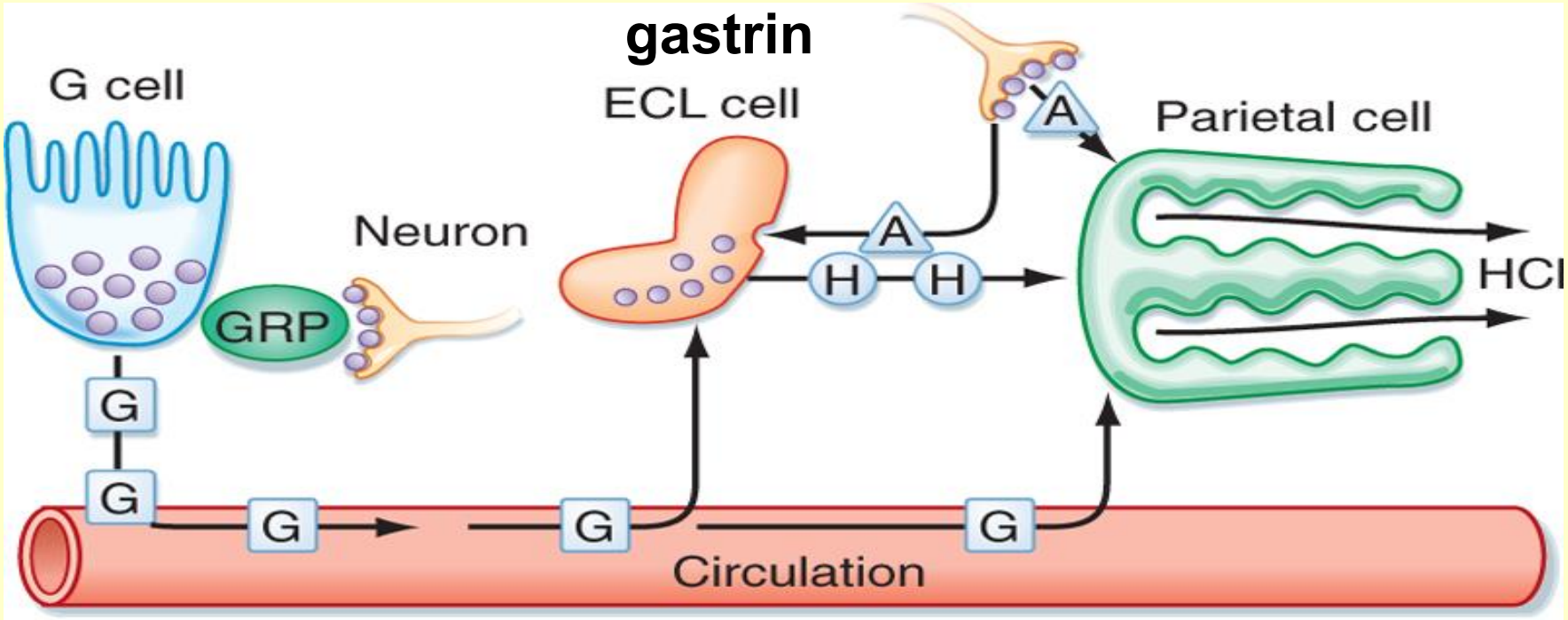
PP – cells - pancreatic polypeptide

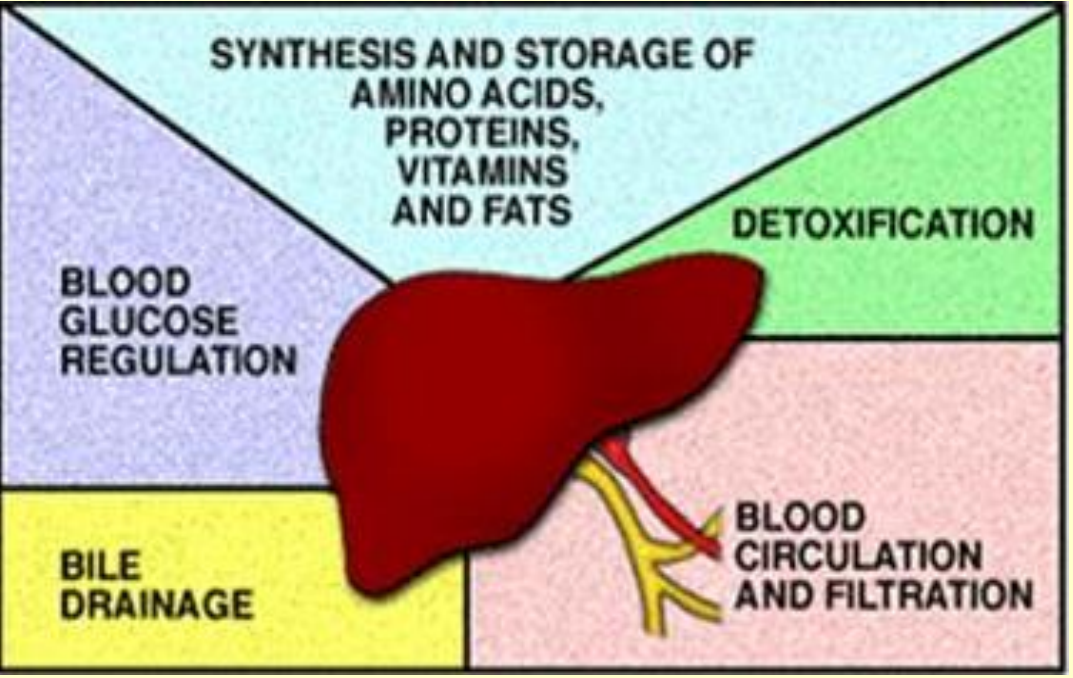
- **inhibits** the exocrine secretions of the pancreas and **stimulates** the release of enzymes by the **gastric chief cells**

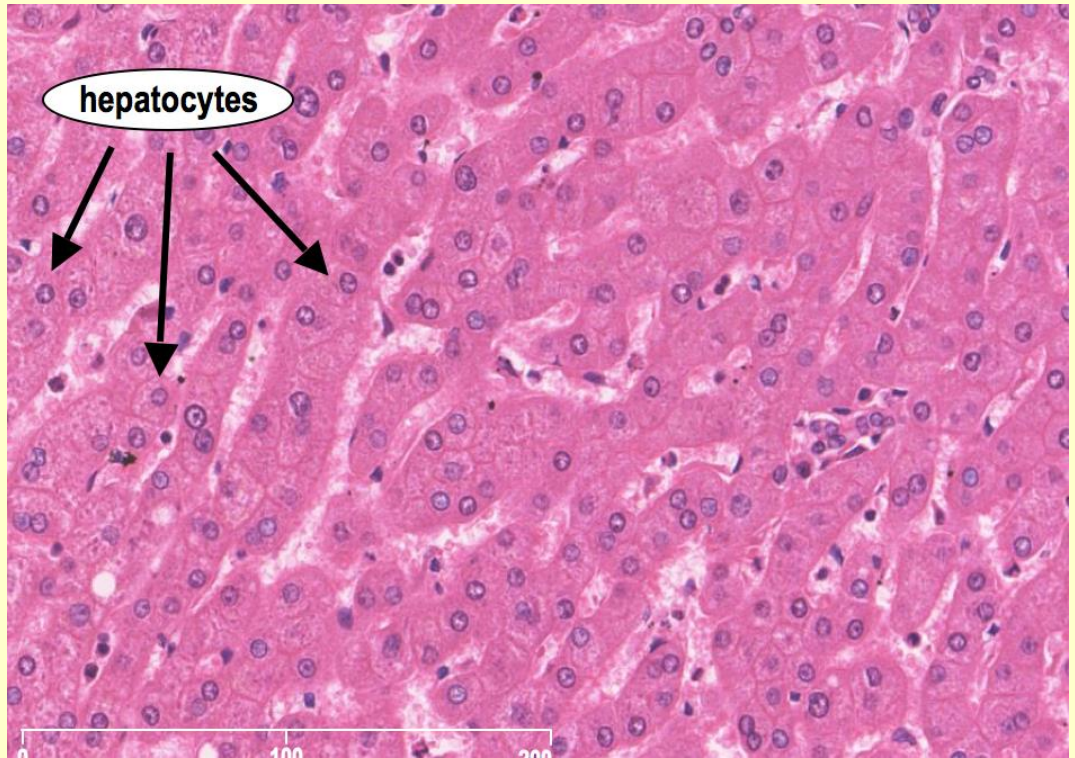
G – cells – gastrin

- **stimulates** production of gastric acid (HCl) by the parietal cells of the stomach





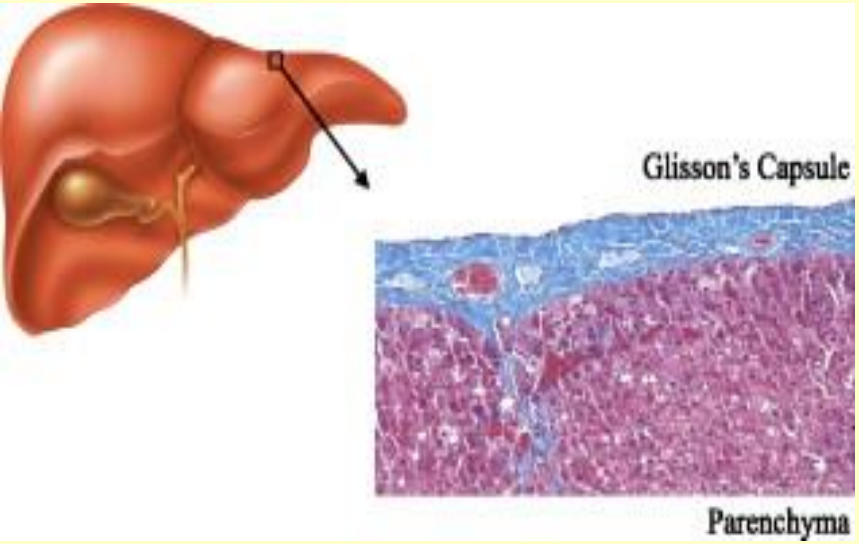




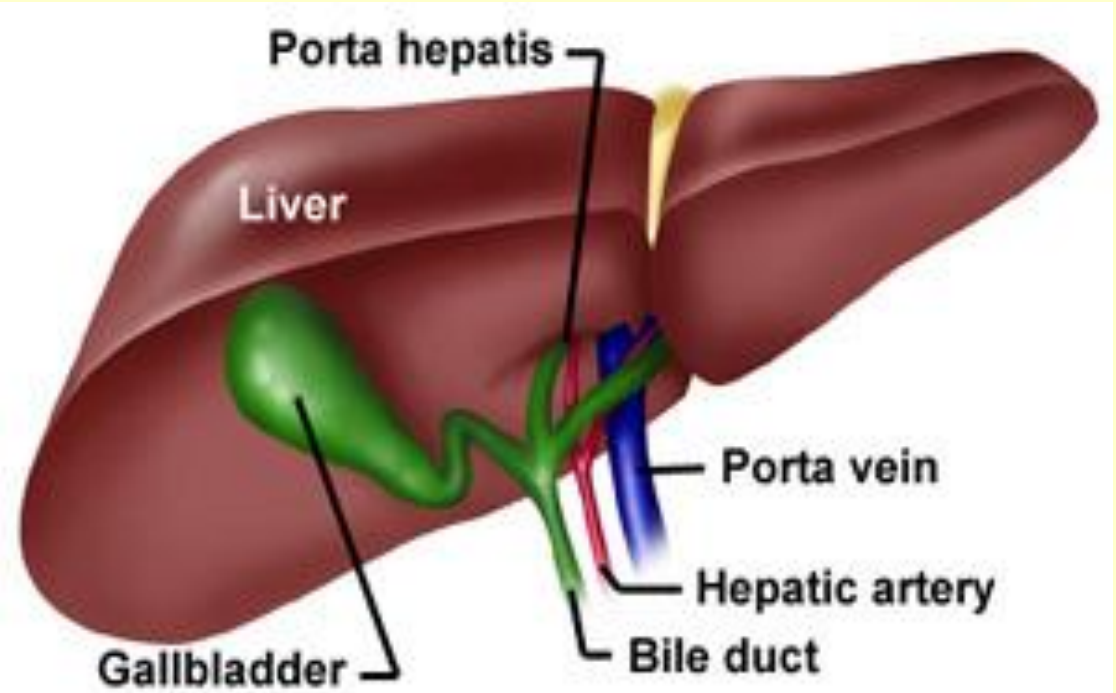
liver

- both **endocrine** and **exocrine** functions
- the same cell, the **hepatocyte -** formation of exocrine secretion and endocrine products.

Liver



- connective tissue capsule, **Glisson's capsule (**at the **porta hepatis** - enters the liver - a conduit for the blood, lymph vessels, bile ducts).

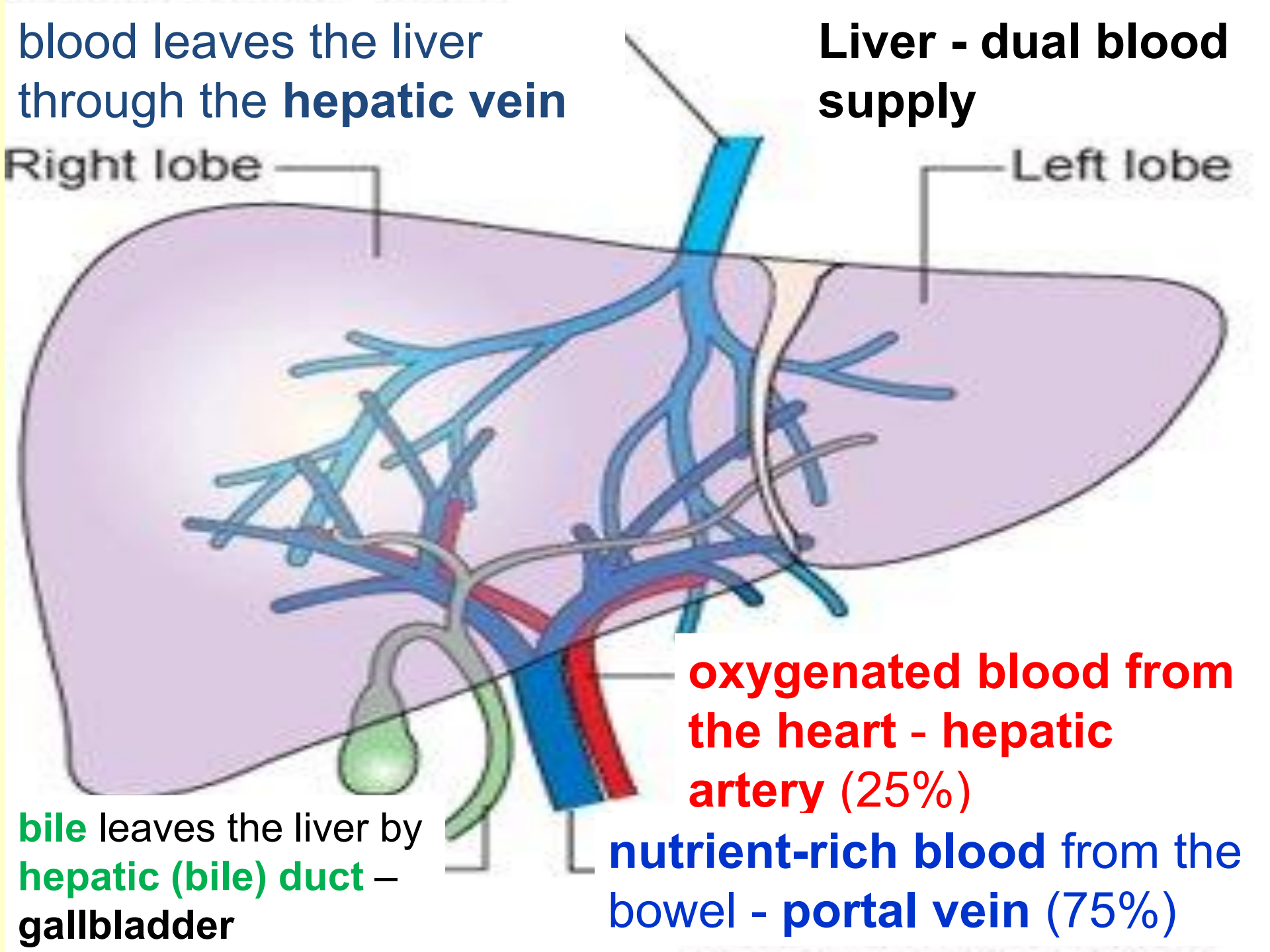


porta hepatis :

- **portal vein (enters)**
- **hepatic artery (enters)**
- **bile duct (exits)**

blood leaves the liver through the **hepatic vein**

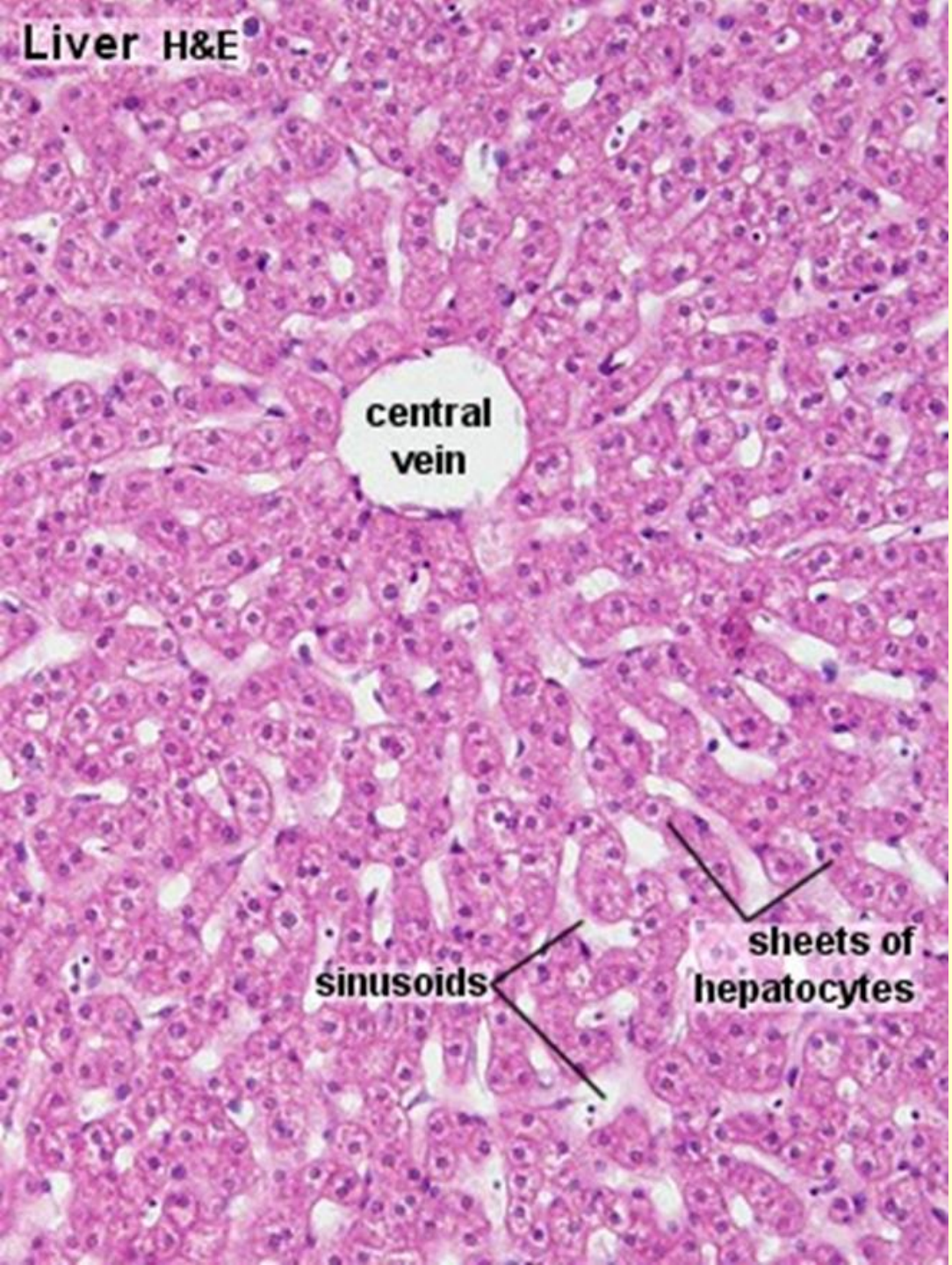
Liver - dual blood supply



oxygenated blood from the heart - hepatic artery (25%)

nutrient-rich blood from the bowel - **portal vein** (75%)

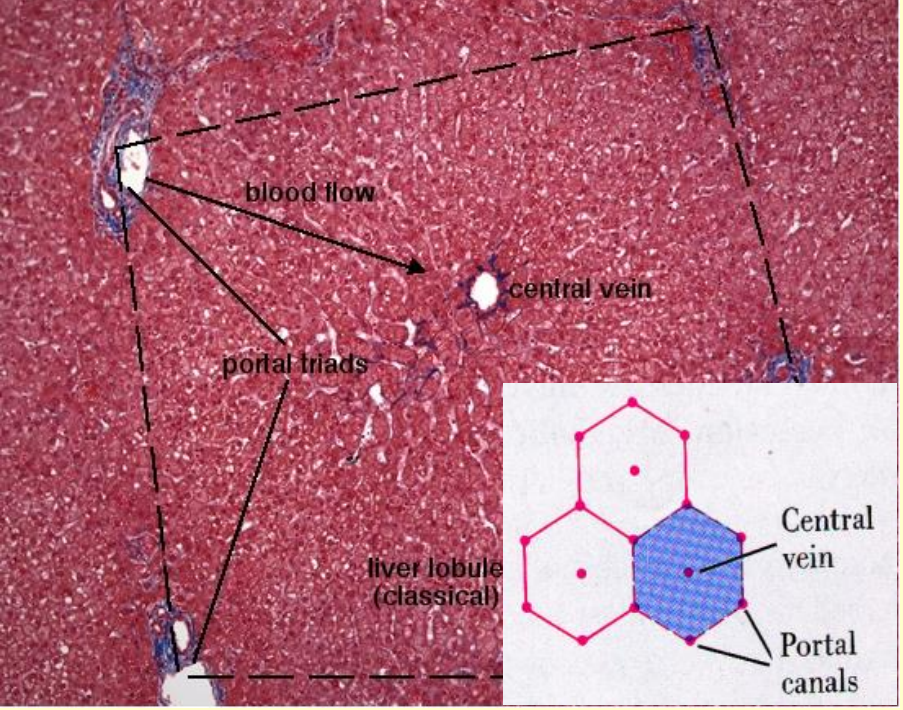
bile leaves the liver by **hepatic (bile) duct** – **gallbladder**



- **liver - parenchymal cells - hepatocytes - 80% of the liver**
- connective tissue elements are sparse

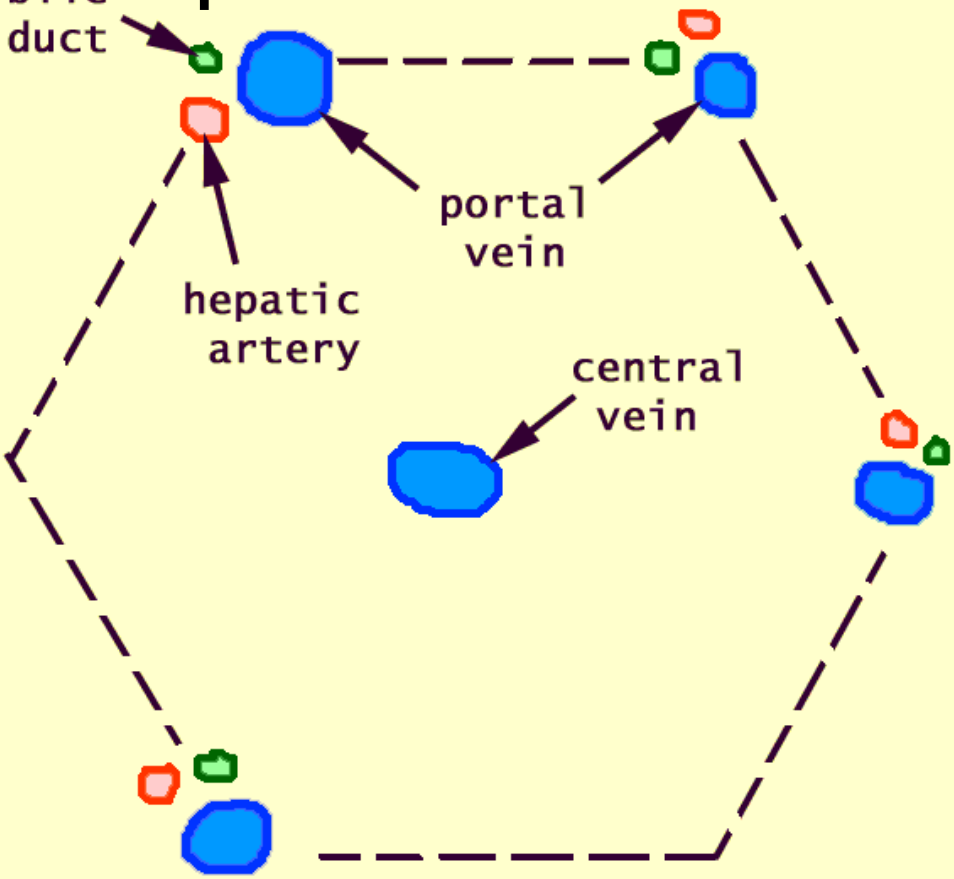
Hepatocytes

- radiate from the central vein - **plates (sheets)** separated by vascular spaces - **hepatic sinusoids**



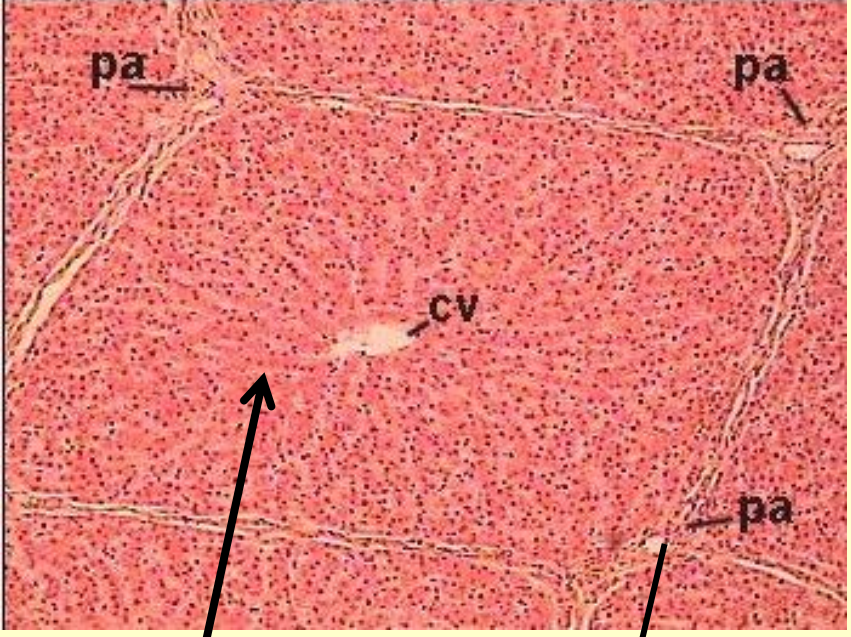
Hepatocytes - hexagon-shaped **classical lobules** (in human boundaries invisible)

portal area - portal triad



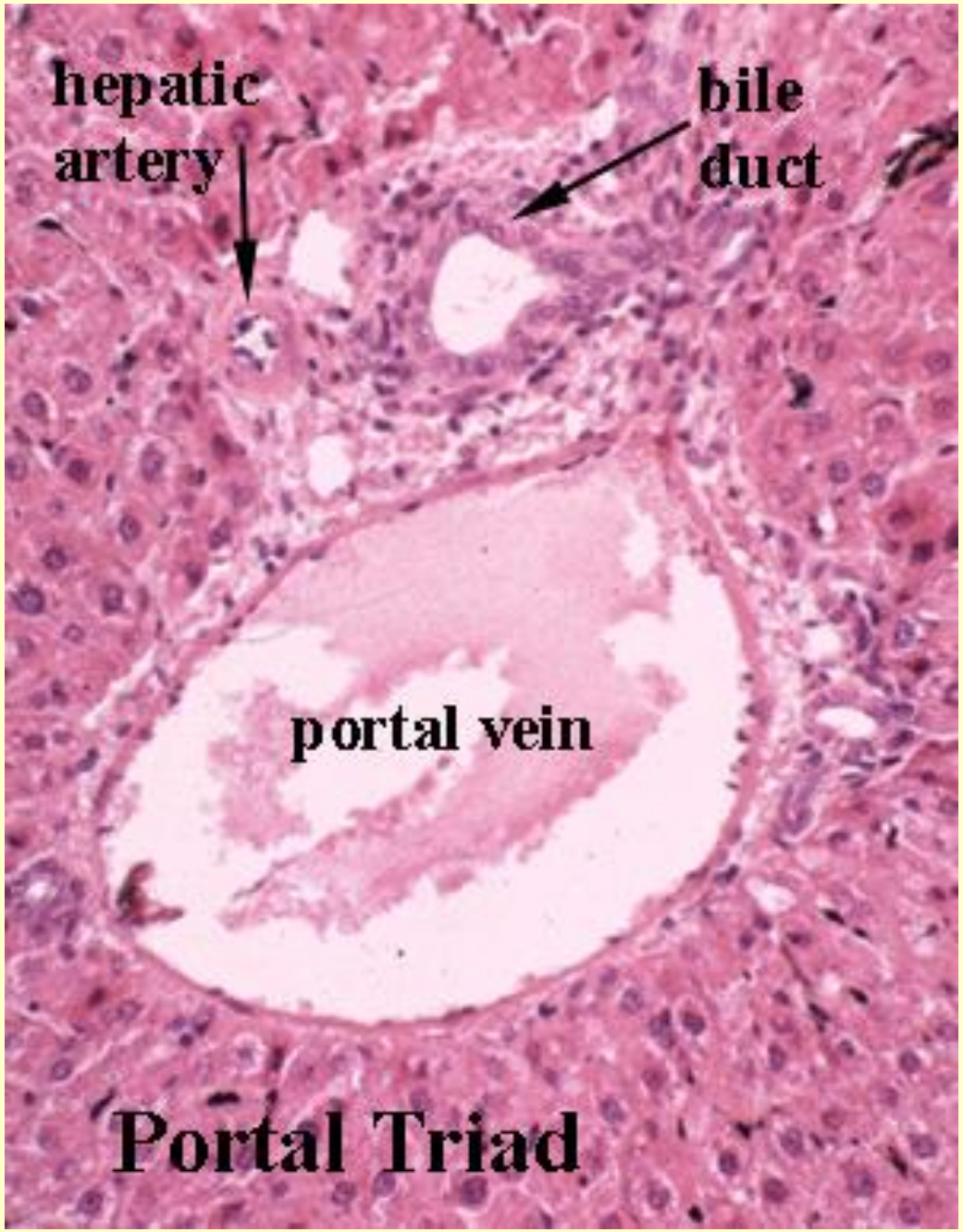
portal area (portal triad):

- **hepatic artery,**
- **portal vein,**
- **interlobular bile ducts,**



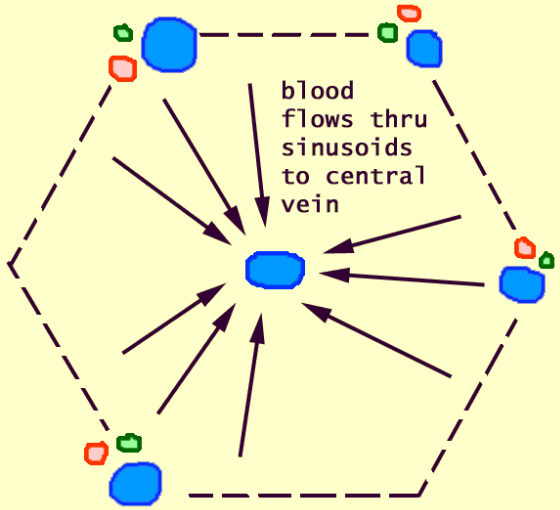
classical lobule

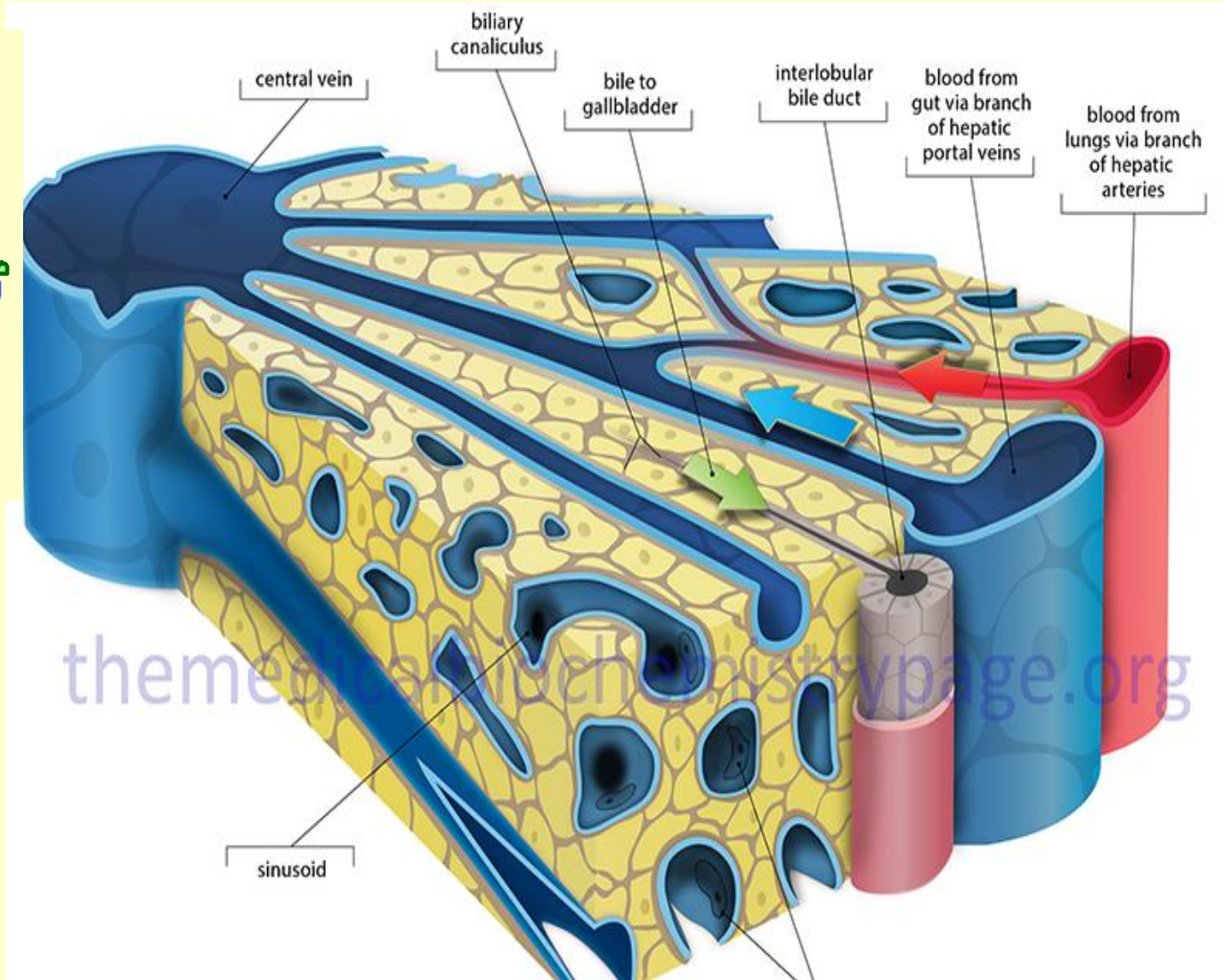
portal area

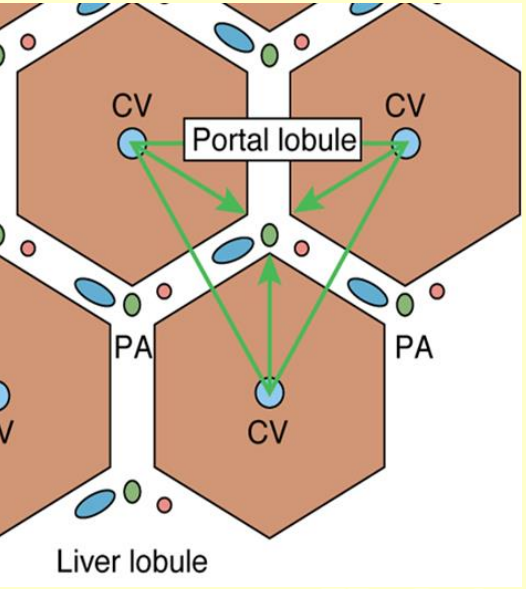


three types of liver lobules: 1. **classic hepatic lobule**

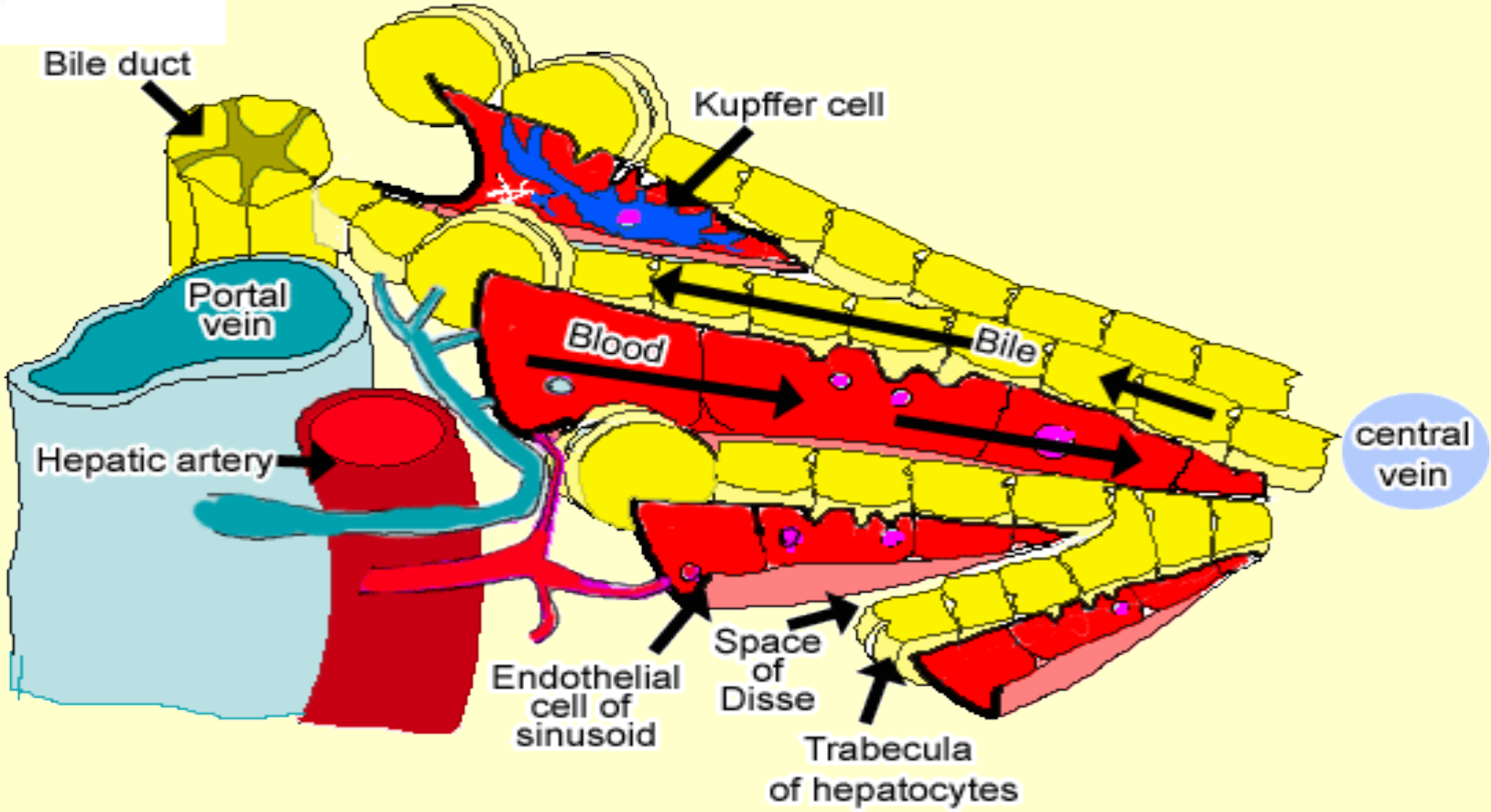
- based on **blood flow**, blood flows from the periphery to the center of the lobule, into the central vein.

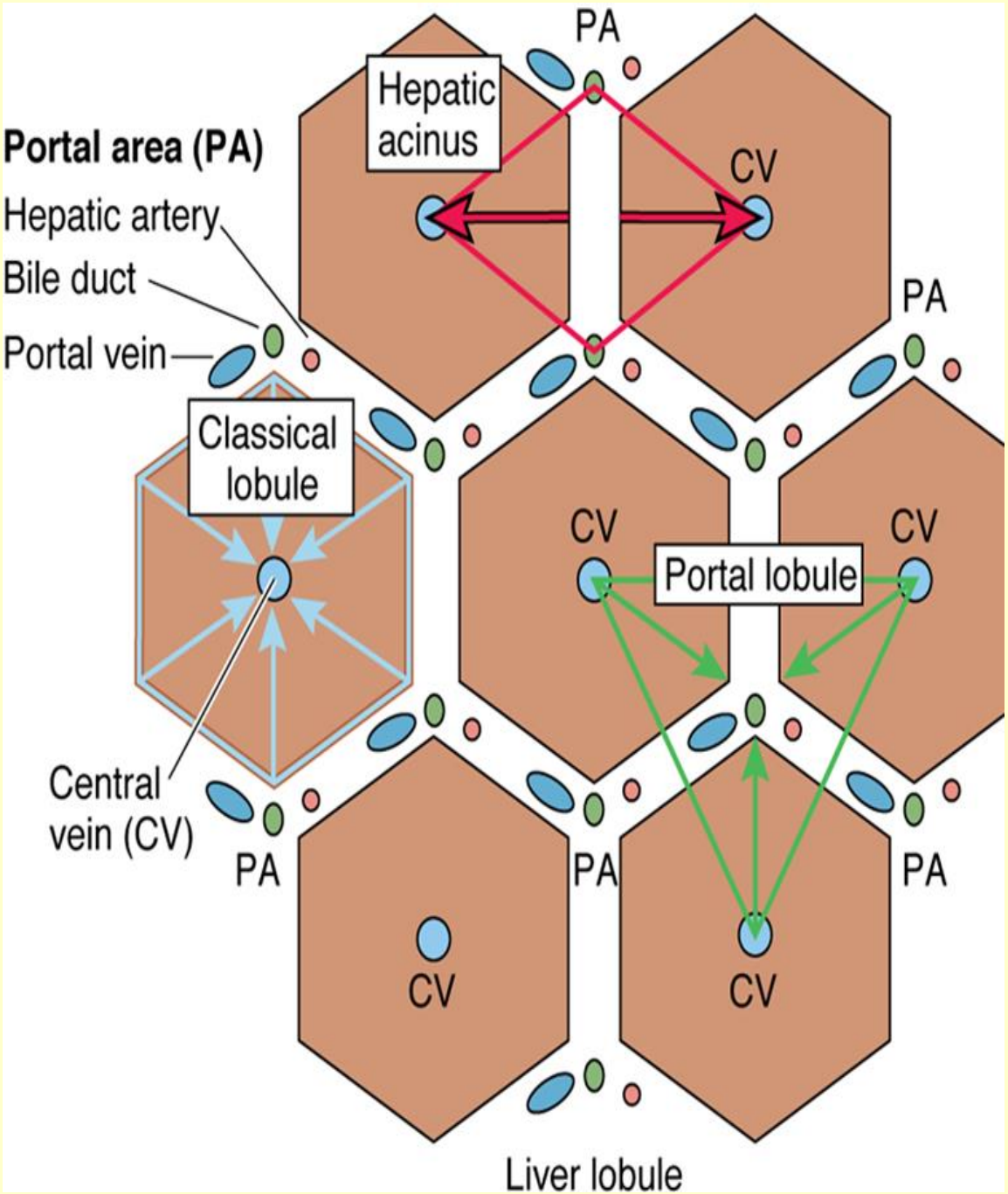






The **portal lobule** - based on **bile secretion** - the triangular region - **portal area** in the center - periphery is bounded by imaginary straight lines connecting the three surrounding central veins.

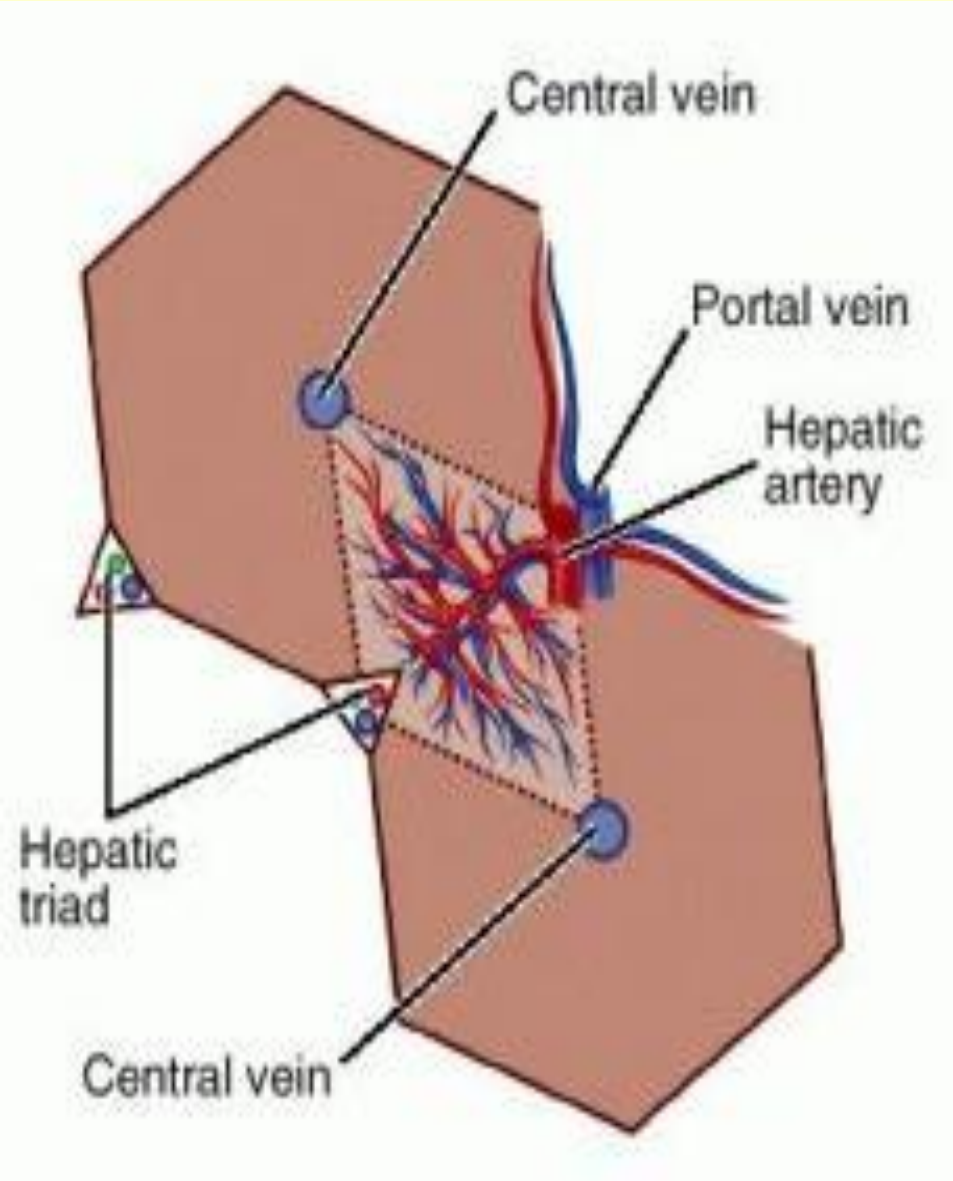




The **hepatic acinus (acinus of Rappaport**)

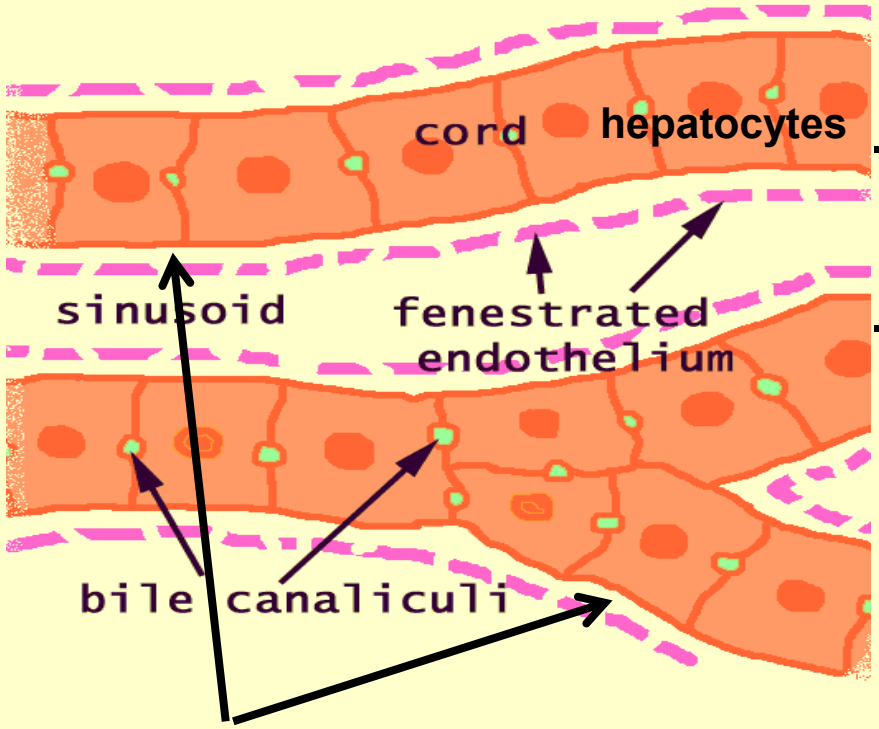
- **the functional unit of the liver**.

hepatic acinus (acinus of Rappaport)



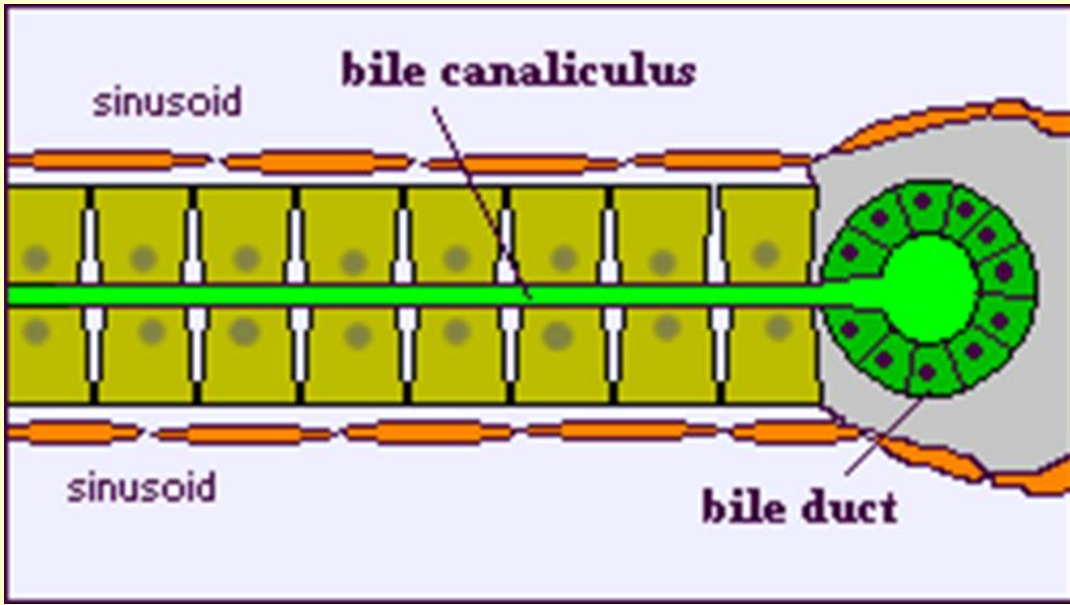
- ovoid to diamond-shaped lobule - two angles occupied by **portal triads** and two opposite angles occupied by **central veins**
- is supplied by a branch of the **portal vein** and **hepatic artery**

Hepatocytes



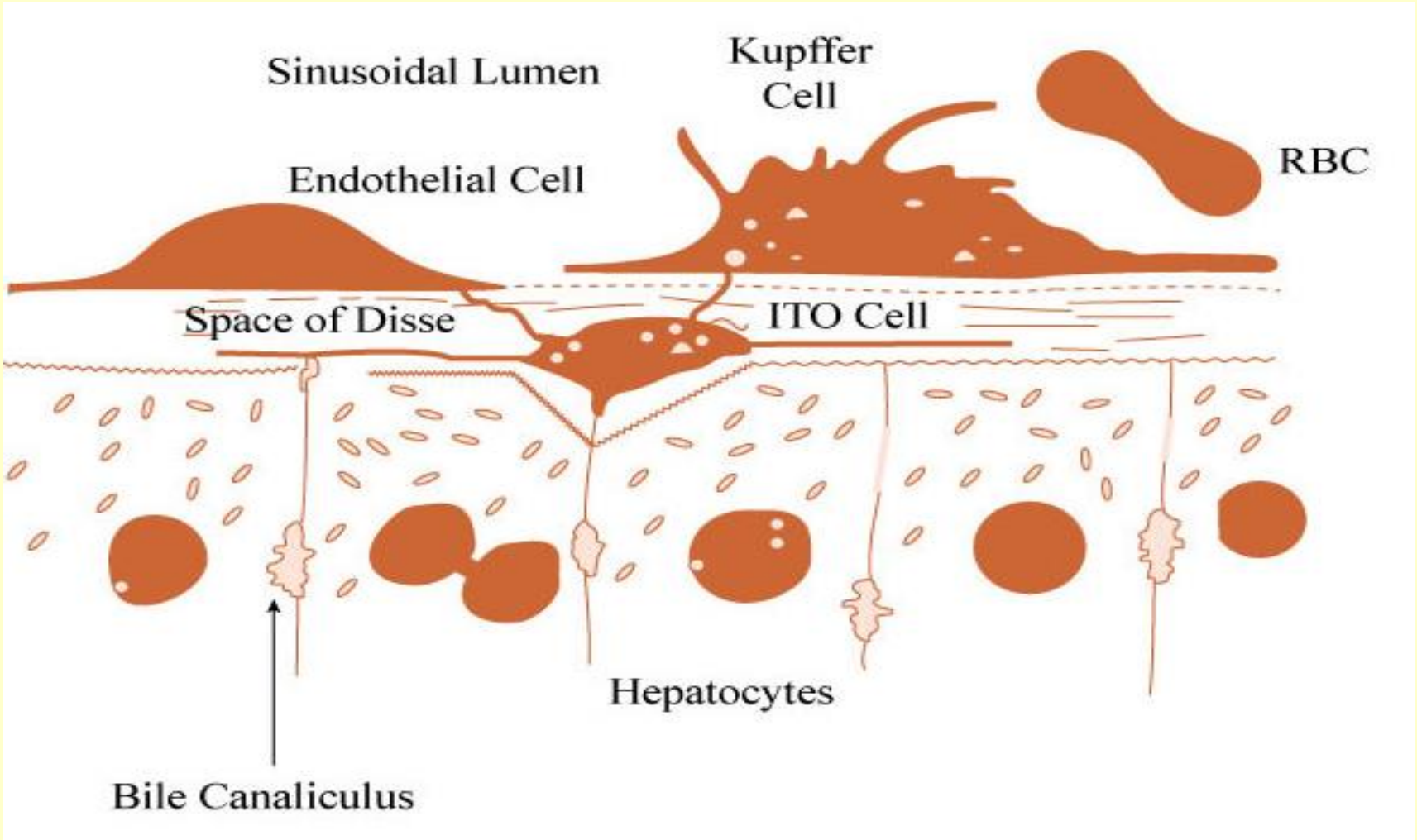
- h**epatocytes** - two domains: **latera**l and **sinusoidal**.
- **lateral domains - bile canaliculi** - conduct bile between hepatocytes to the periphery of the classical lobules.

- the **sinusoidal domains** – in contact with the **space of Disse**



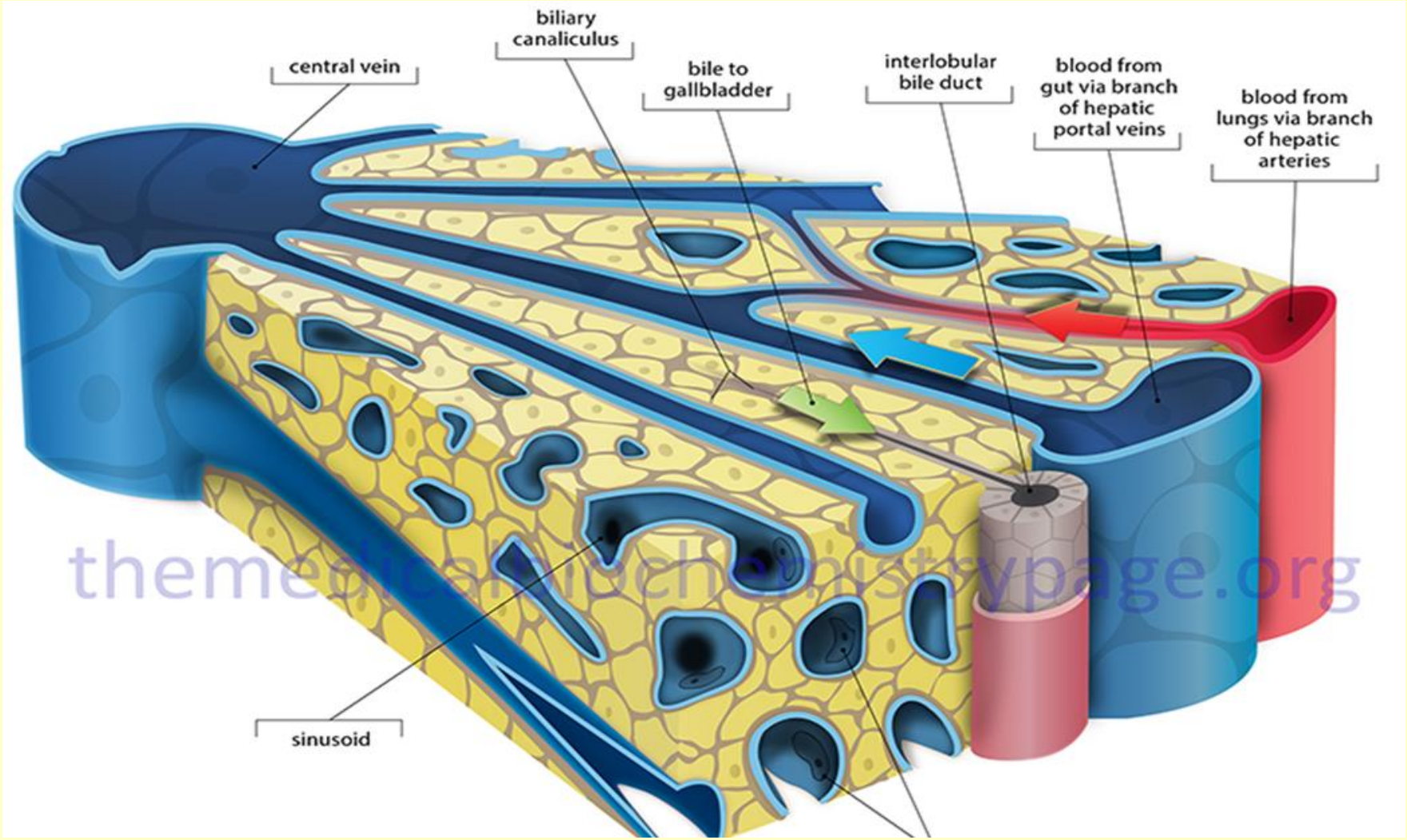
Perisinusoidal space space of Disse

- between **hepatocytes** and a **sinusoid**
- contains **Ito cells** (**hepatic stellate cells**) - **store** fat or fat soluble **vitamins (vitamin A)**



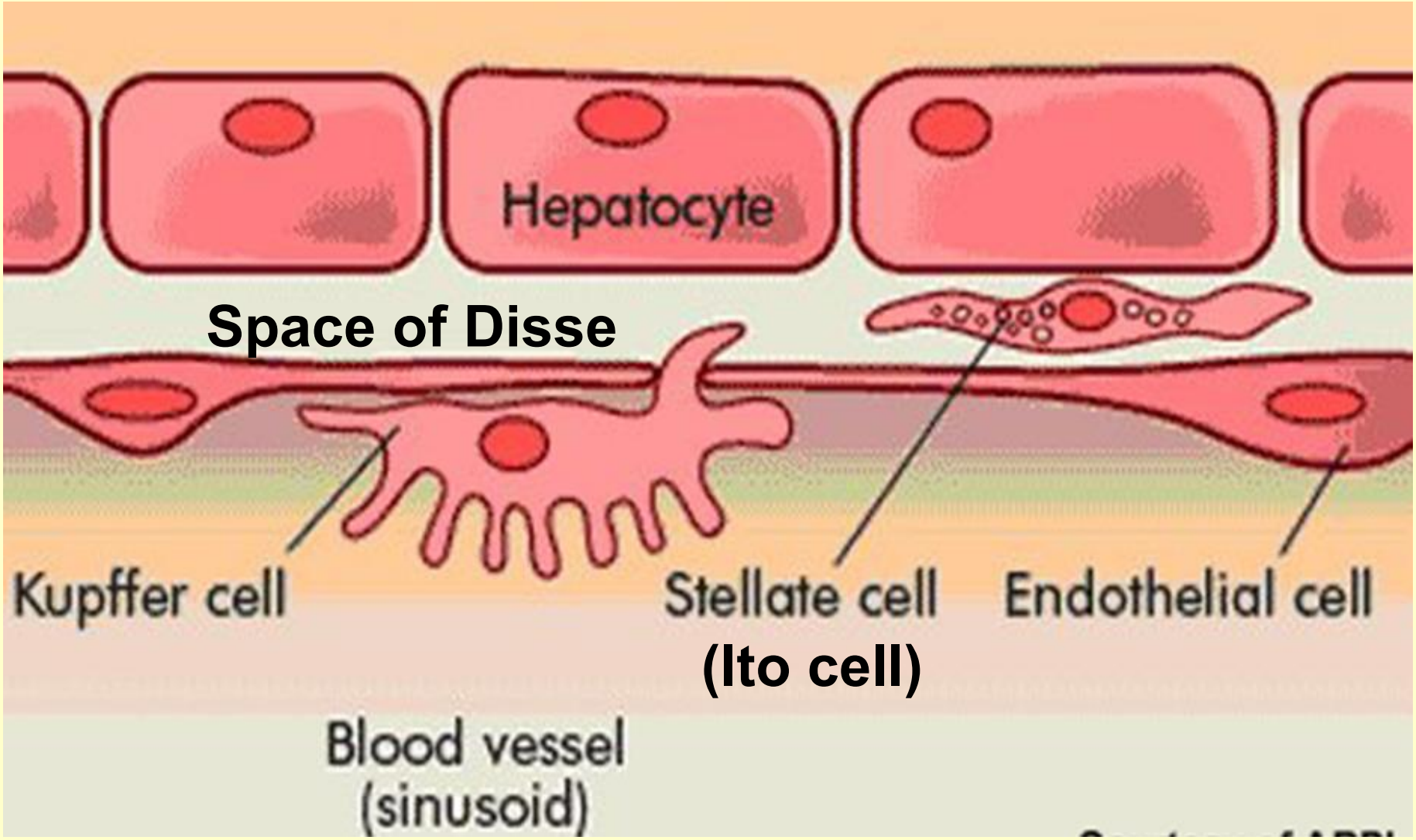
liver sinusoid - sinusoidal blood vessel (**fenestrated**, **discontinuous endothelium**)

- **oxygen-rich blood** from the hepatic artery and the **nutrient-rich blood** from the portal vein.



Stellate macrophages (Kupffer cells) - inside sinusoids

- destroy foreign material (bacteria)



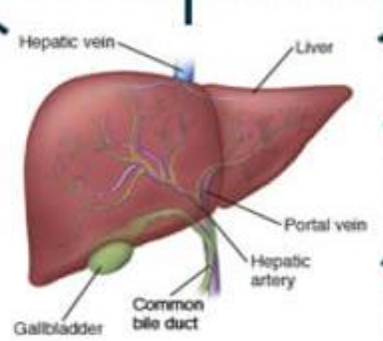
The liver performs over 500 vital functions

Detoxification:
- Drugs/Alcohol
- Fatty acids
- Steroid hormones
- Ammonia → Urea
- Environmental toxins/allergens

Production of Cholesterol:
- Precursor to sex hormones, Vitamin D

Storage of Micronutrients:
- Minerals: Copper, Zinc, Magnesium, Iron
- Vitamins: Vitamin A, D, E, K, B12

Metabolism:
- Conversion of T4 → T3
- Detoxification of fat



Blood Sugar Balance:
- Storage of glycogen

Immune System:
- Contains viruses and pathogens
- Maintenance of the hepatic and portal vein immune system

Production of Bile:
- Needed for digestion
- GI anti-microbial

Protein Synthesis:
- Blood clotting (prothrombin)
- Cholesterol transport (lipoproteins)
- Immune Function (globulins)
- Oncotic pressure (albumin)
- Copper bioavailability (ceruloplasmin)

The **liver** – functions

- **production** of blood plasma proteins: **prothrombin, fibrinogen** (formation of blood clots) and **albumins** (regulate the osmotic pressure of the blood - bind water, cations (Ca^{2+}, Na^{+}, K^{+})

Major Types:

Albumin *(60%)*

Major component of osmotic pressure of plasma

Globulins *(35%)*

Antibodies (immunoglobulin) and transport proteins

Fibrinogens *(4%)*

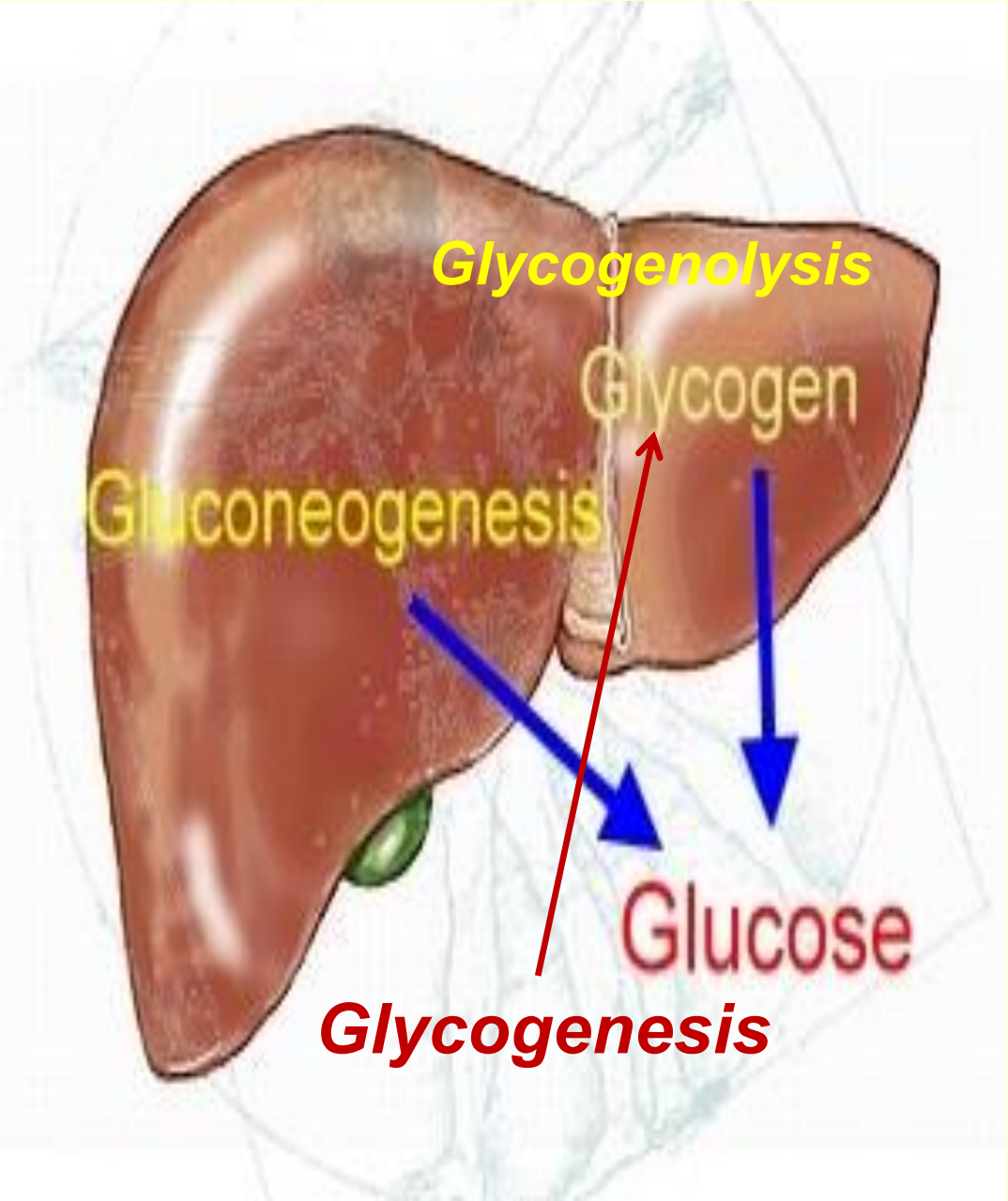
Functions in blood clotting

Other *(<1%)*

Various roles (α-1-antitrypsin, coagulation factors, etc.)

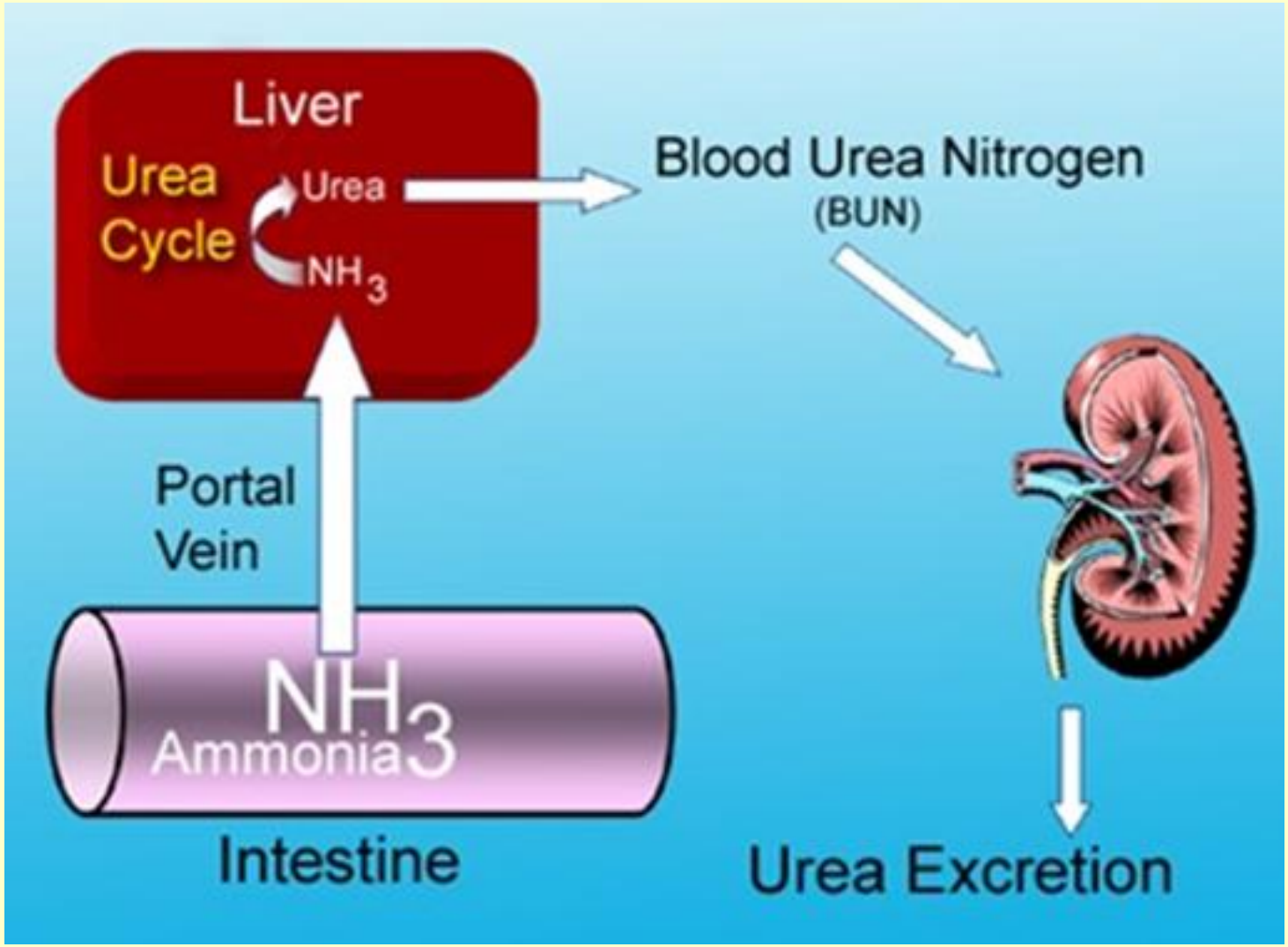
carbohydrate metabolism:

- ***Gluconeogenesis*** - synthesis of glucose
- ***Glycogenolysis*** - breakdown of glycogen into glucose
- ***Glycogenesis*** - formation of glycogen from glucose



storage of vitamins (**vitamins A, D, E, K**), and minerals (**iron-Fe and copper-Cu**)

elimination of **ammonia** – converting into **urea**

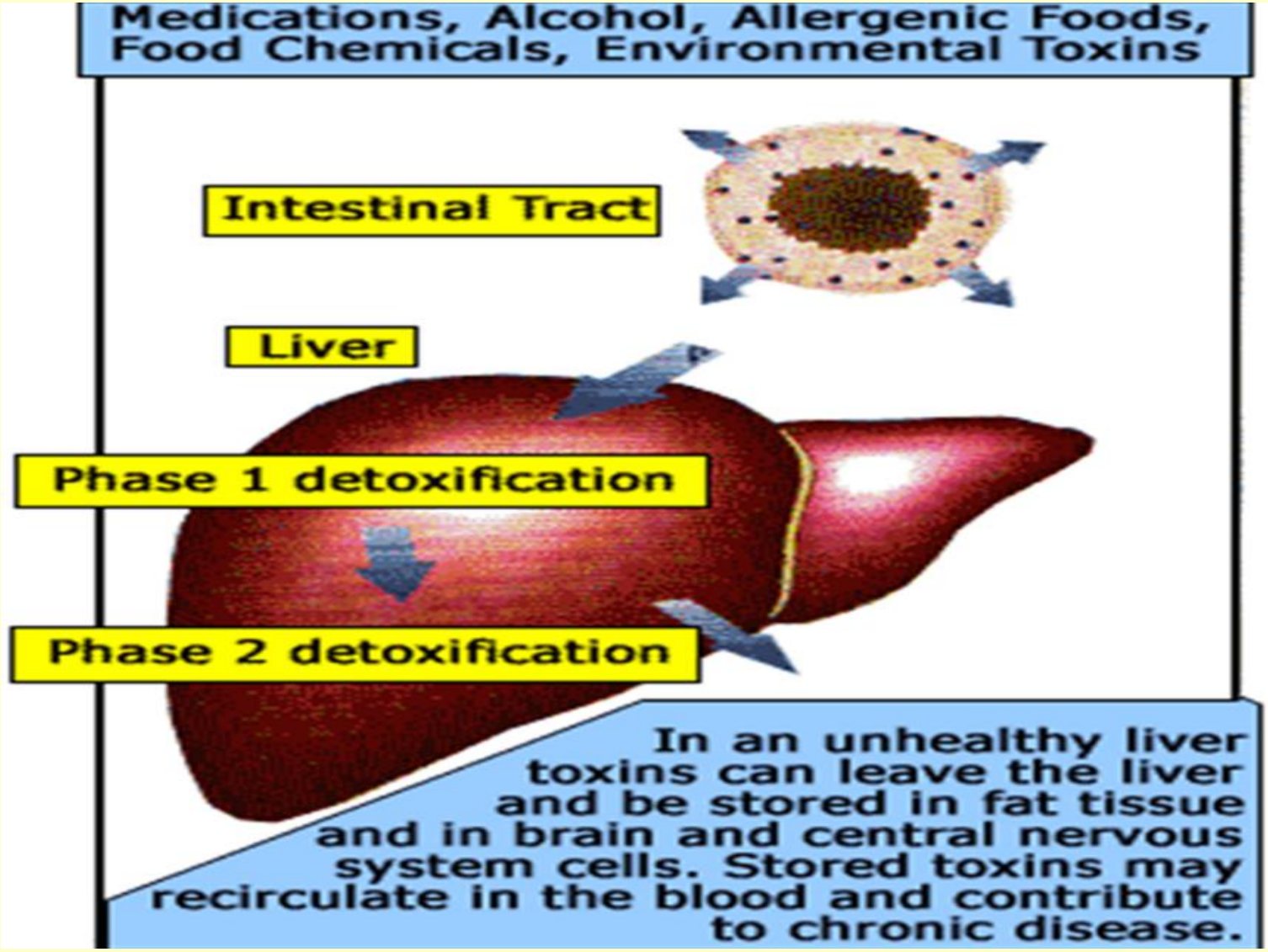


Protection

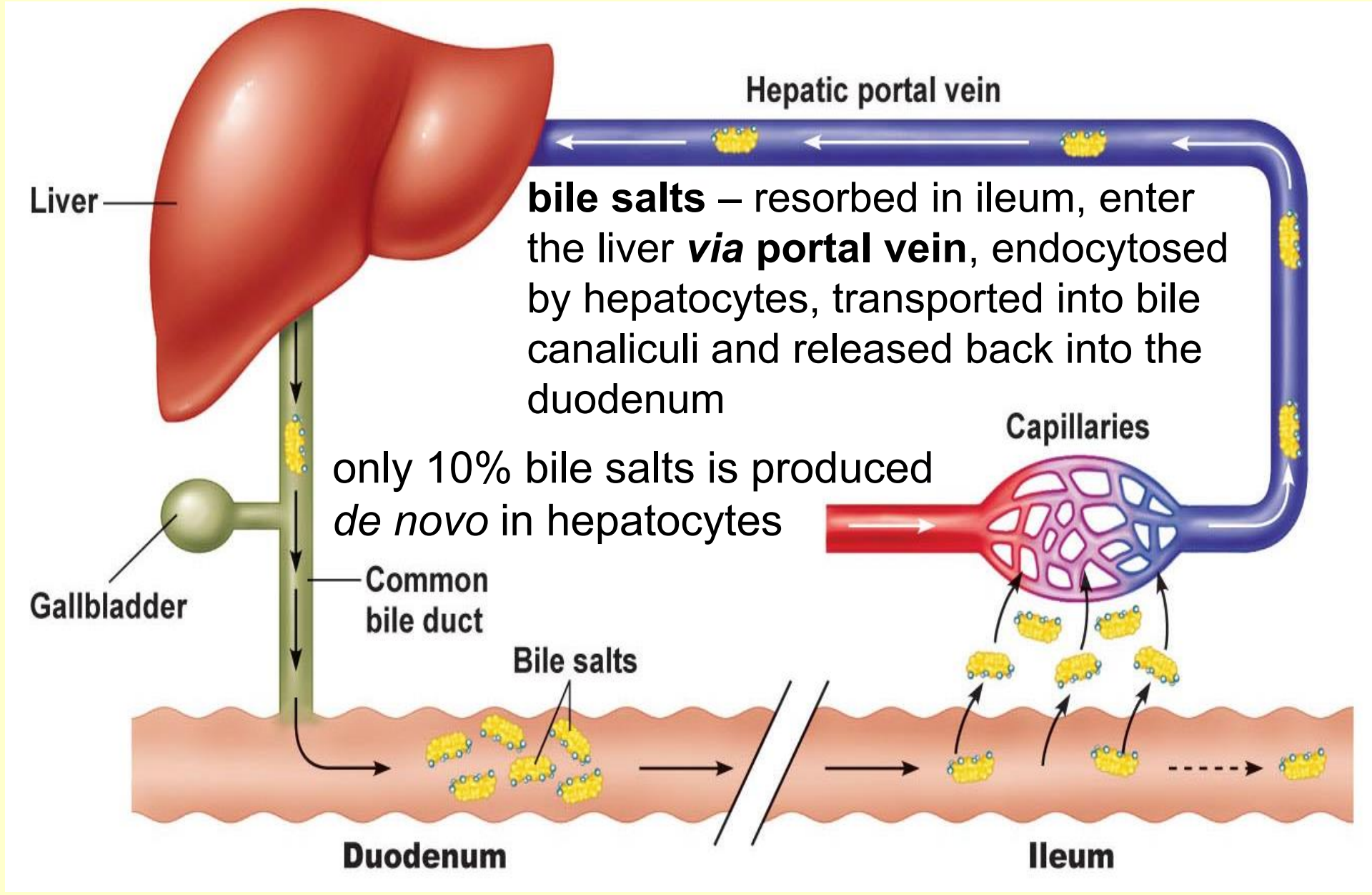
immune system - IgA from the mucosa of alimentary canal transported to the liver - released to the bile)

Kupffer cells - macrophages (phagocytosis)

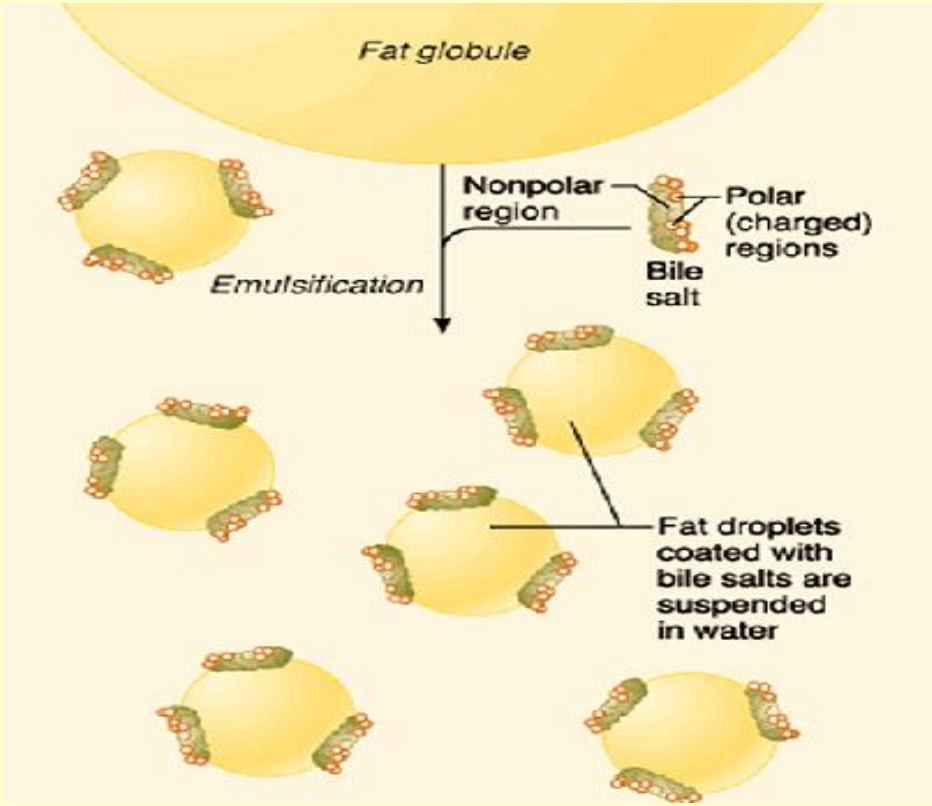
Detoxification - enzymes in hepatocytes **metabolize** many **toxins**, **alcohol and drugs** into inactive metabolites

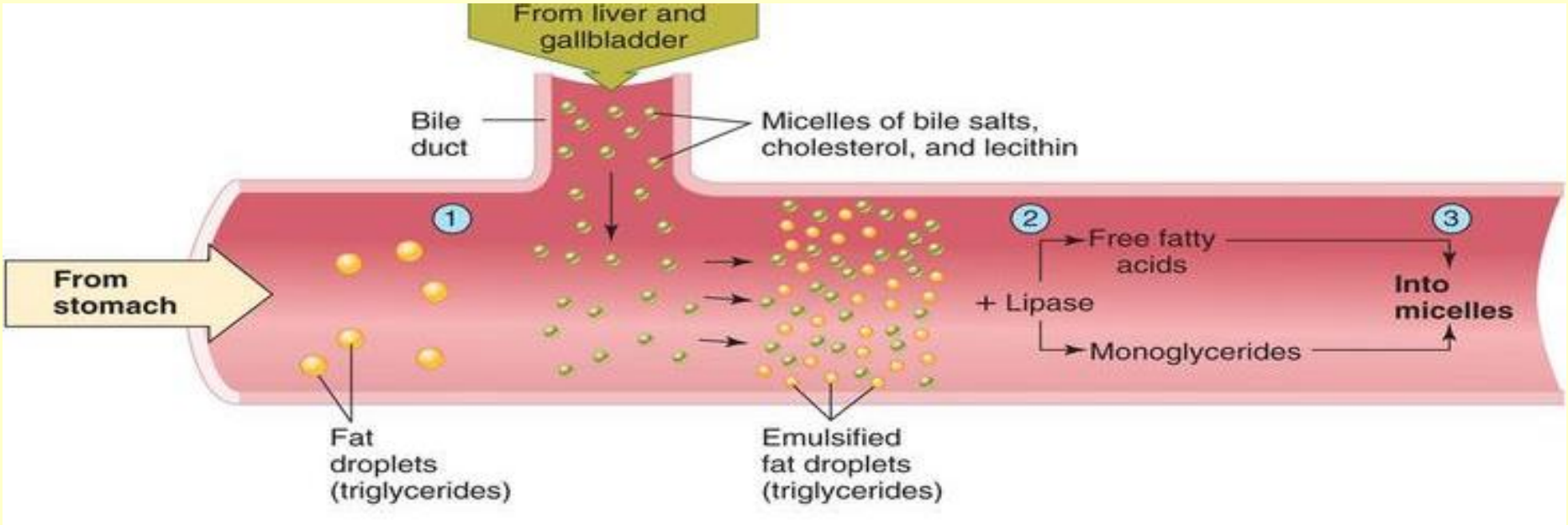


Liver - production of the ***bile***



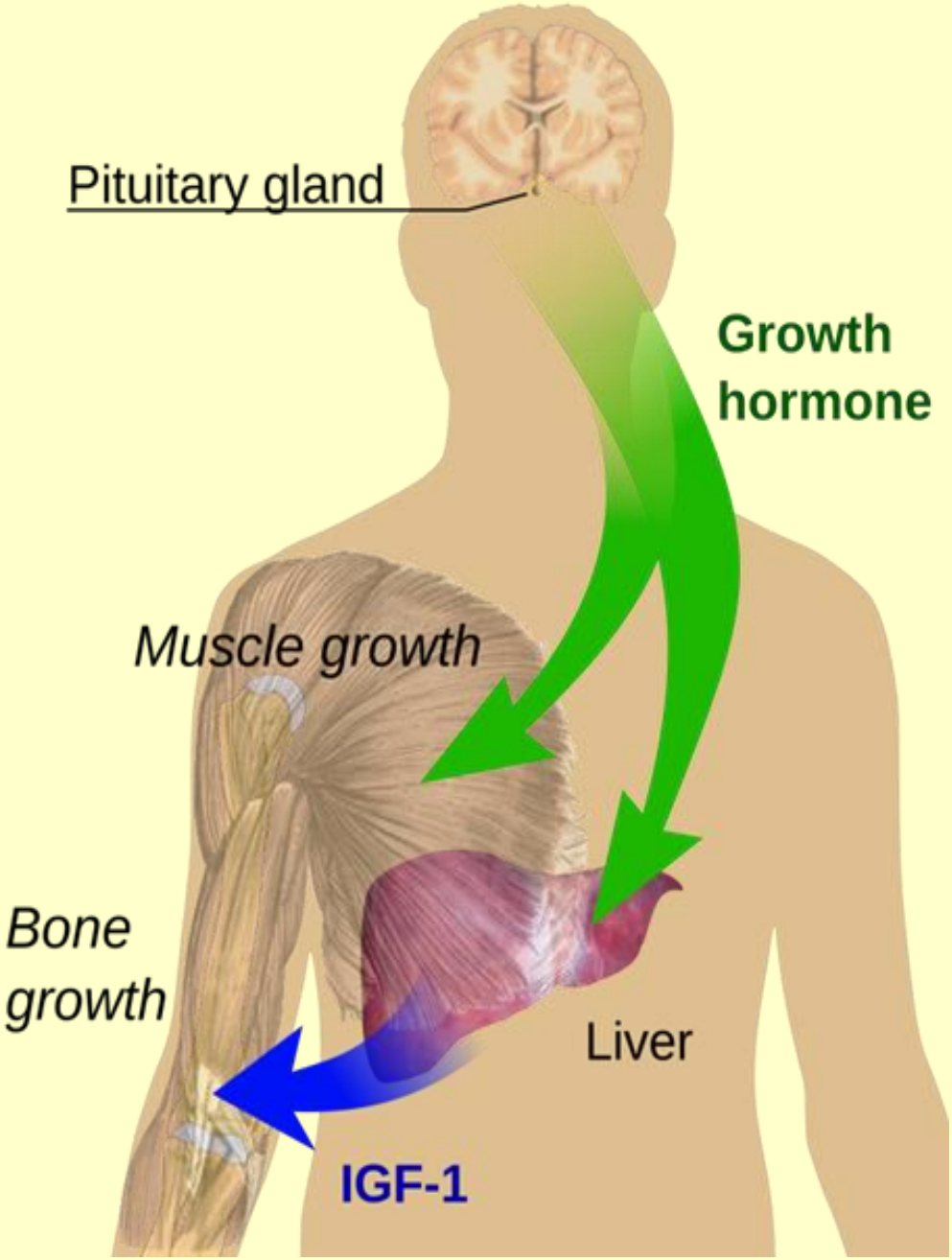
- bile salts – fats emulsification – digestion by pancreases lipase into fatty acids and monoglycerides





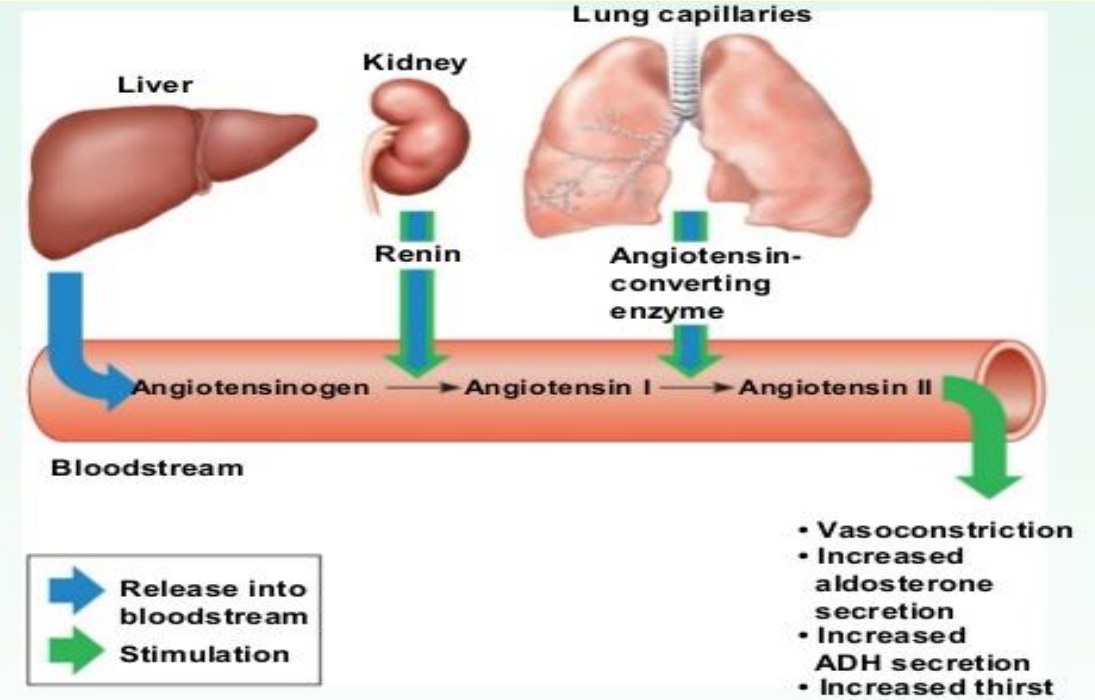
Endocrine function of the liver

- **Insulin-like growth factor 1 (IGF-1)** - regulation of cell growth and development (proliferation of chondrocytes of growth plate)

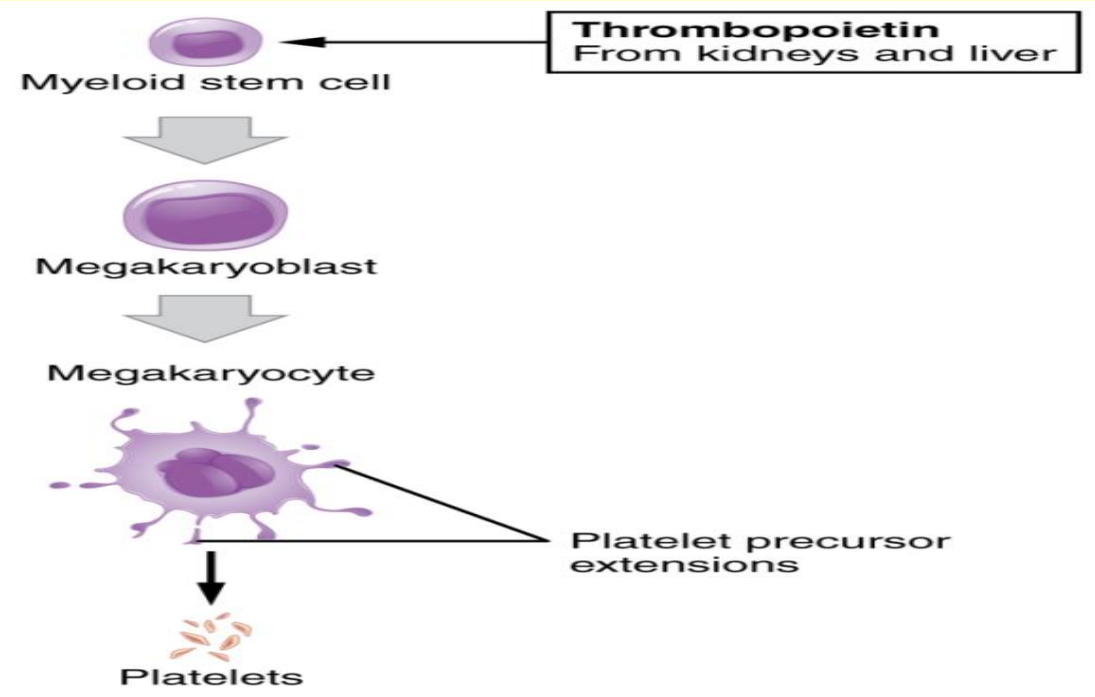


Endocrine function of the liver

Angiotensinogen - angiotensin precursor - increases blood pressure (**vasoconstrictor**)

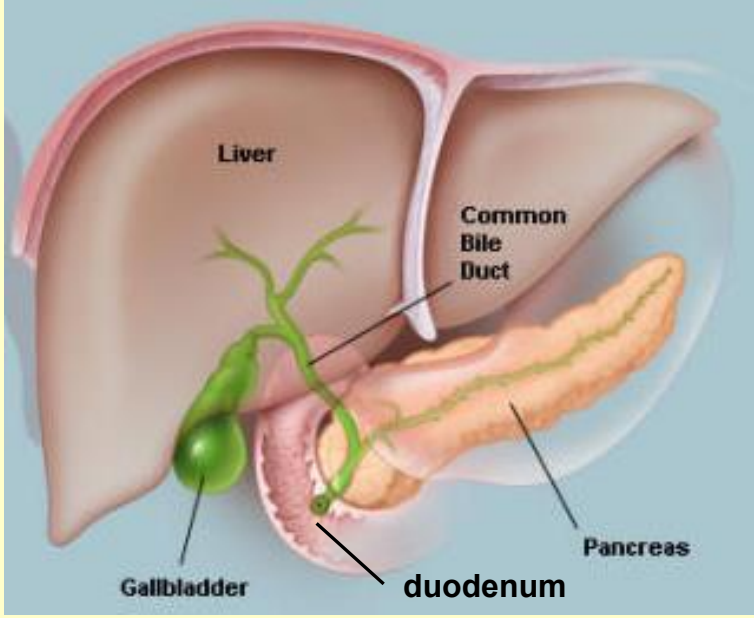


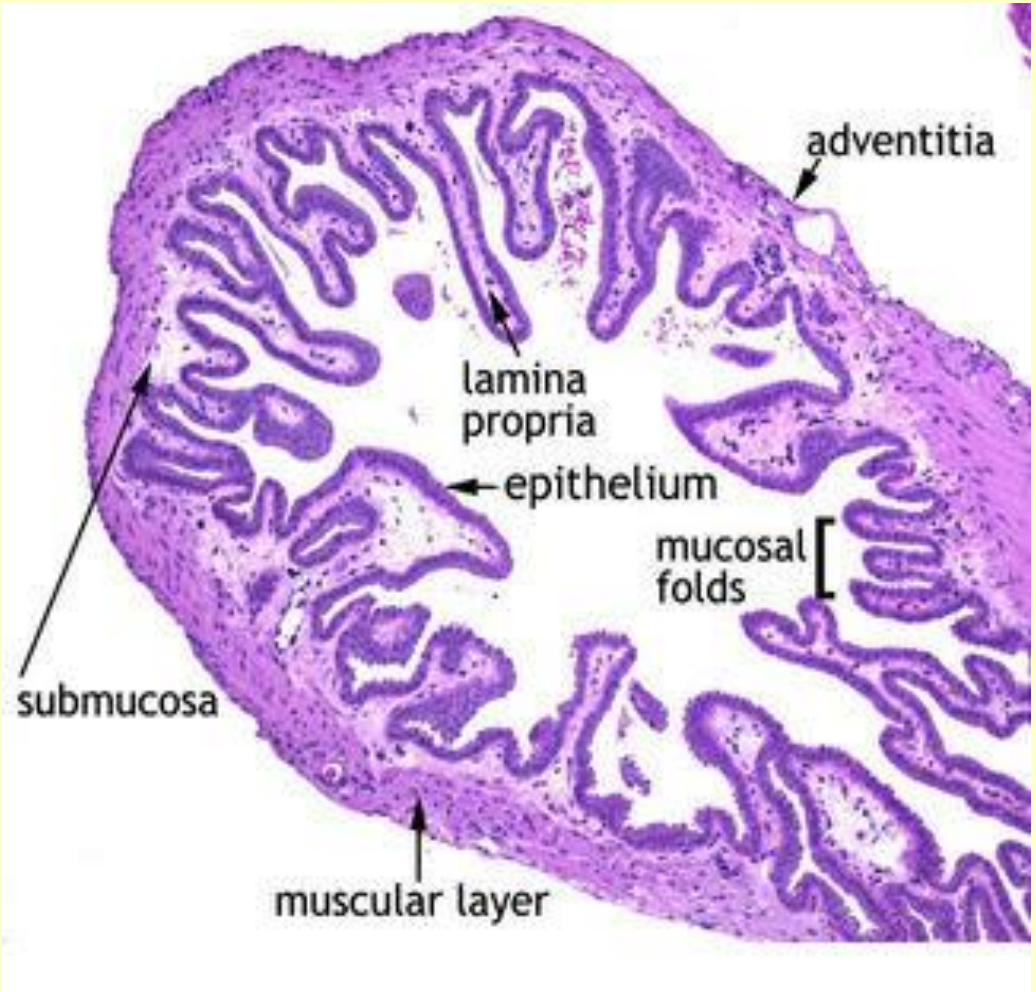
Thrombopoietin - production of megakaryocytes - production of blood thrombocytes (platelets)



Gallbladder

- stores and concentrates the bile
- releases the bile into the duodenum

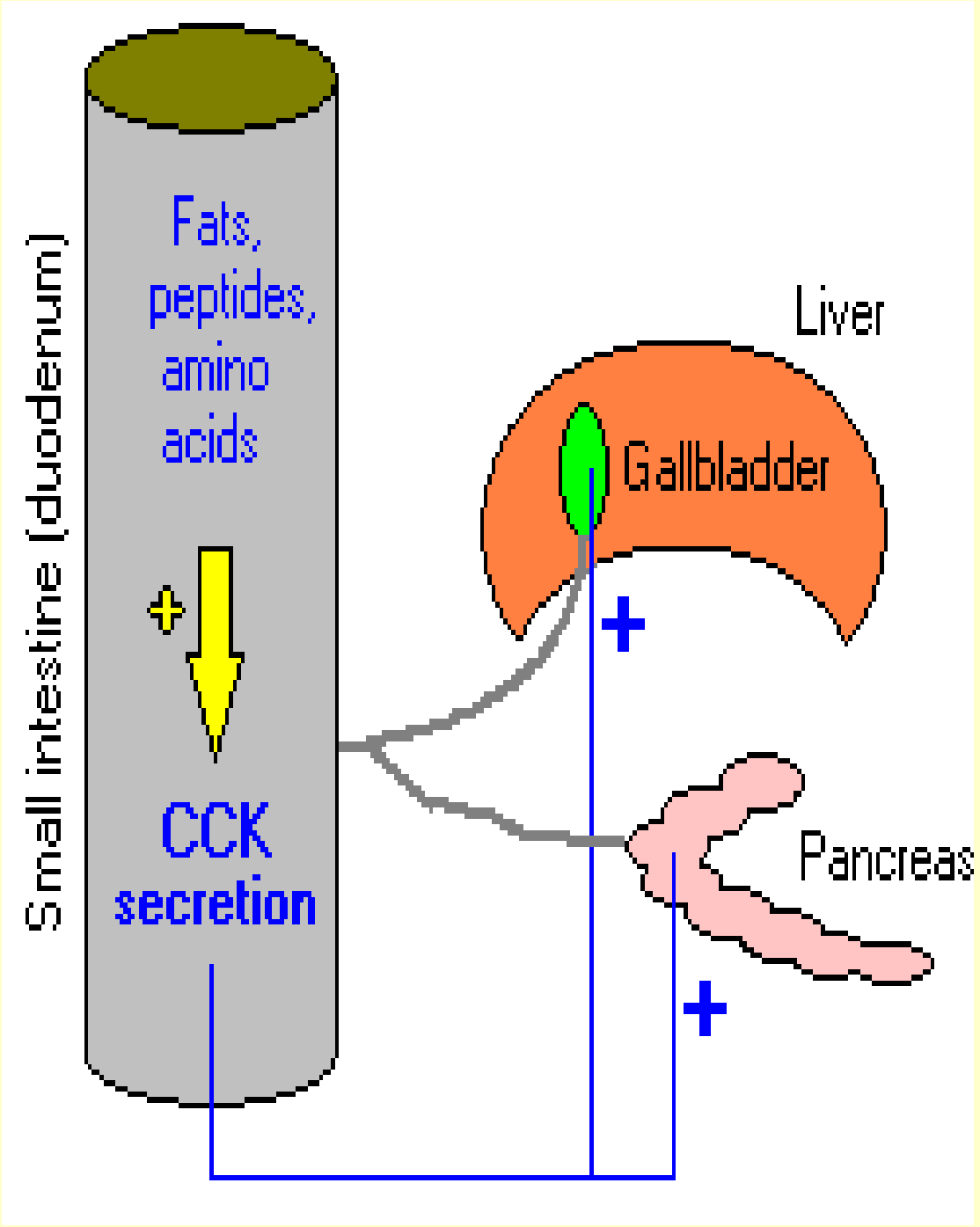




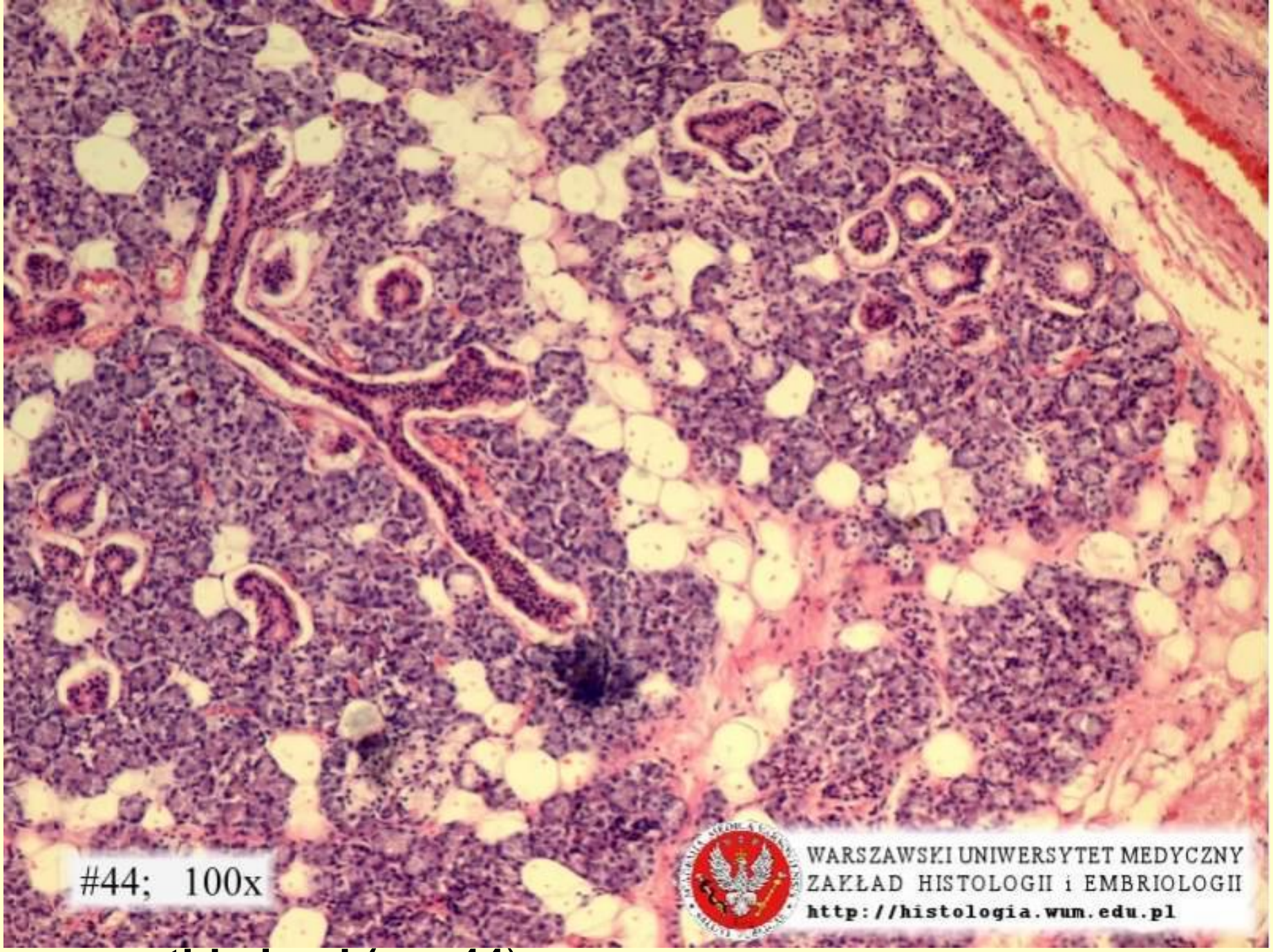
The wall of gallbladder

- mucosa (folded)
  - simple columnar epithelium
  - lamina propria
- submucosa
- muscularis
- adventitia

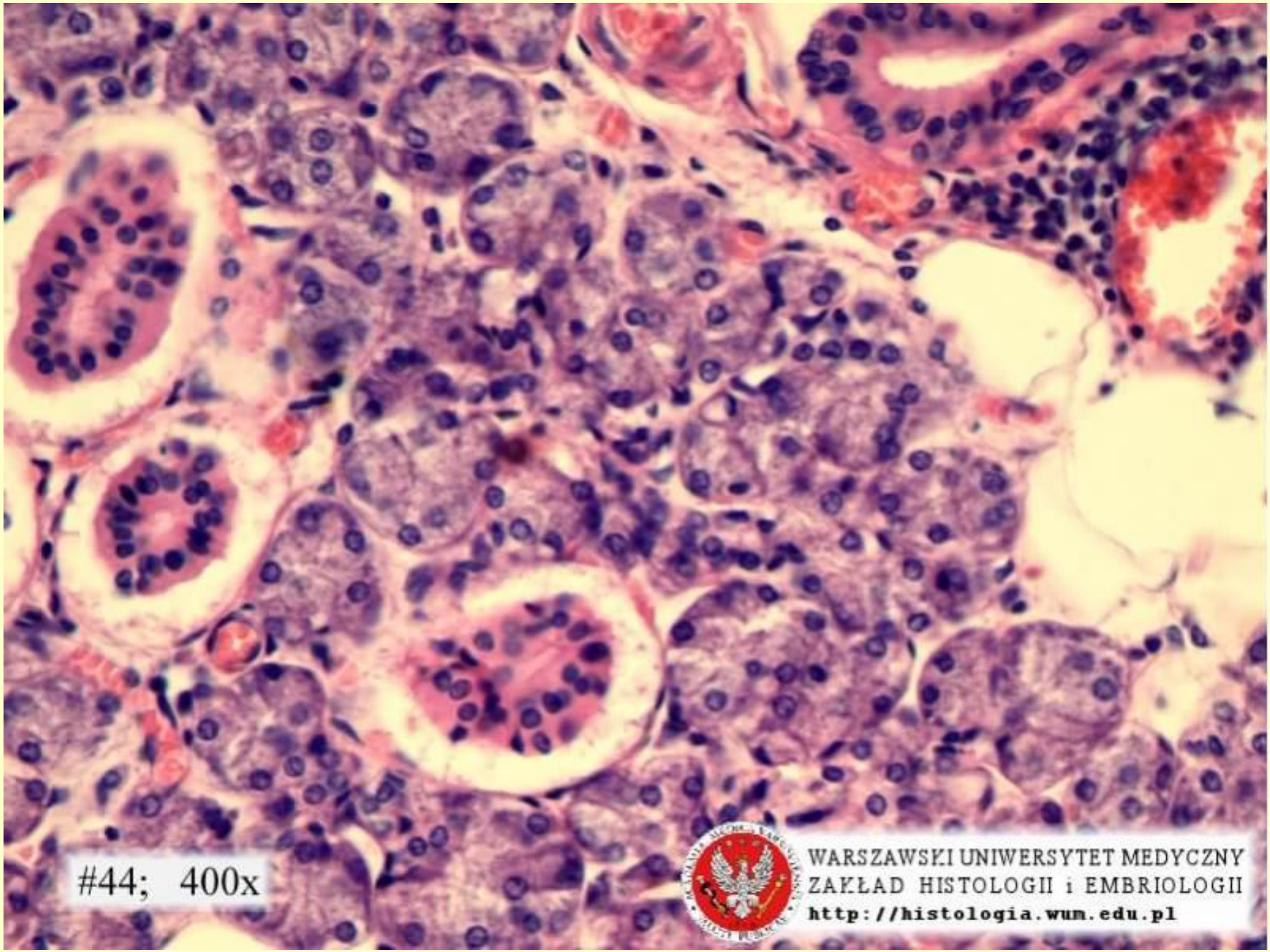
Fatty meal – DNES cells (I cells) of duodenum – **cholecystokinin (CCK)** – contraction of gallbladder – the bile is released into the duodenum



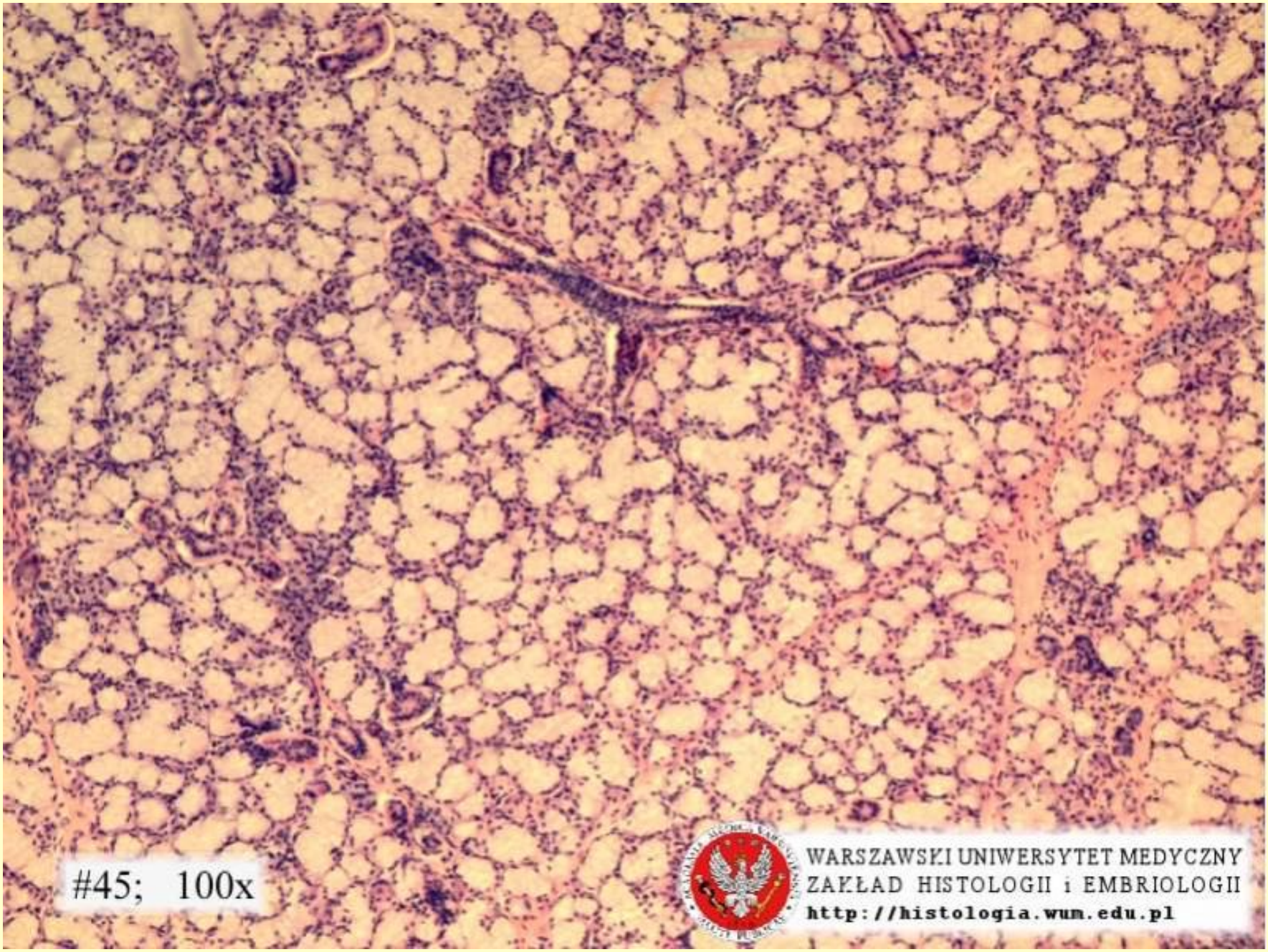
Slides for today



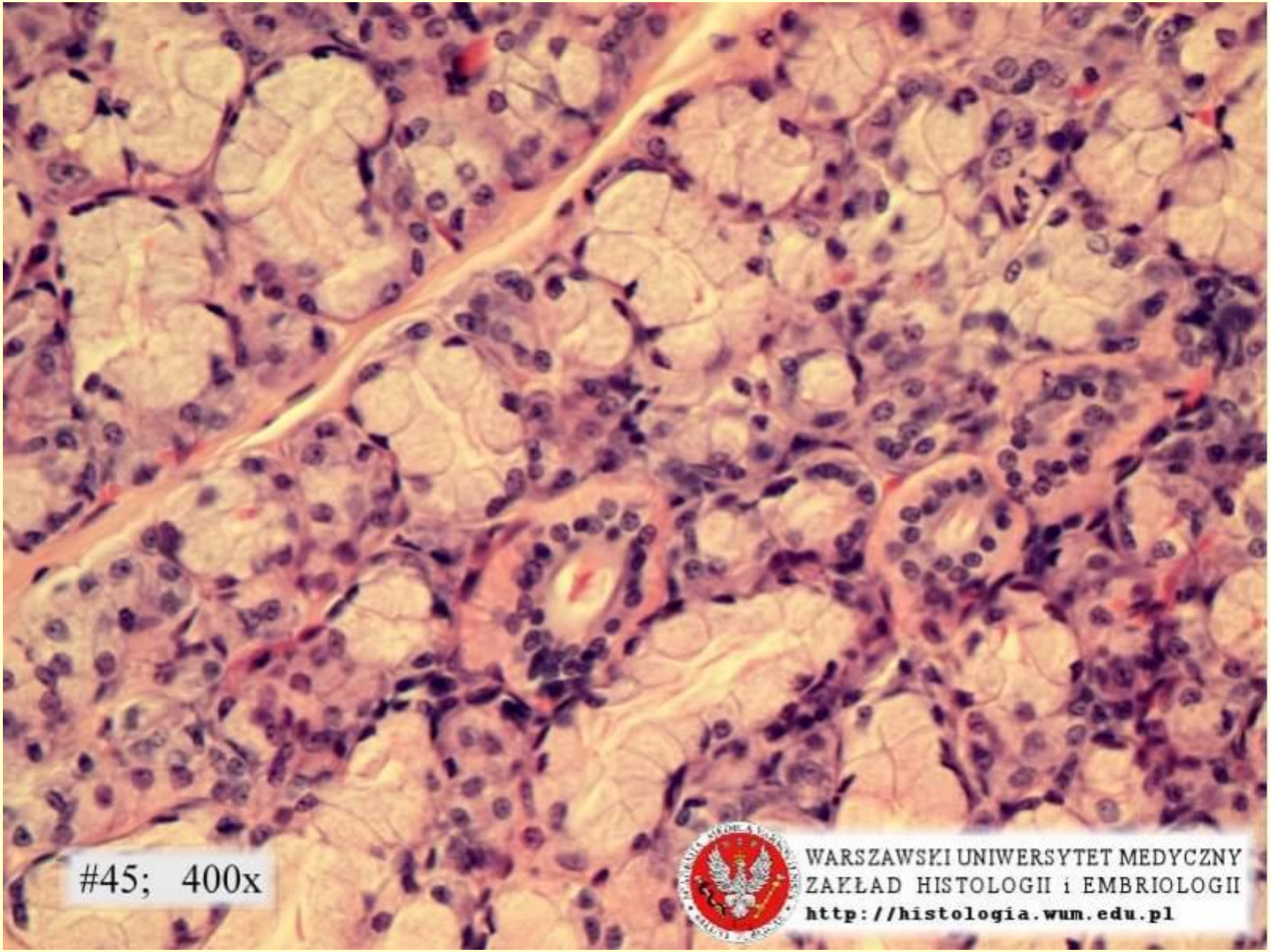
parotid gland (no. 44)



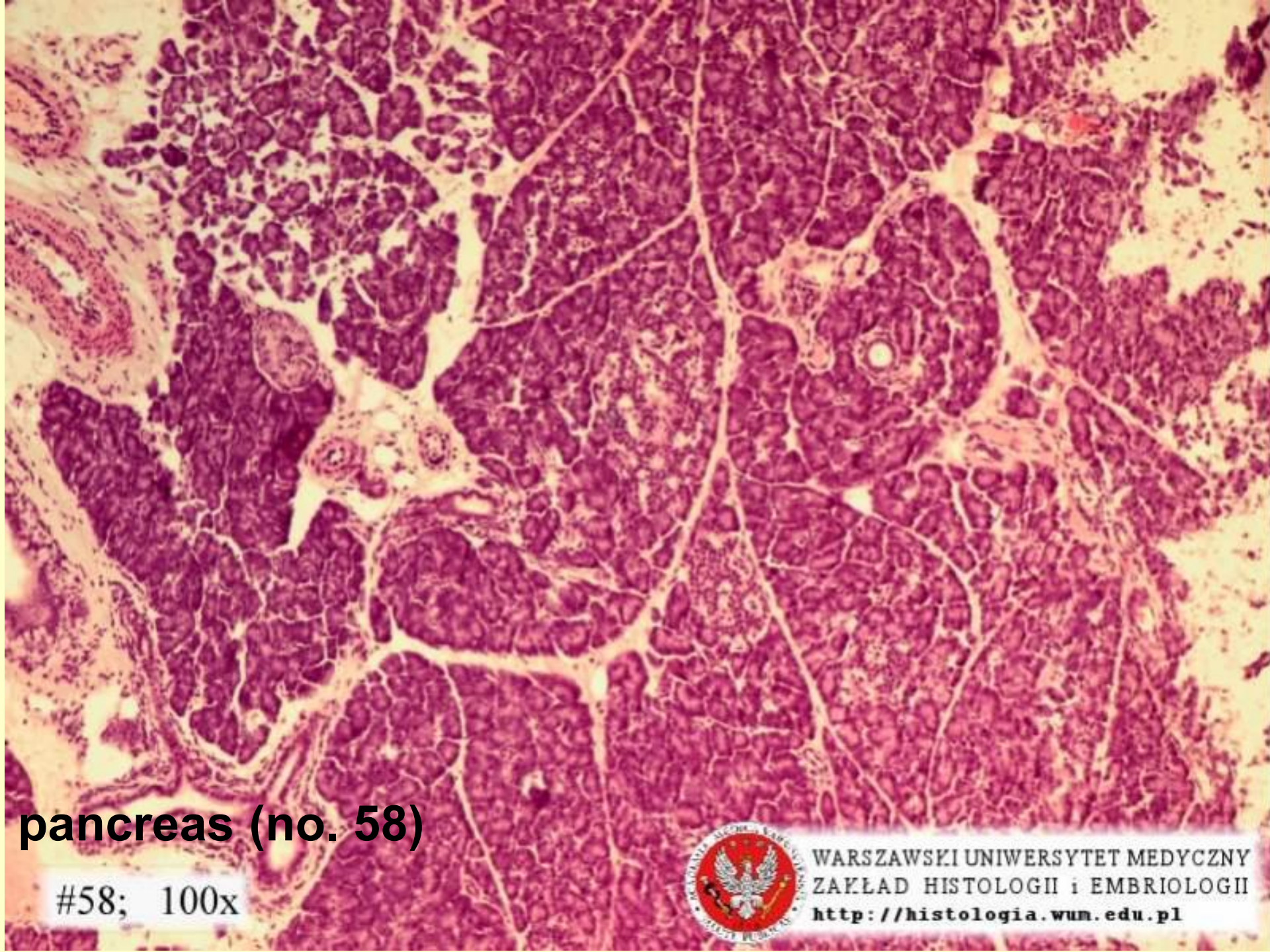
parotid gland (no. 44)

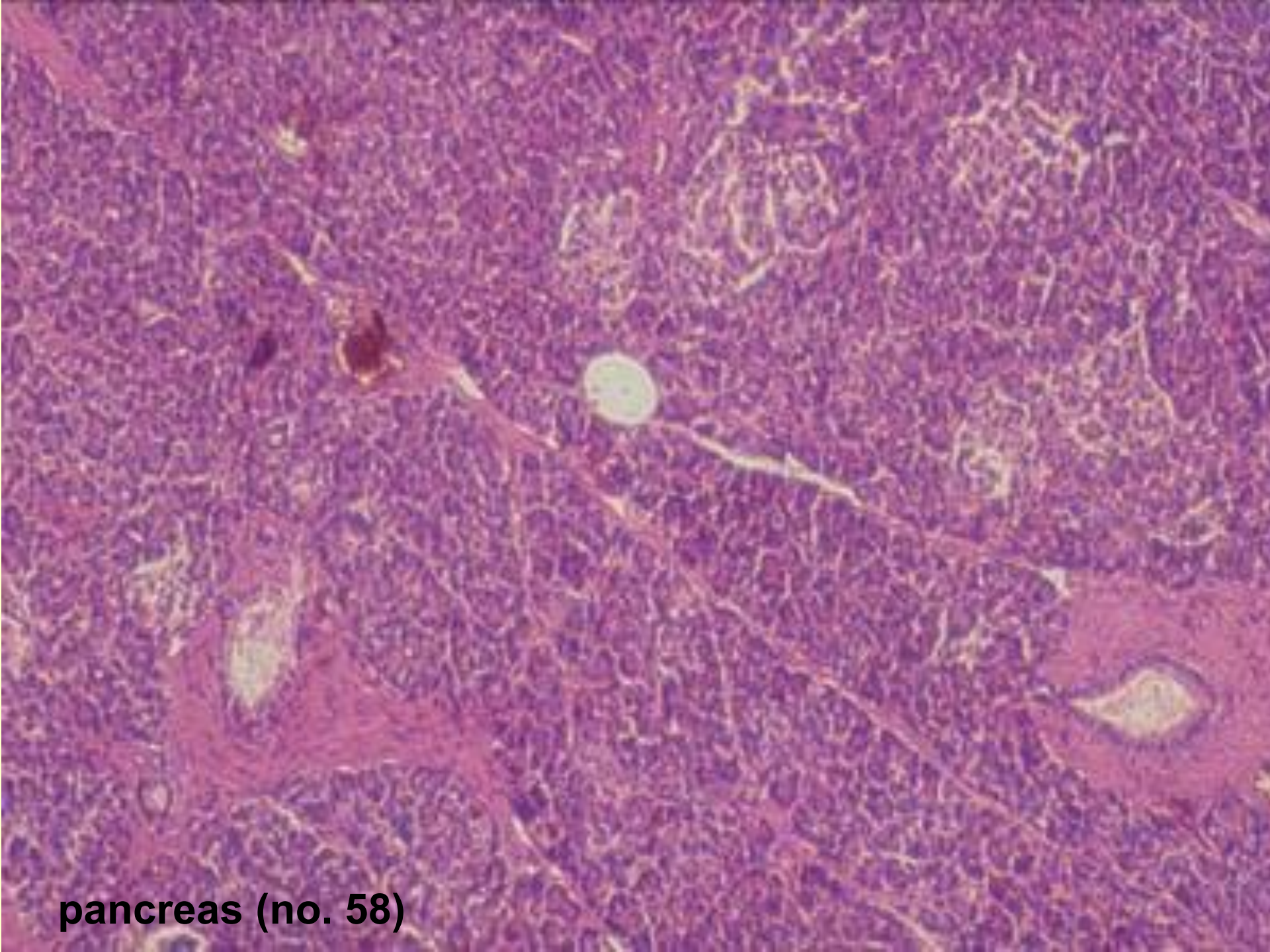


sublingual gland (no. 45)

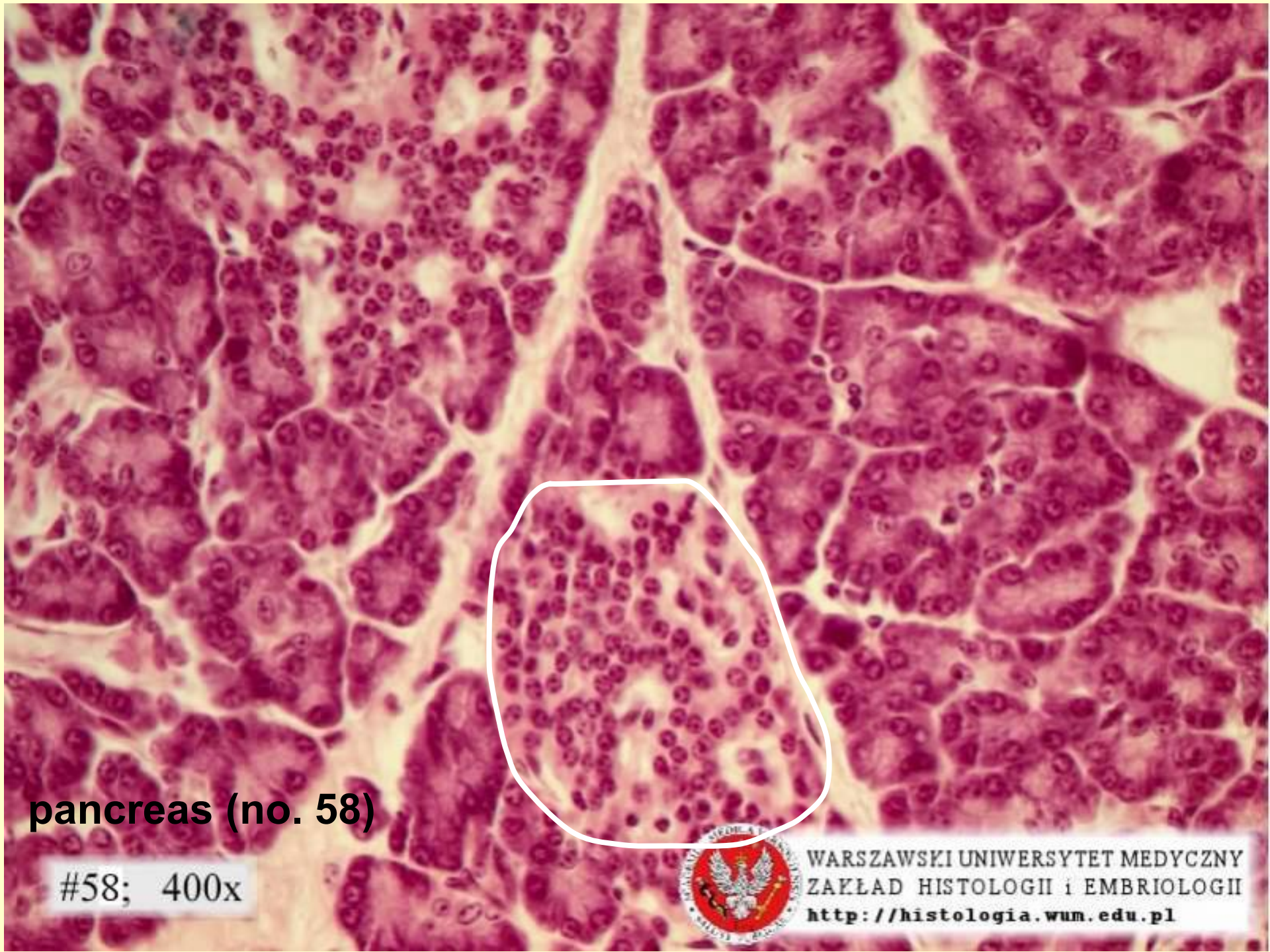


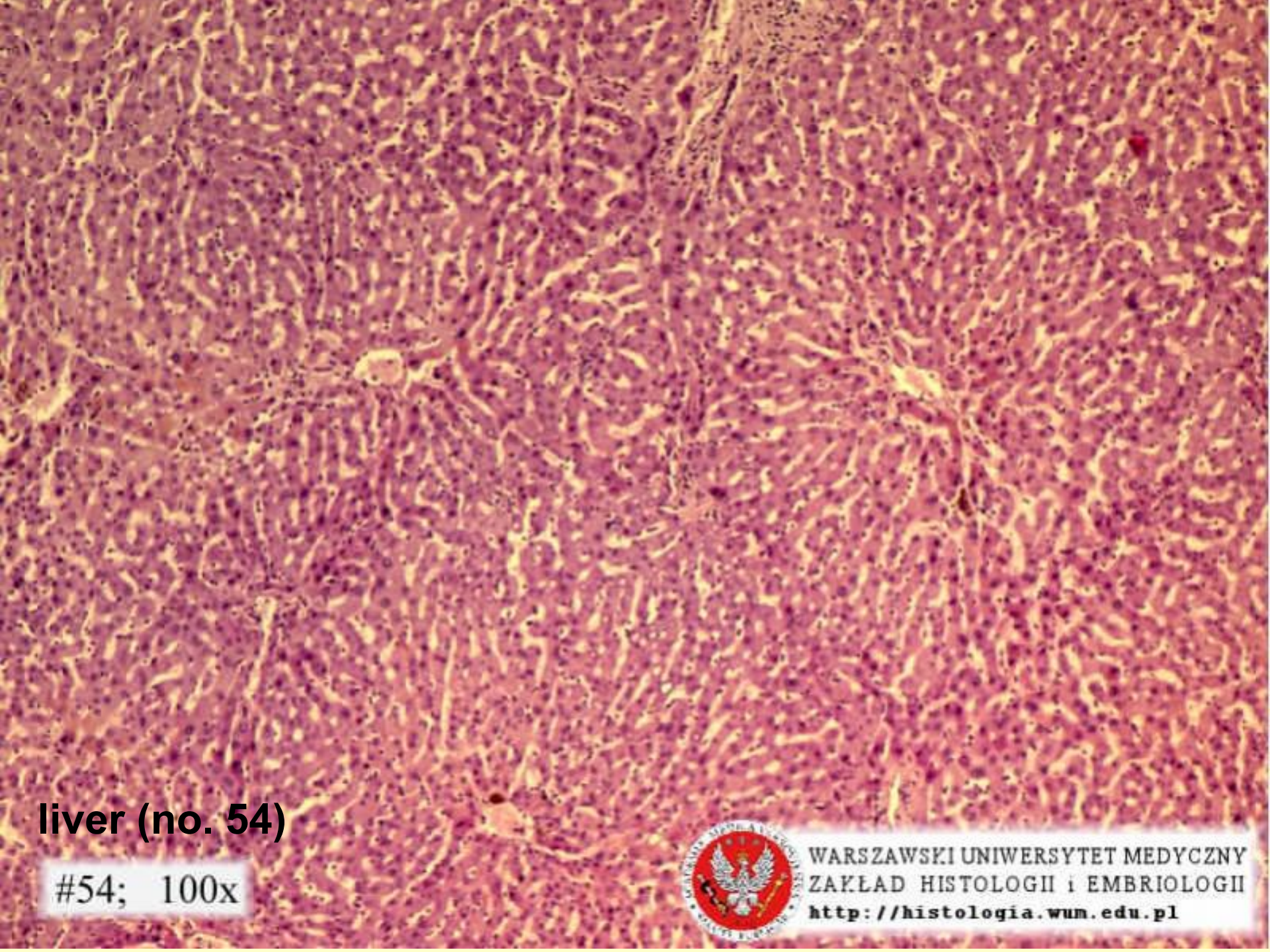
sublingual gland (no. 45)

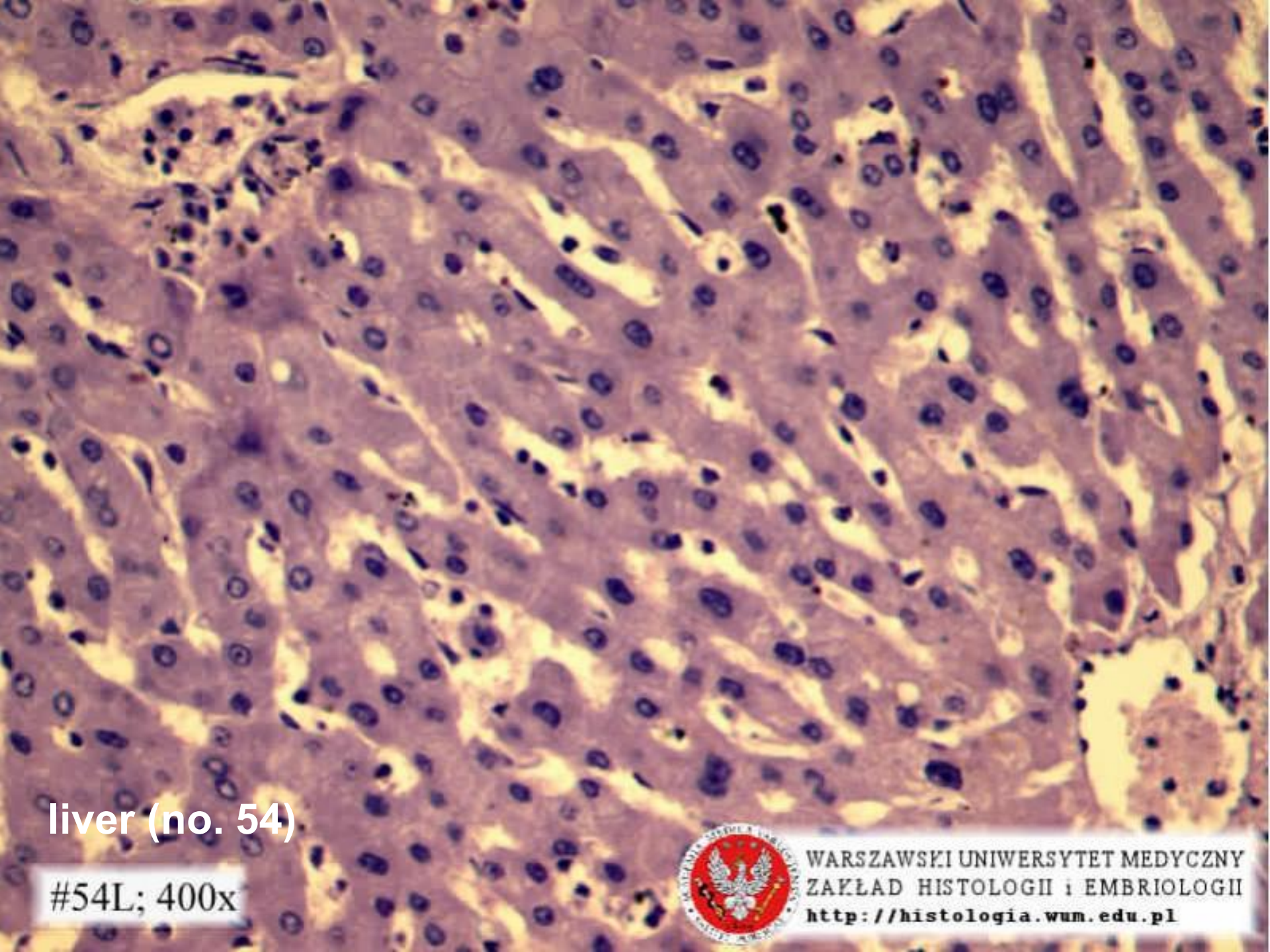

pancreas (no. 58)
#58; 100x
WARSZAWSKI UNIWERSYTET MEDYCZNY
ZAKŁAD HISTOLOGII i EMBRIOLOGII
http://histologia.wum.edu.pl

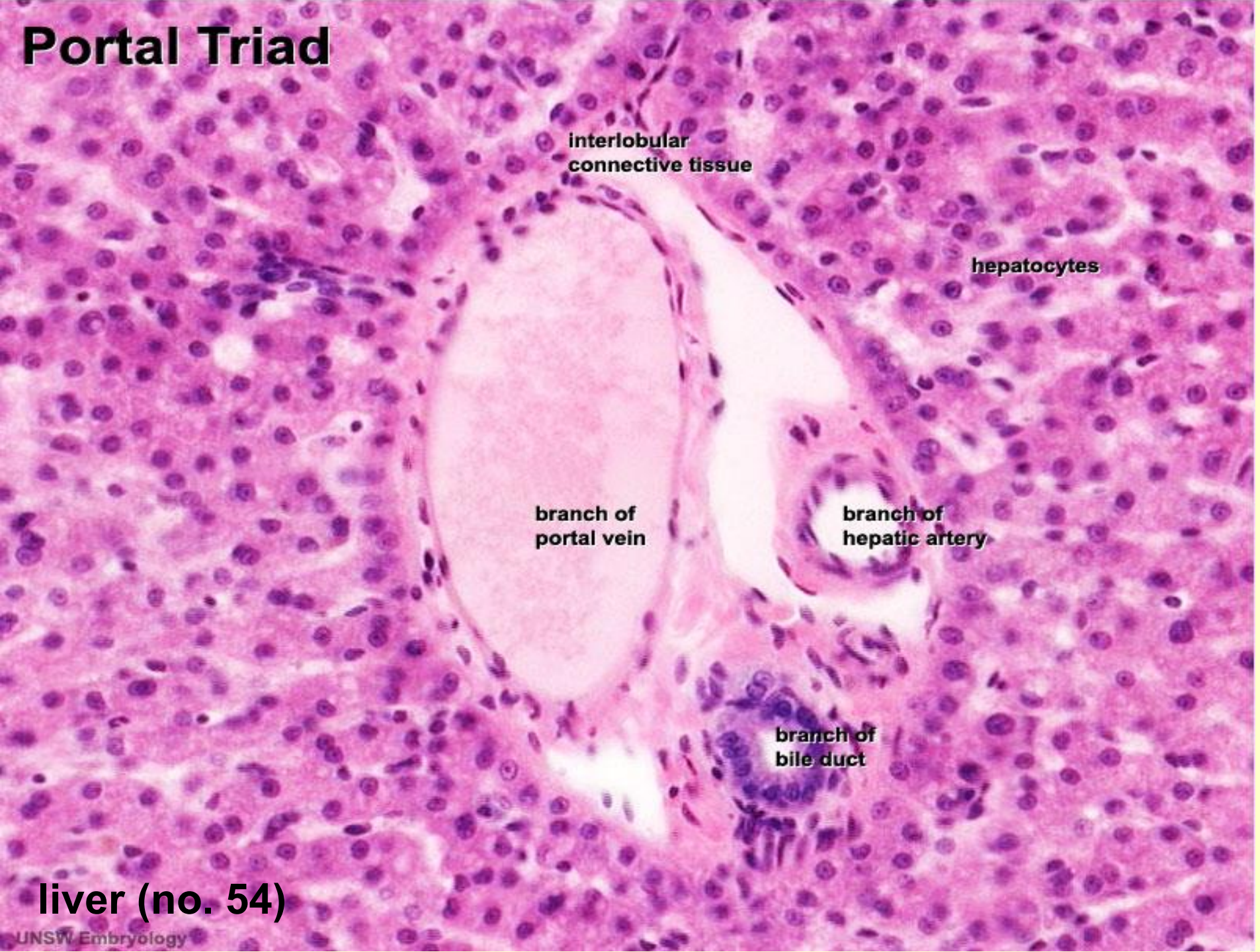


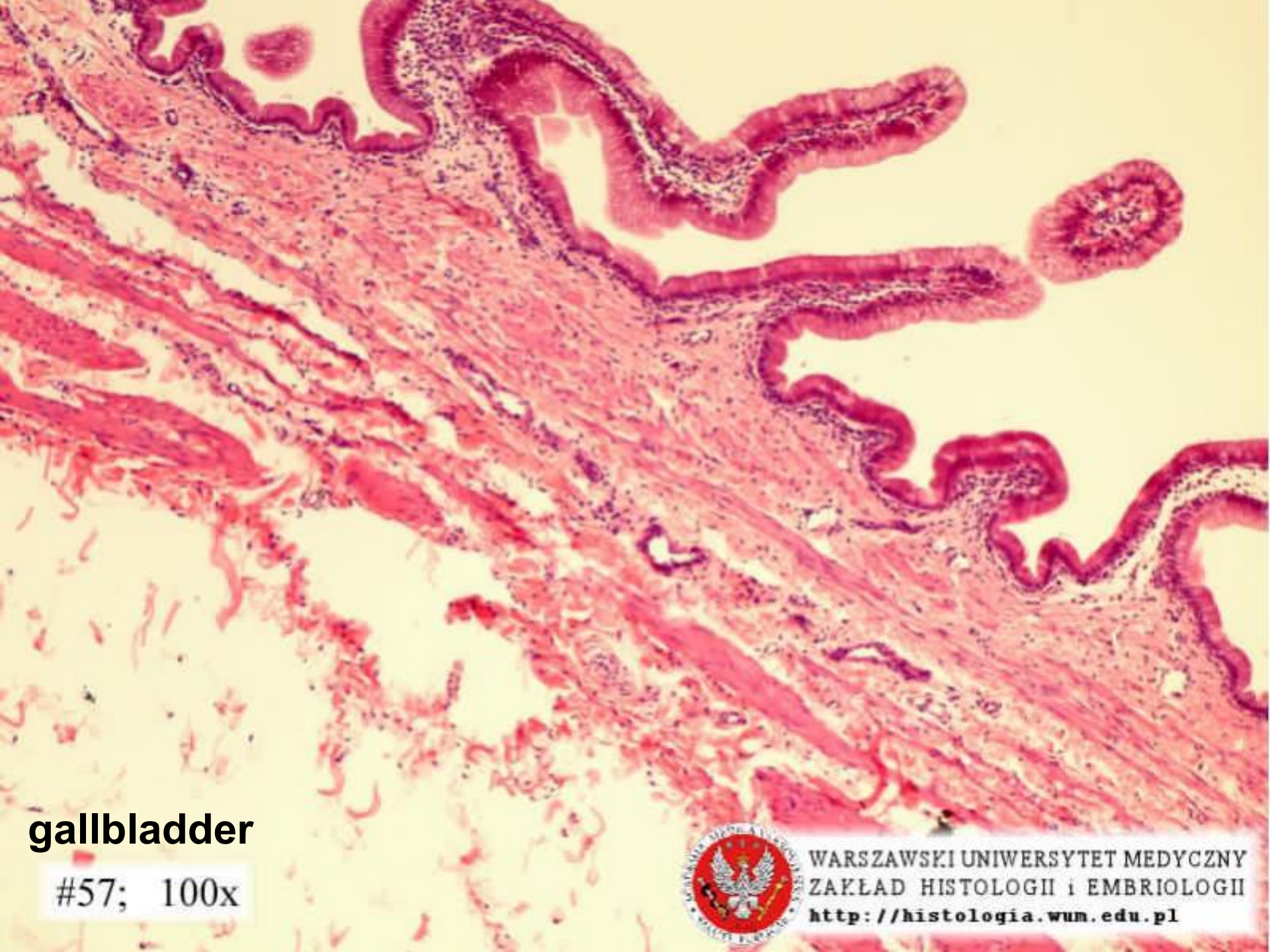
pancreas (no. 58)


pancreas (no. 58)
#58; 400x
WARSZAWSKI UNIWERSYTET MEDYCZNY
ZAKŁAD HISTOLOGII i EMBRIOLOGII
http://histologia.wum.edu.pl


liver (no. 54)
#54; 100x
WARSZAWSKI UNIWERSYTET MEDYCZNY
ZAKŁAD HISTOLOGII i EMBRIOLOGII
http://histologia.wum.edu.pl

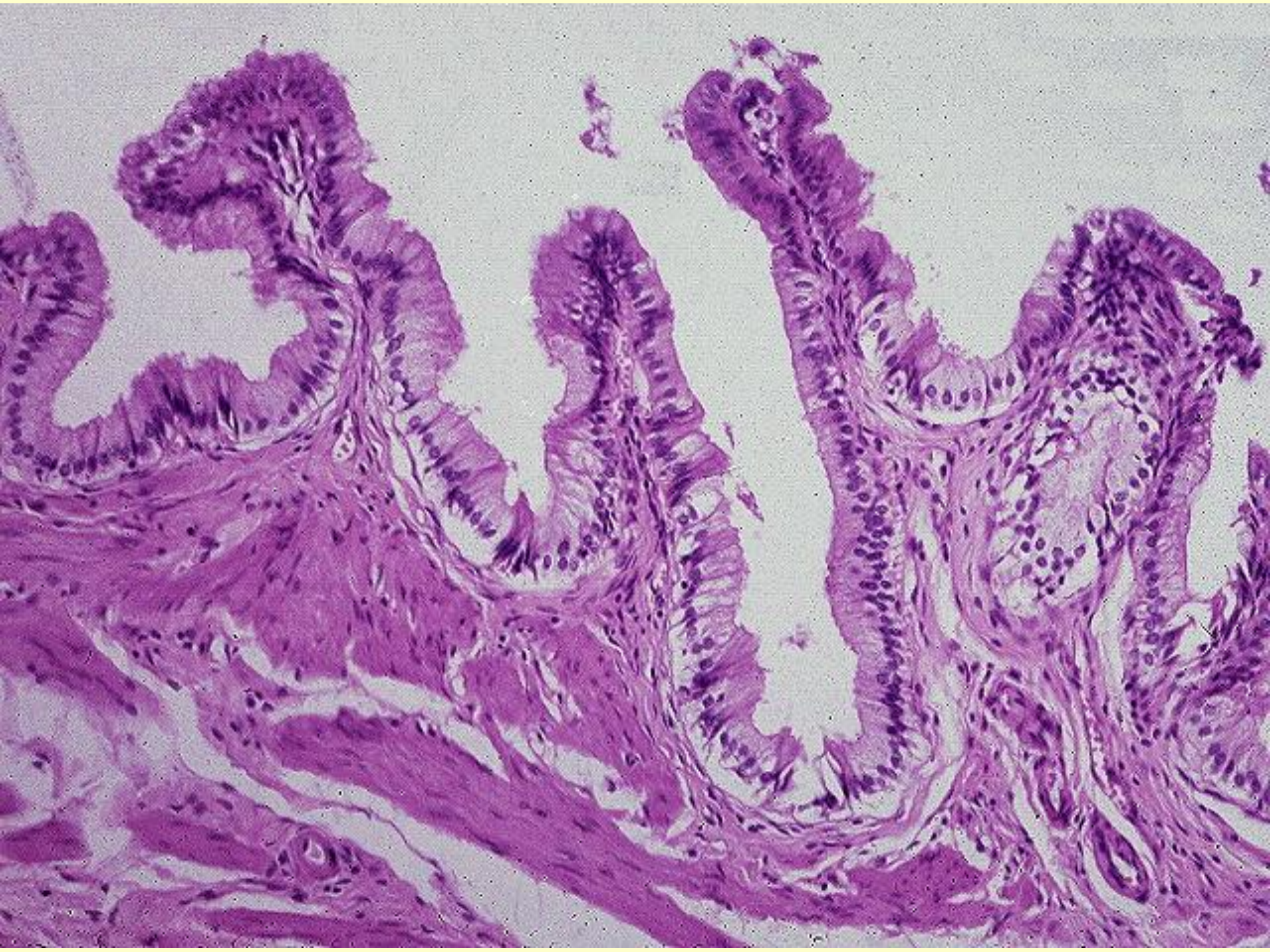

liver (no. 54)
#54L; 400x
WARSZAWSKI UNIWERSYTET MEDYCZNY
ZAKŁAD HISTOLOGII i EMBRIOLOGII
http://histologia.wum.edu.pl


Portal Triad
interlobular
connective tissue
hepatocytes
branch of
portal vein
branch of
hepatic artery
branch of
bile duct
liver (no. 54)
UNSW Embryology

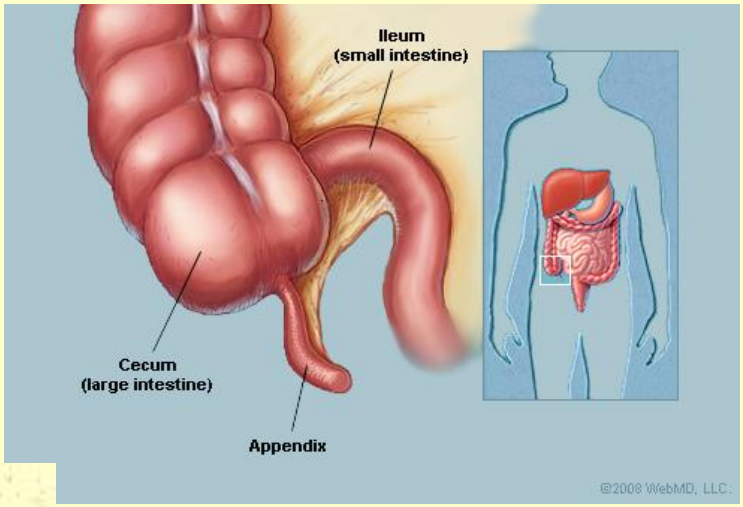


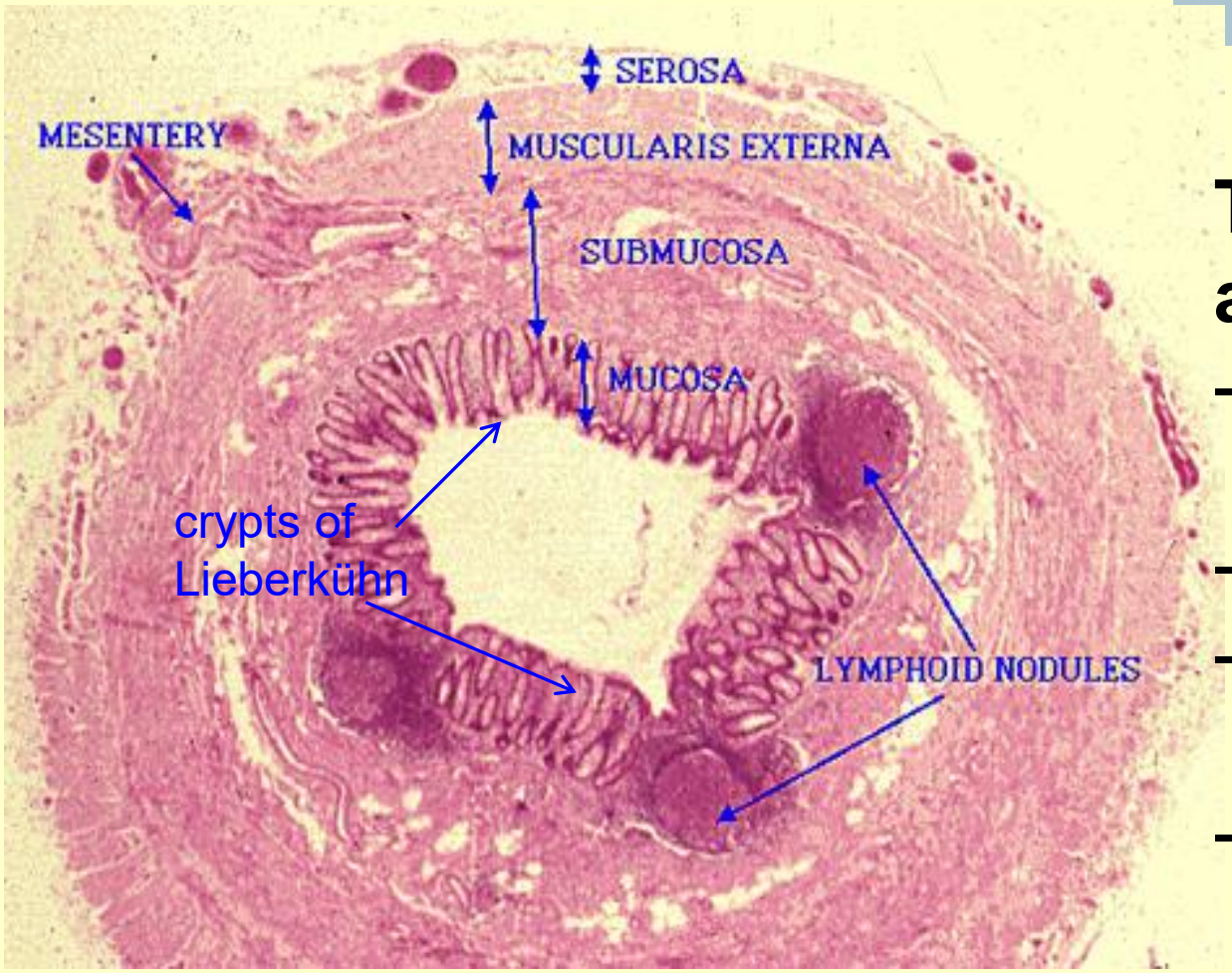
gallbladder

#57; 100x



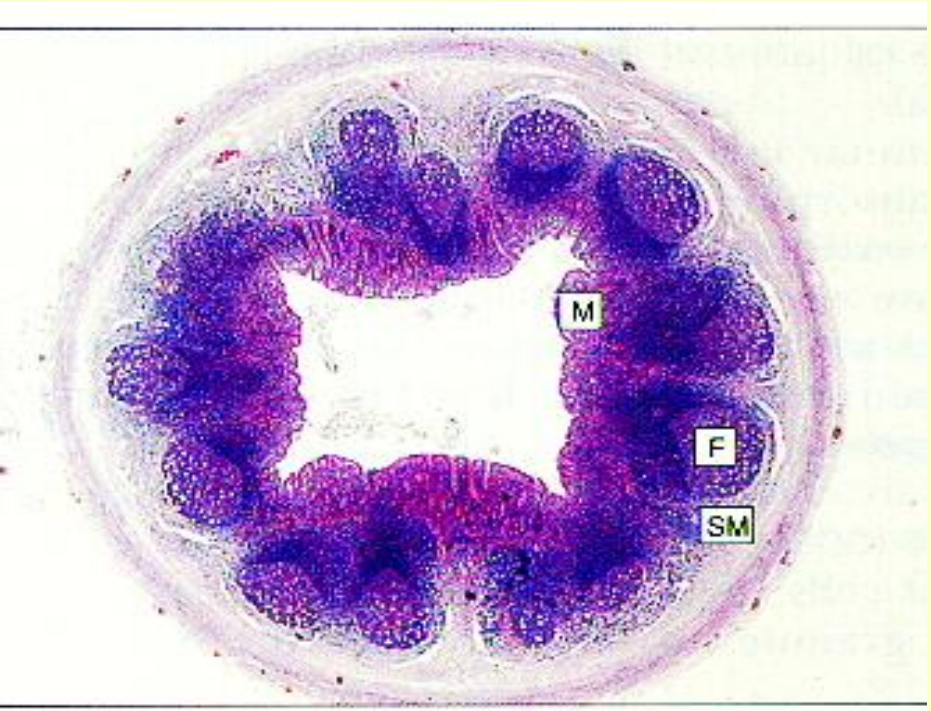
The **appendix** (or **vermiform appendix**) - connected to the cecum

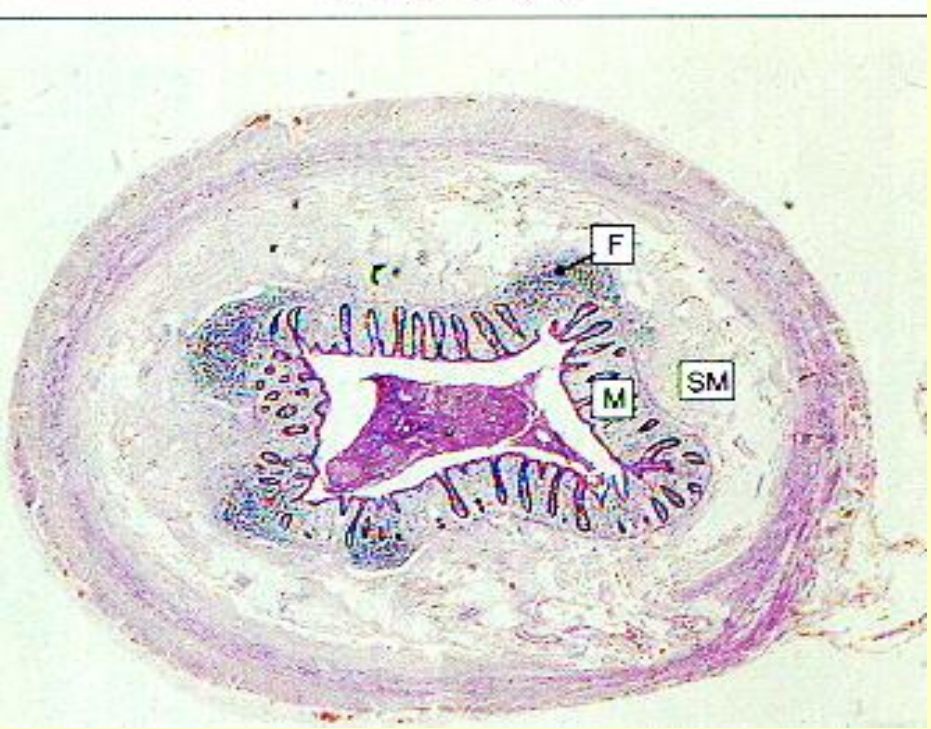




The wall of appendix

- **Mucosa (**lymphoid nodules)
- **Submucosa**
- **Mascularis externa**
- **Serosa**





Appendix - a role in the immune response in children

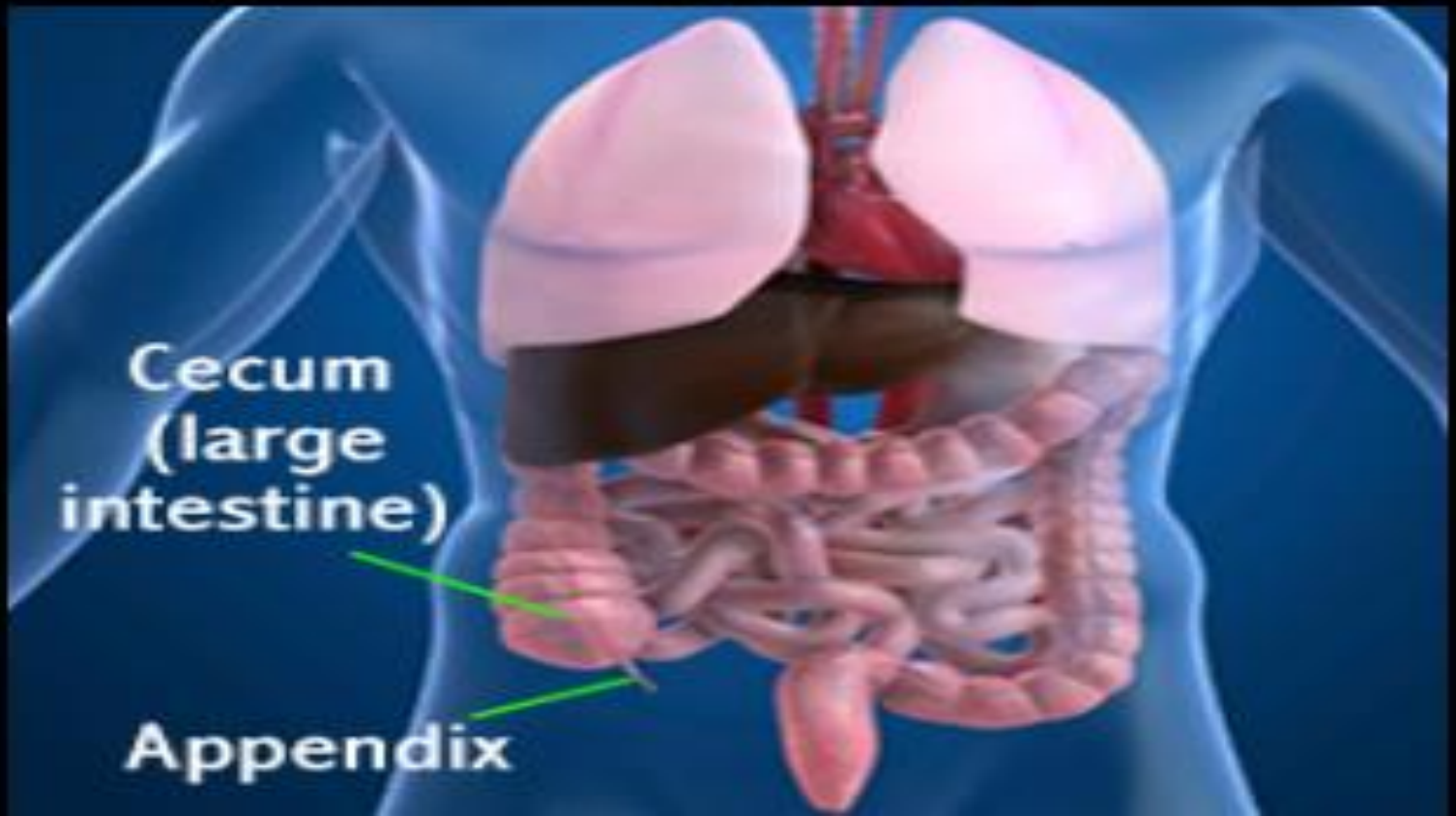
10 - year-old child

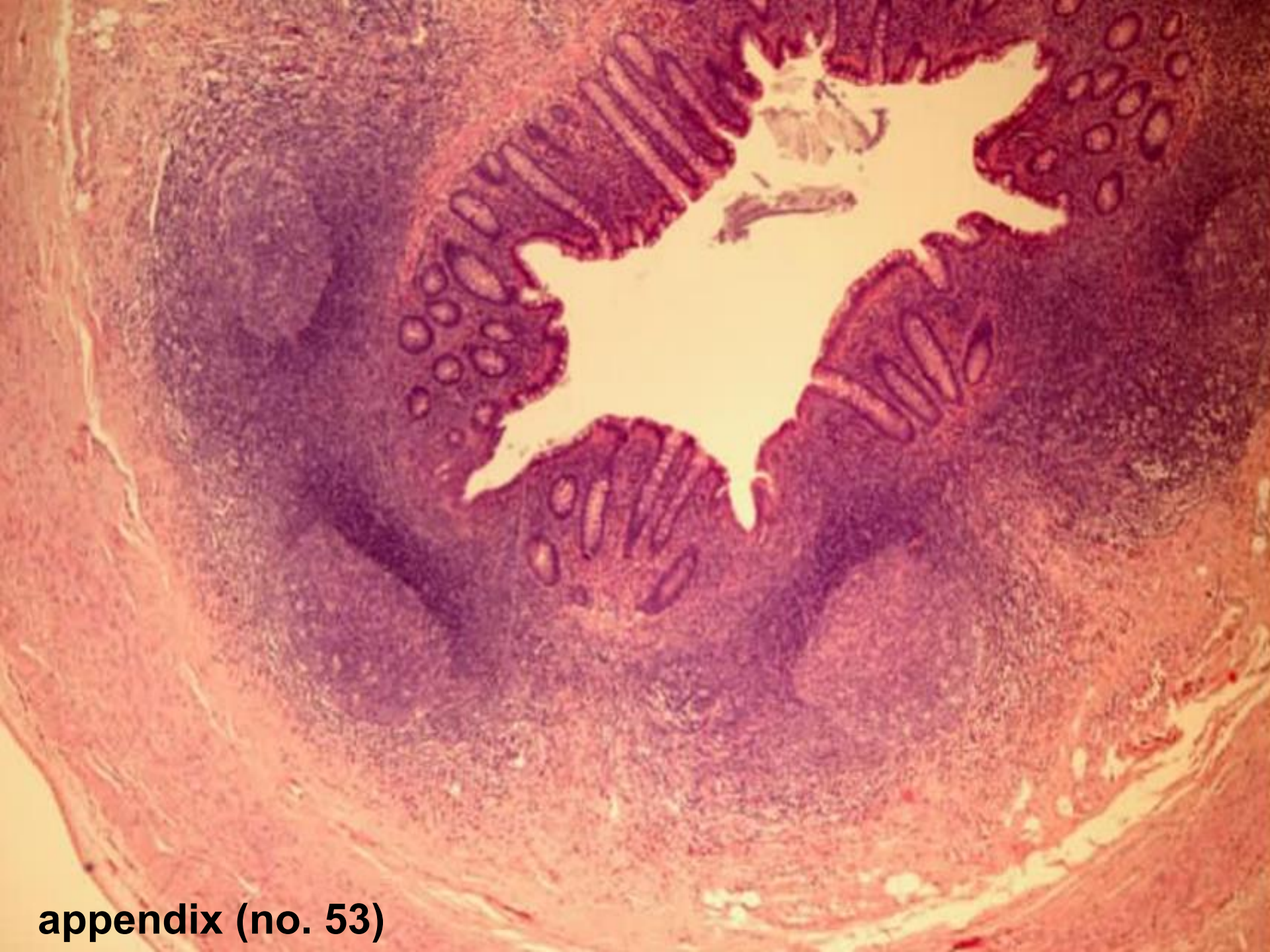
M – mucosa
SM – submucosa
F – lymphoid follicles

36-year-old men

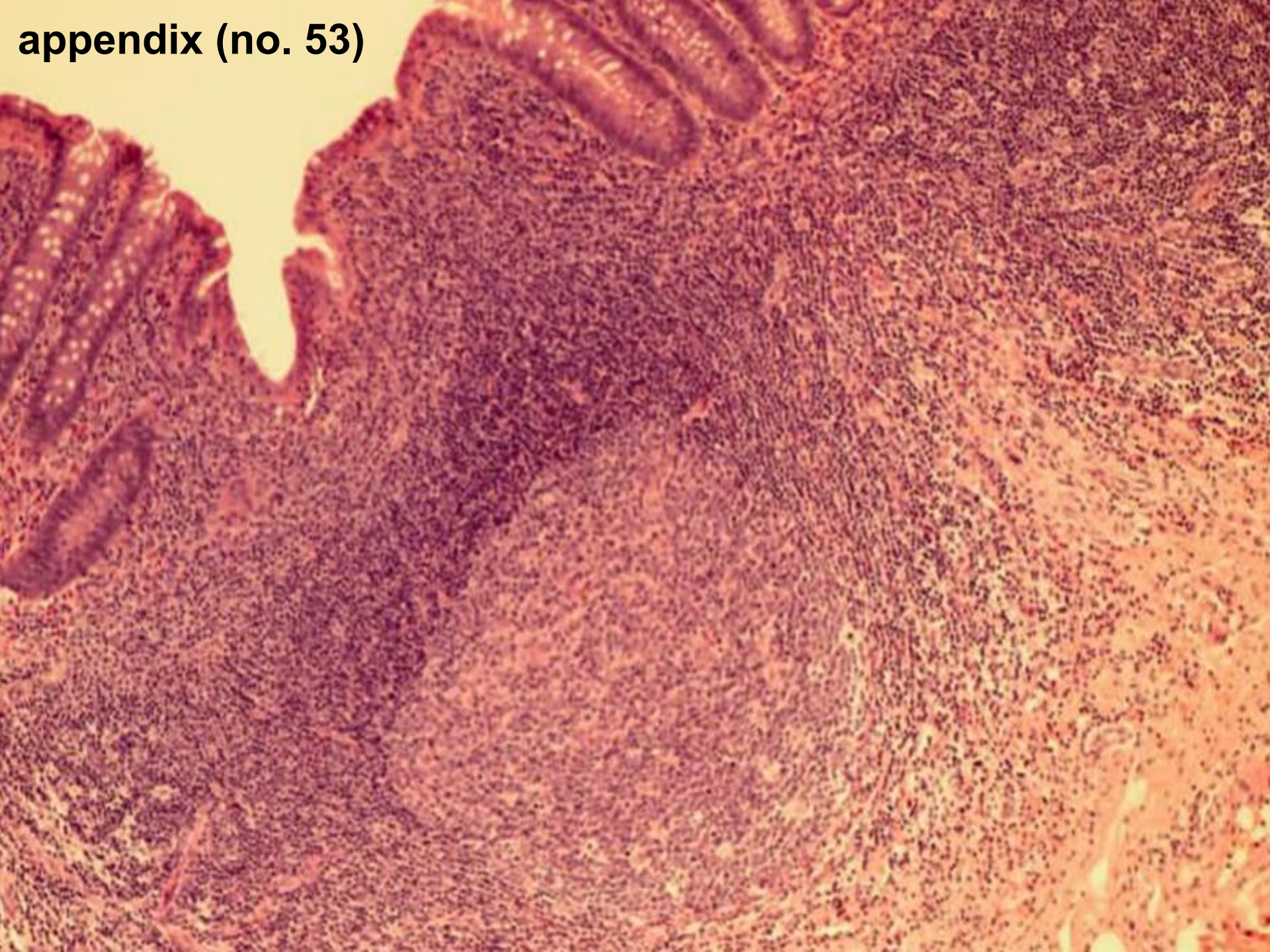
Disappearance of follicles

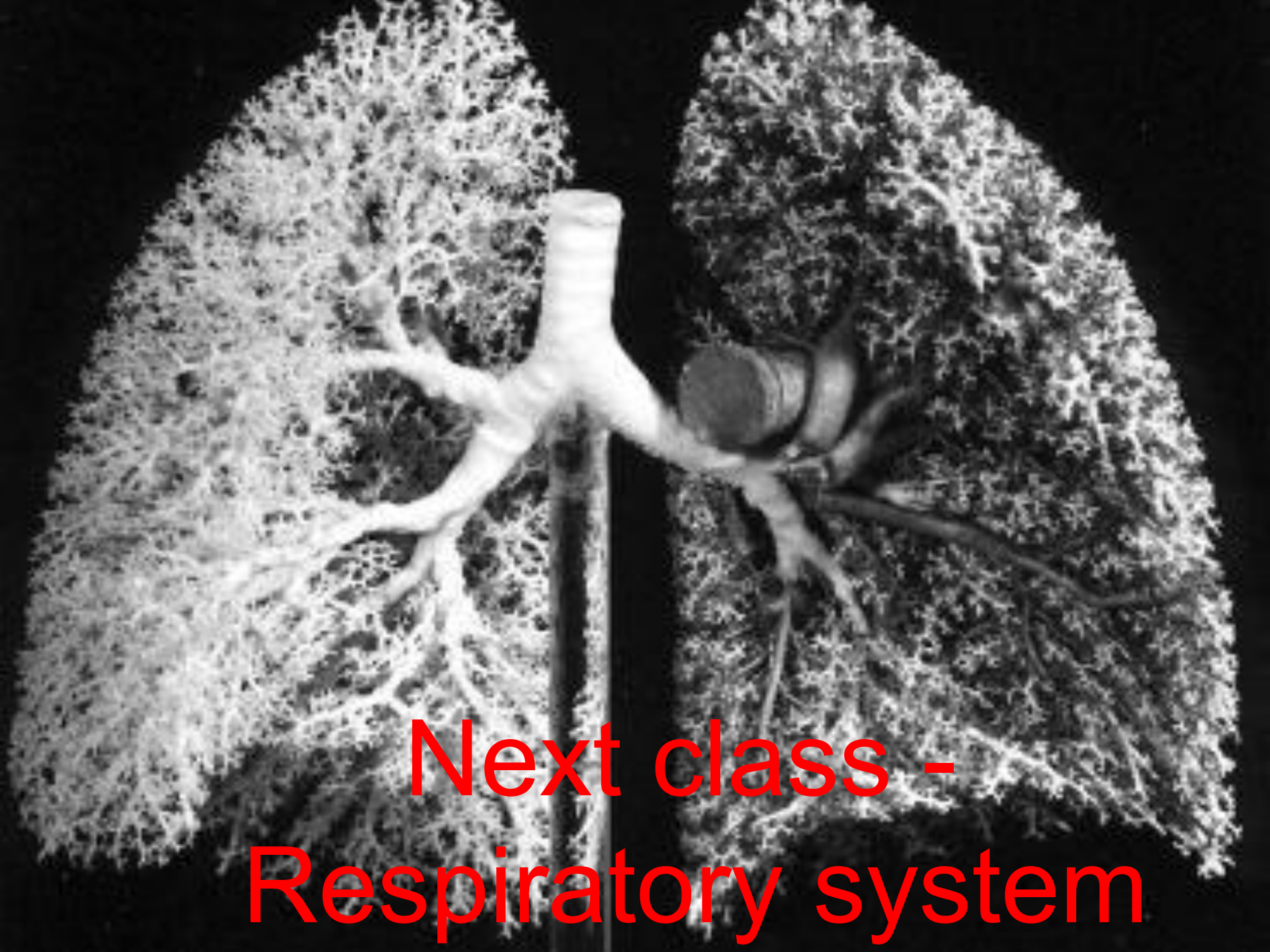
Your appendix could actually be useful. There's evidence that it functions as a 'safe house' for good bacteria, which can flush out infection in your large intestine.



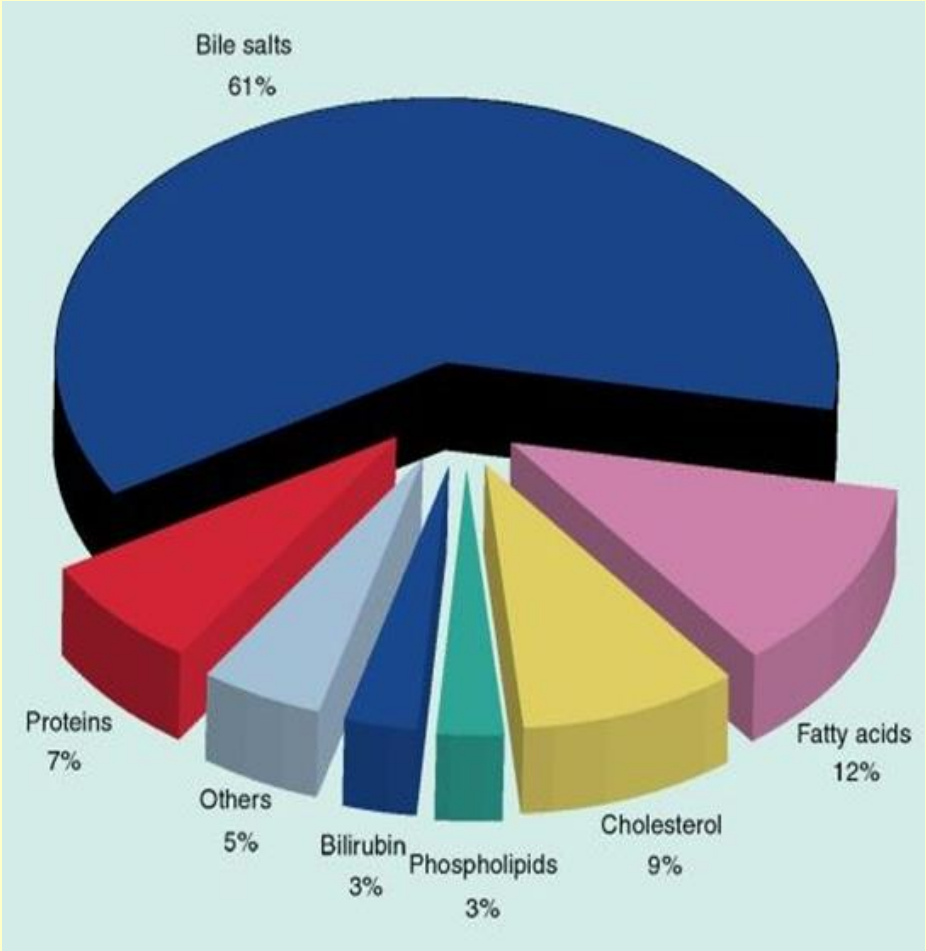


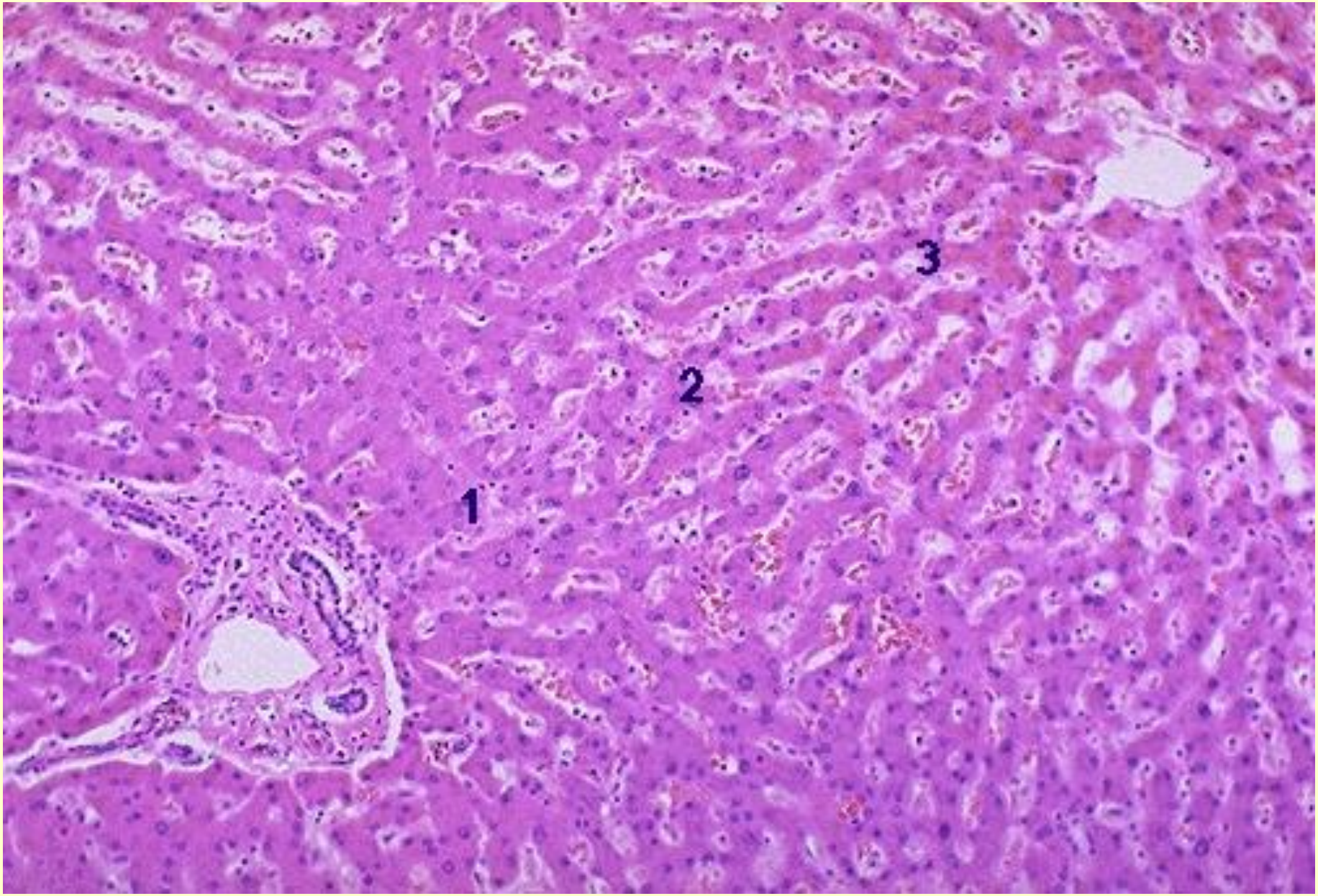
appendix (no. 53)


appendix (no. 53)

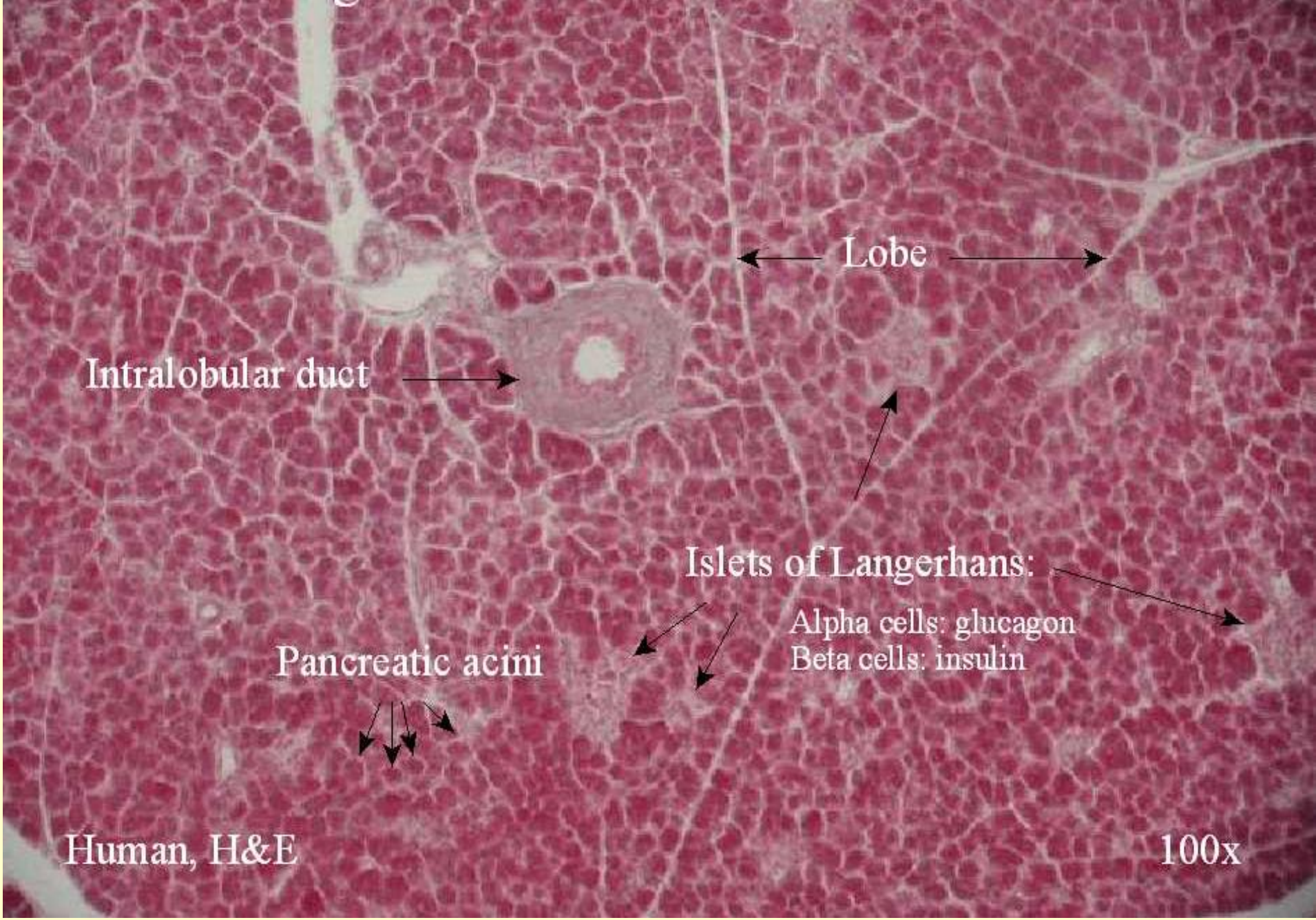

Next class -
Respiratory system

- bile salts
- cholesterol, fatty acids, bilirubin (toxic product of degradation of hemoglobin)
- electrolytes (sodium and bicarbonate ions)
- IgA





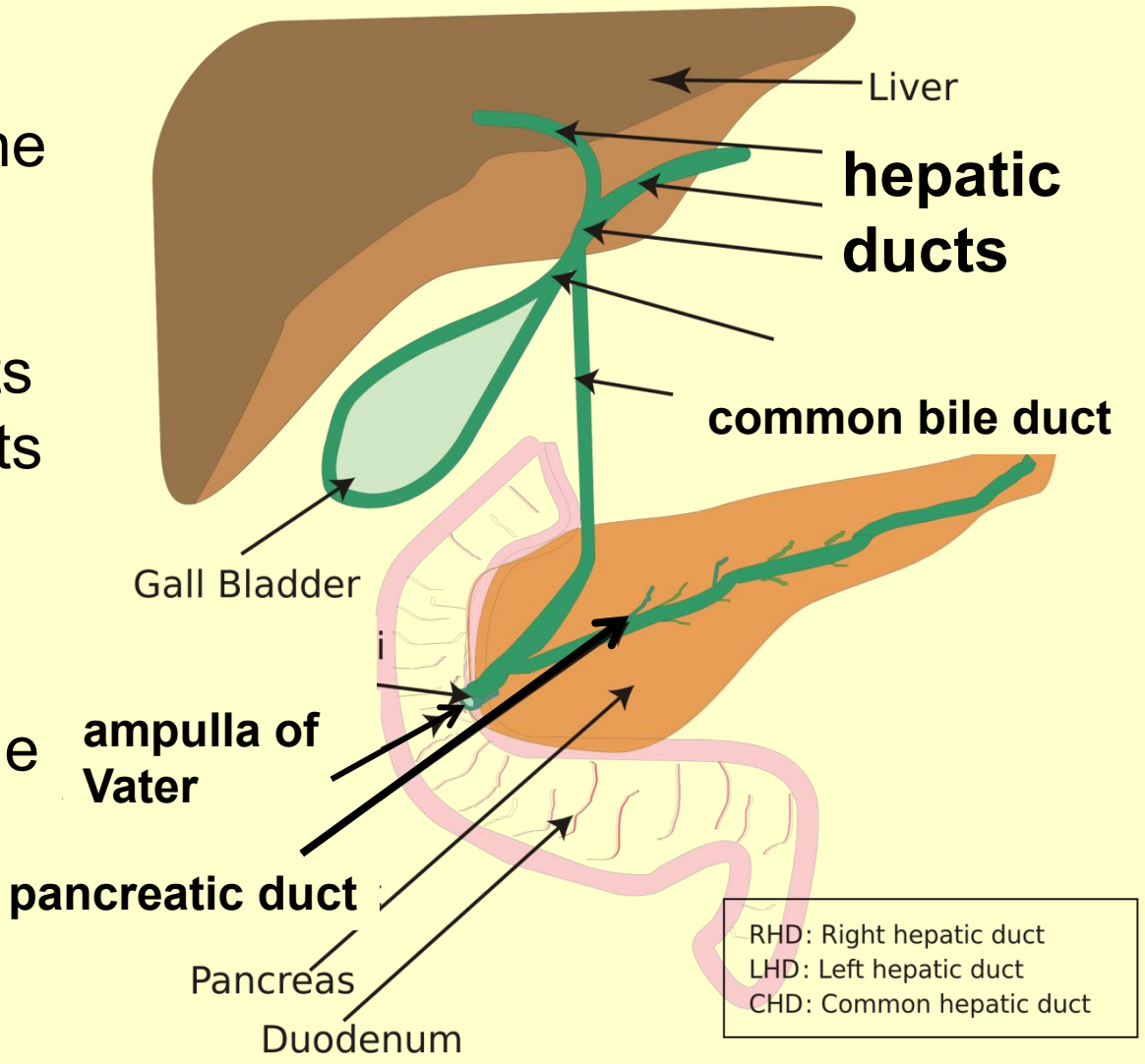
liver (no. 54)



pancreas (no. 58)

Gallbladder

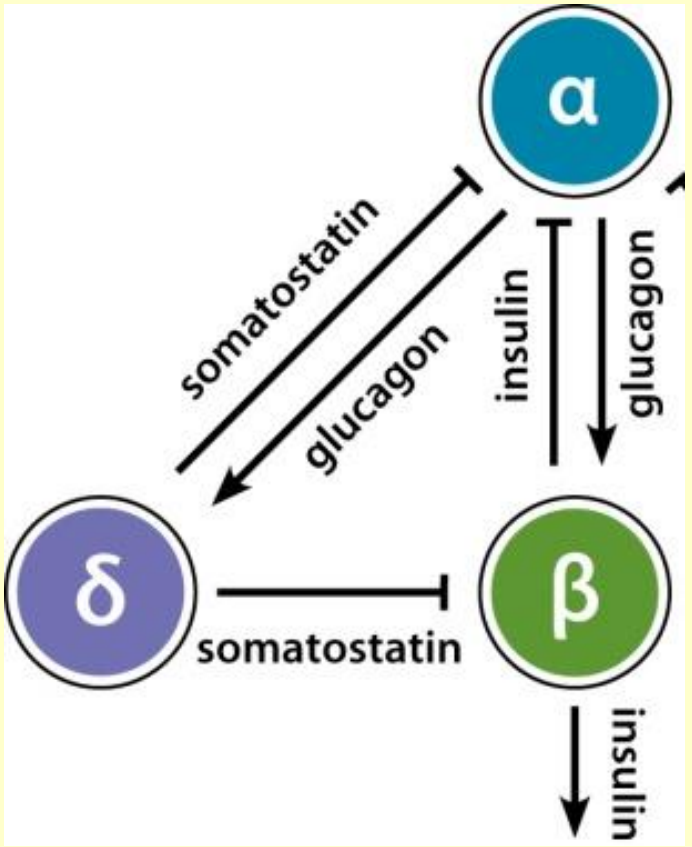
- the bile flows through the **hepatic ducts** into the gallbladder
- the gallbladder contracts and releases its contents into the **common bile duct**
- the union of the **pancreatic duct** and the **common bile duct – ampulla of Vater**

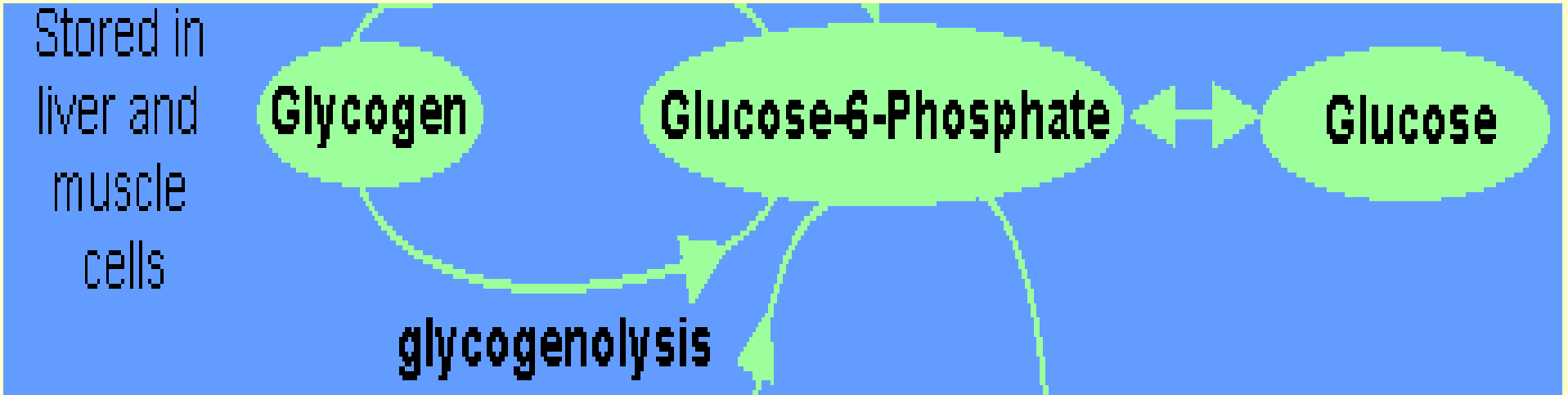


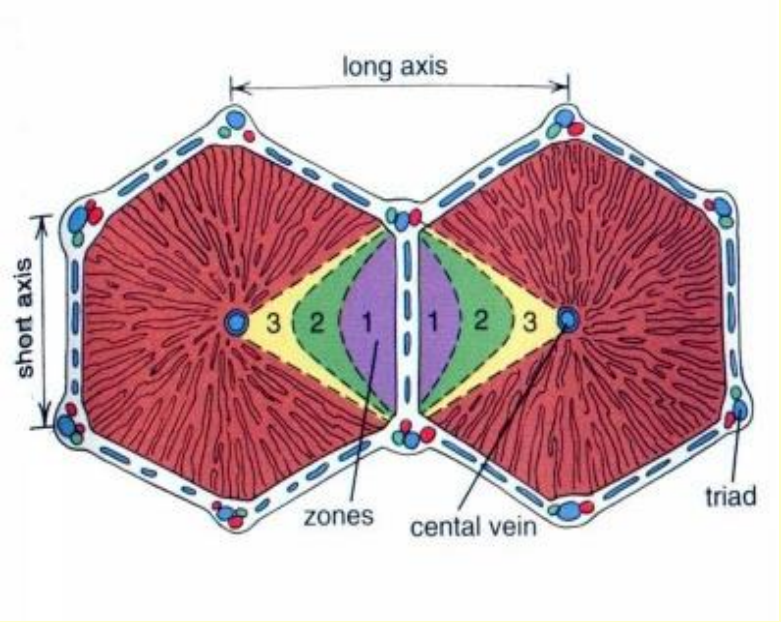
δ (D, D_1) cells

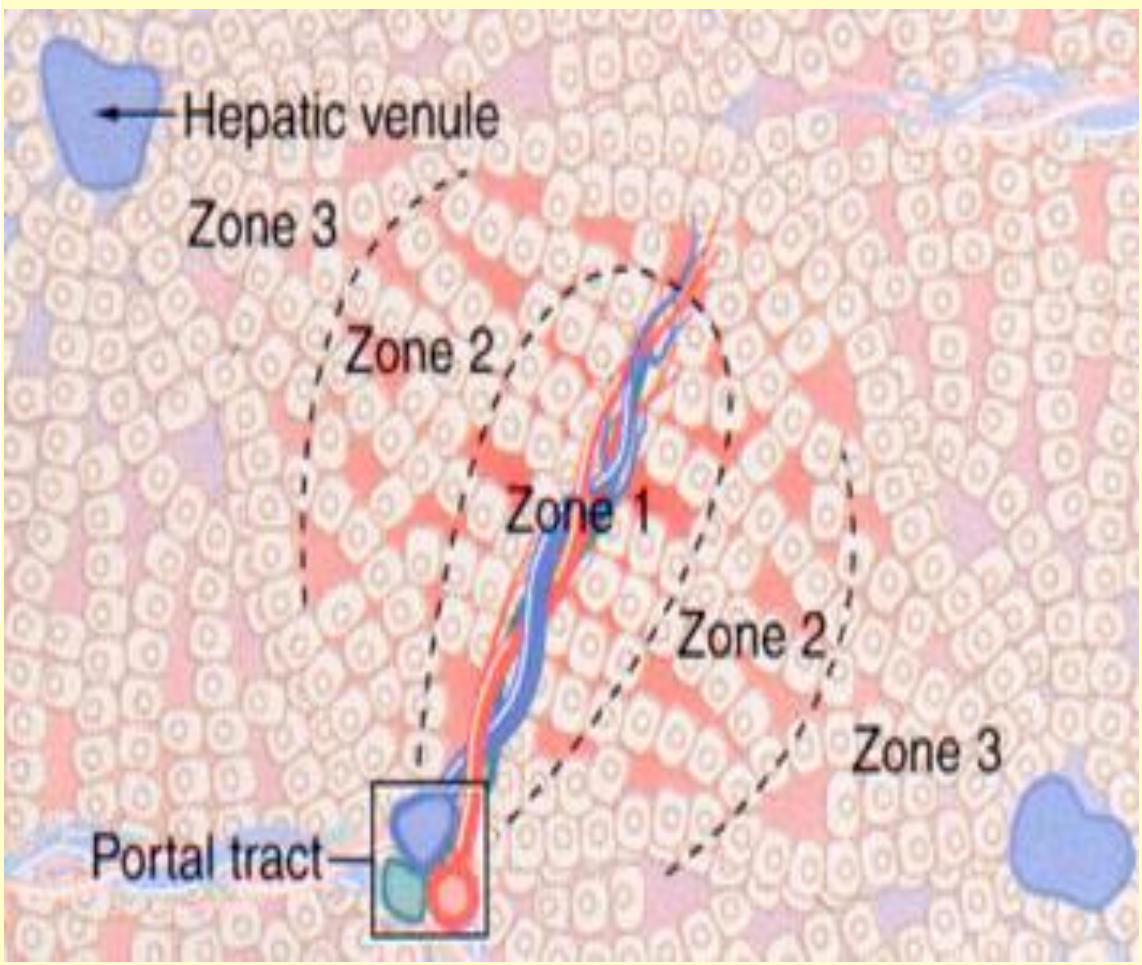
D - **somatostatin** - inhibits α and β cells, reduces contraction of smooth muscles of alimentary canal and gallbladder

D_1 - **vasoactive intestinal peptide (VIP) –** induces **glycogenolysis** (formation of glucose from glycogen), inhibits motility of the gut, controls ions and water secretion by epithelial cells





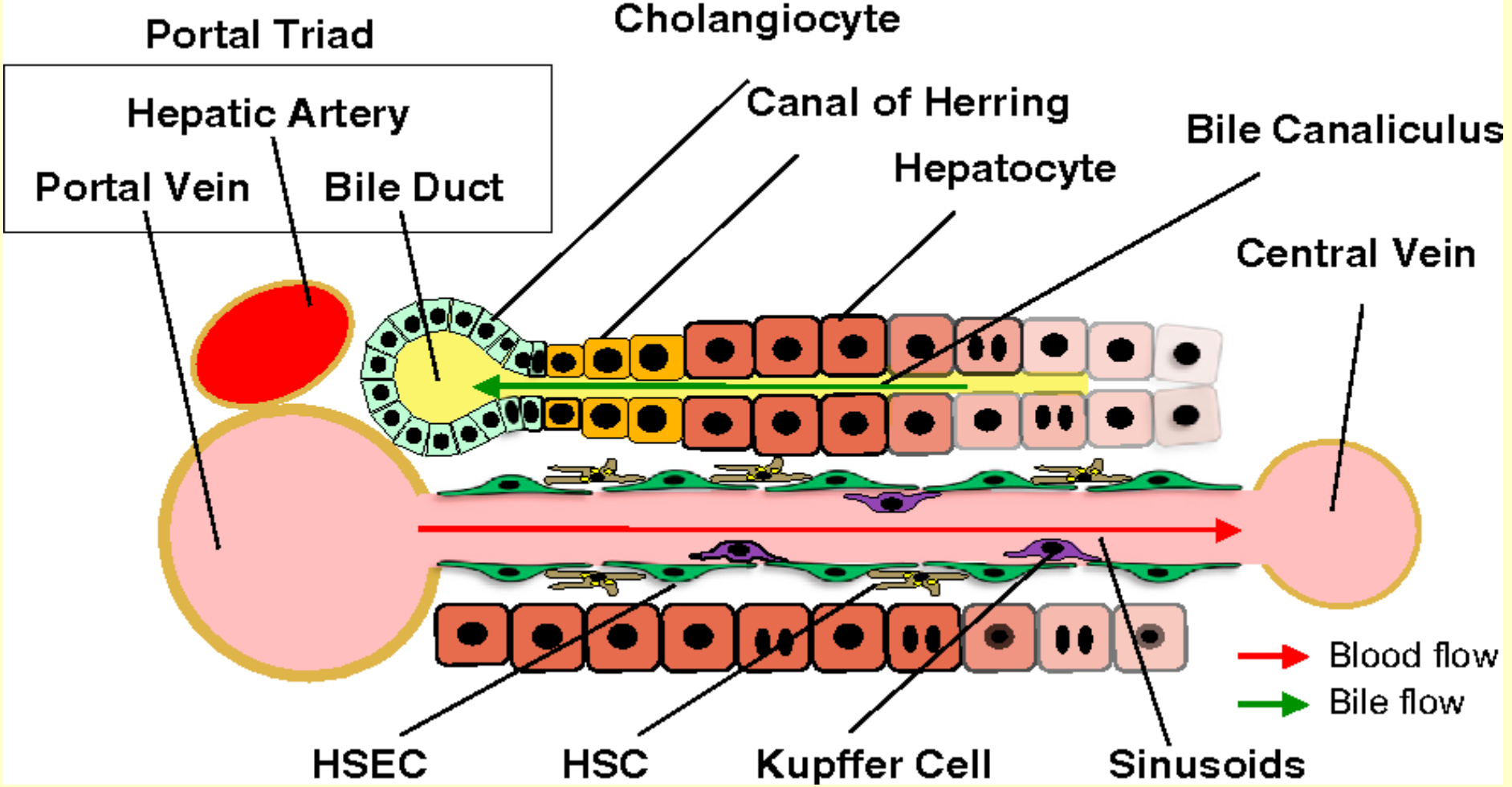




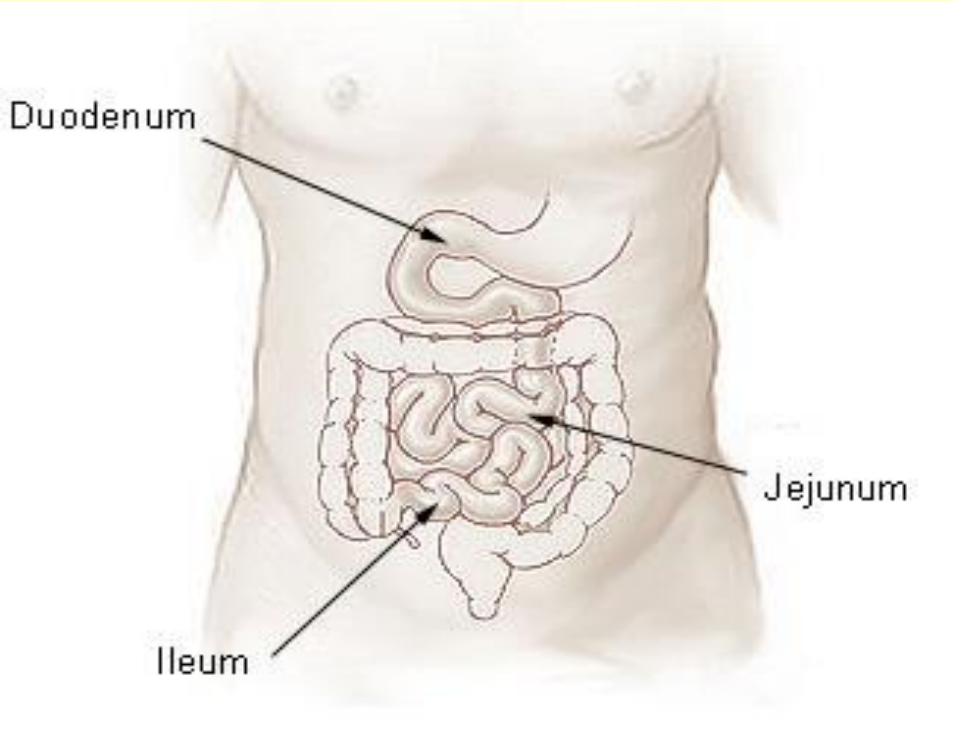
- three concentric regions of hepatic parenchyma,
- the outermost layer, zone 3 - the most oxygen-poor of the three zones.
- zone 1 is the richest in oxygen.

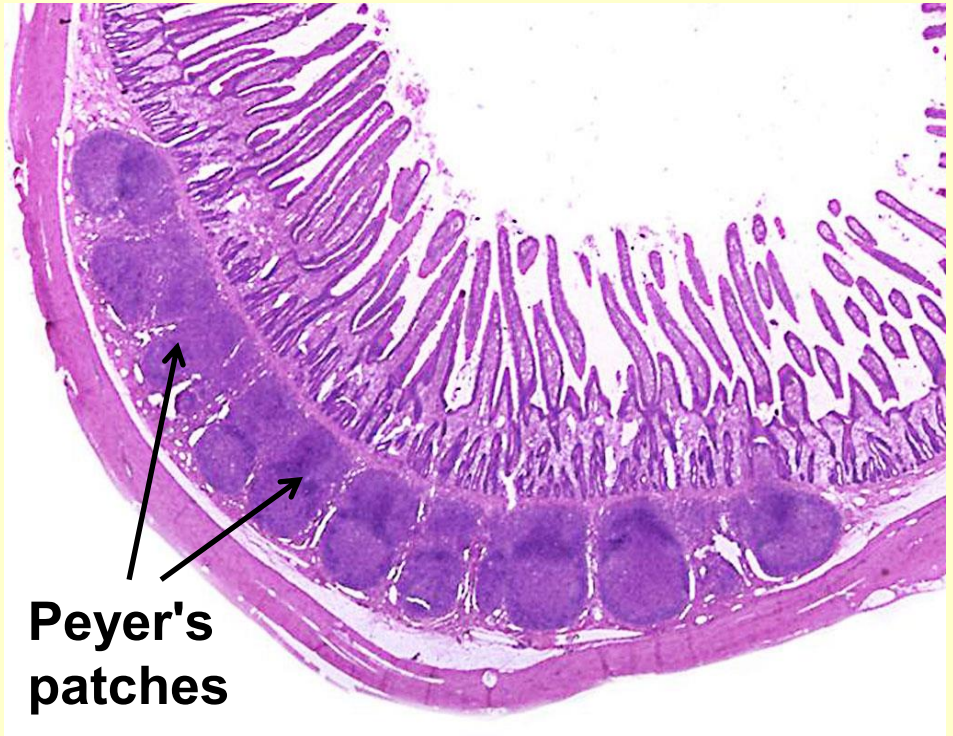
Bile transport

- bile canaliculi, canal of Herring, bile ductules, bile ducts, common hepatic duct, cystc duct - gallbladder



- The **ileum** - absorption of **vitamin B12**, **bile salts** and products of digestion that were not absorbed by the jejunum





Ileum - Peyer's patches - unencapsulated lymphoid nodules (differentiate the ileum from the duodenum and jejunum).

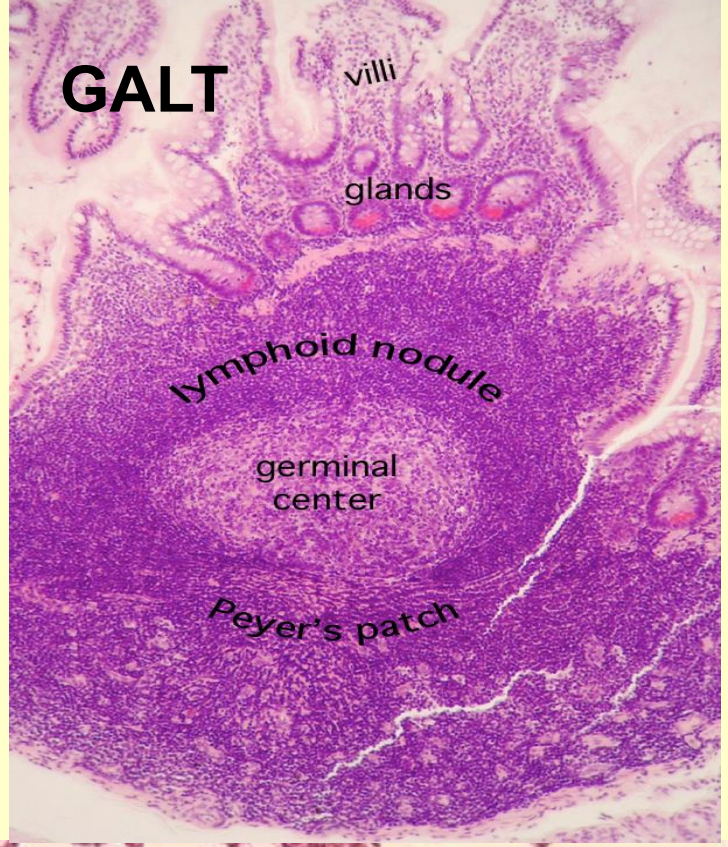
The wall of ileum

- **Mucosa (**Peyer's patches in the lamina propria)
- **Submucosa**
- **Mascularis externa**
- **Serosa**

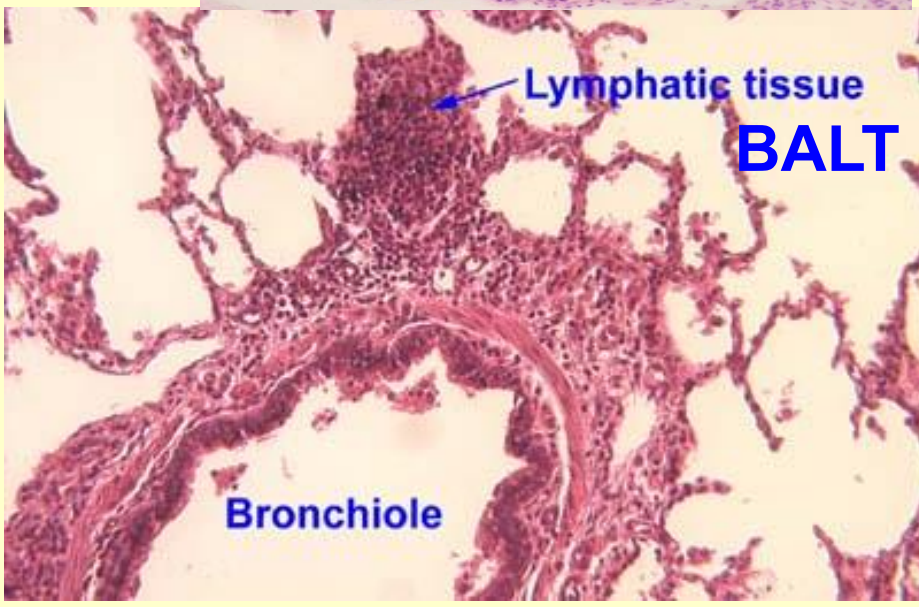
- lymphoid nodules in submucosa - strong immune response

Peyer's patches - immune response within the mucosa - **B and T cells, macrophages, and dendritic cells**

- the part of **Mucosa Associated Lymphoid Tissue (MALT) -** lymphoid nodules in the mucosa of the respiratory, digestive, and urinary systems.

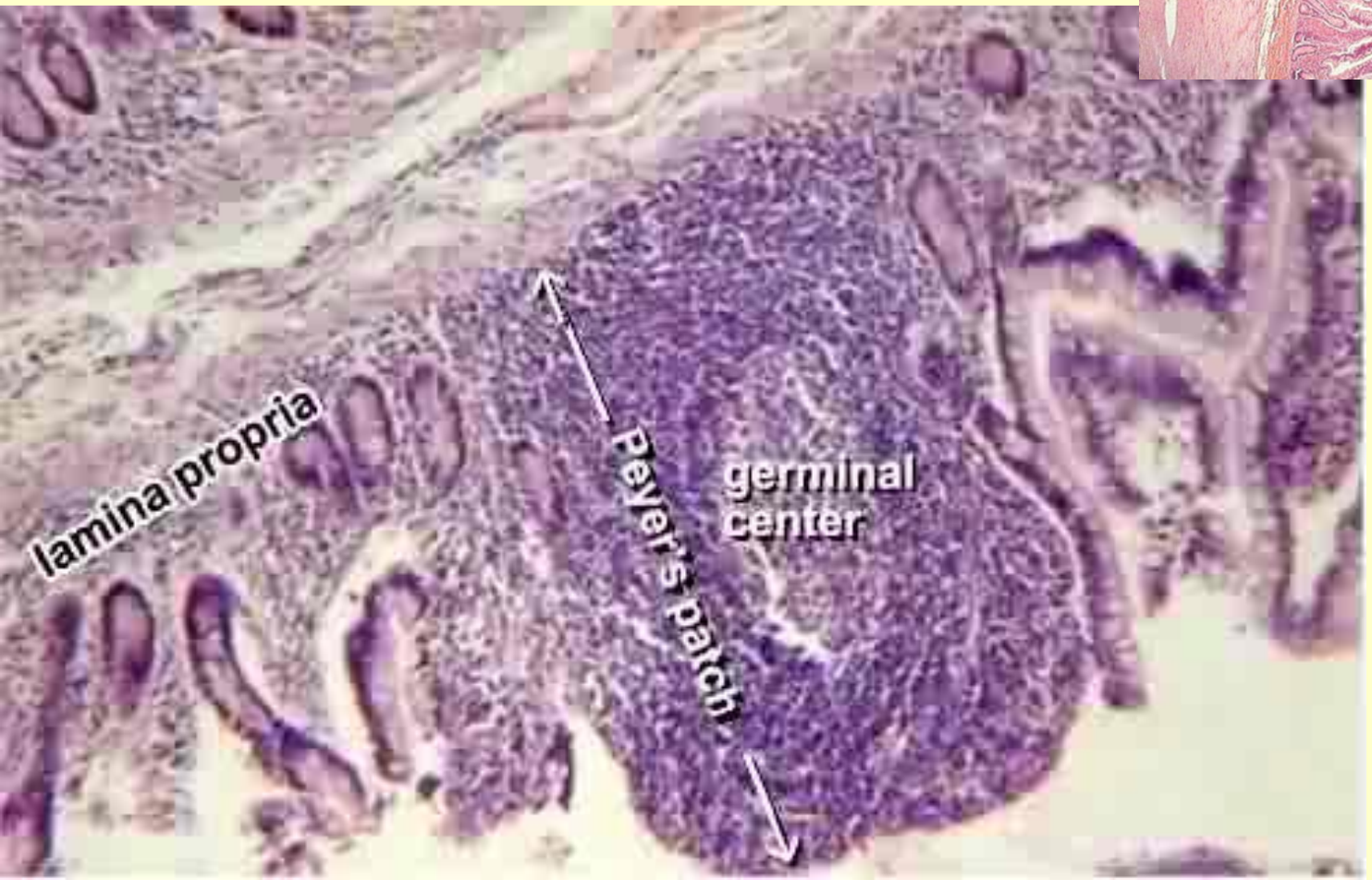


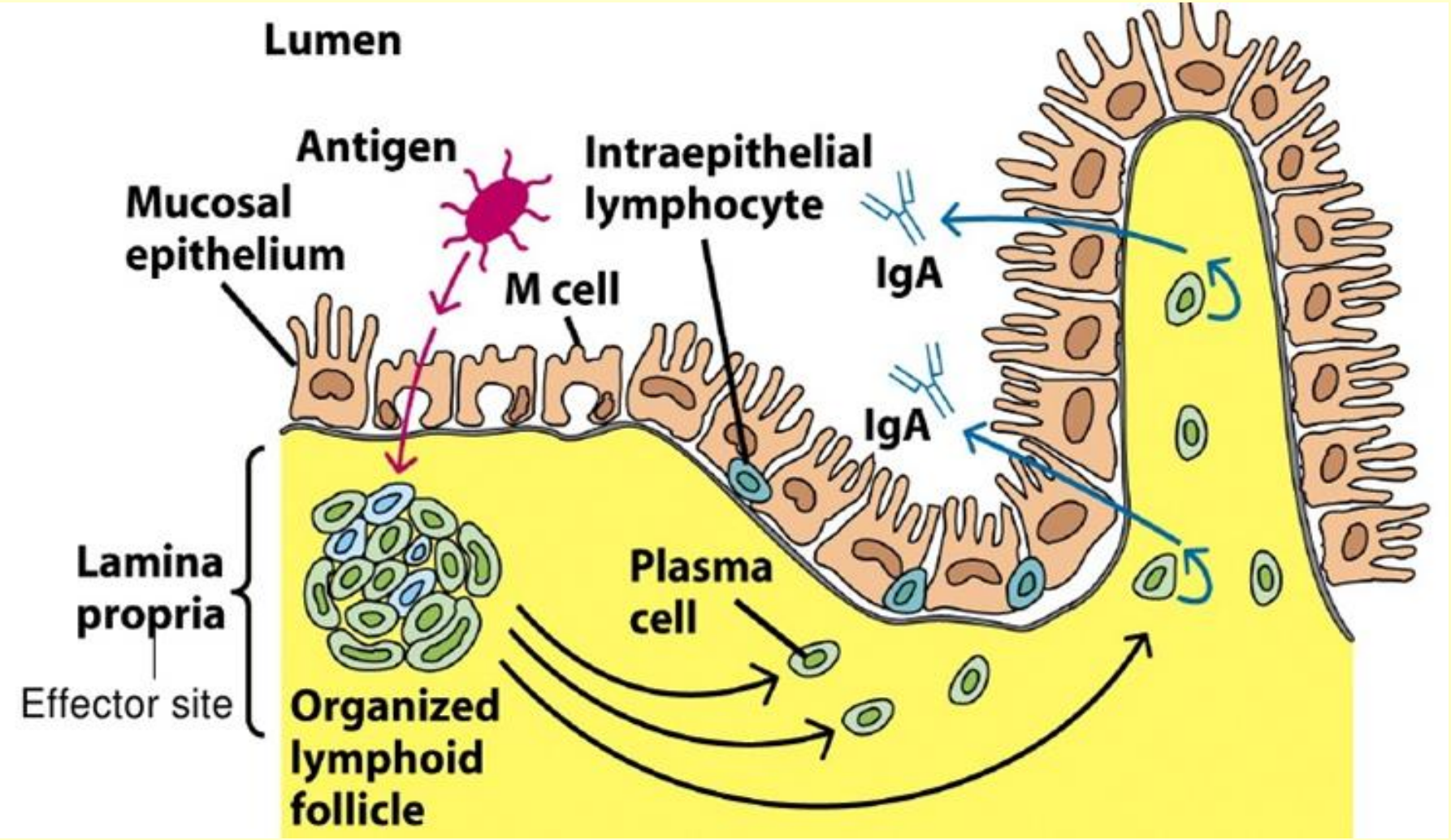
GALT/BALT/NALT
(gut/bronchus/nasal-associated lymphoid tissue)



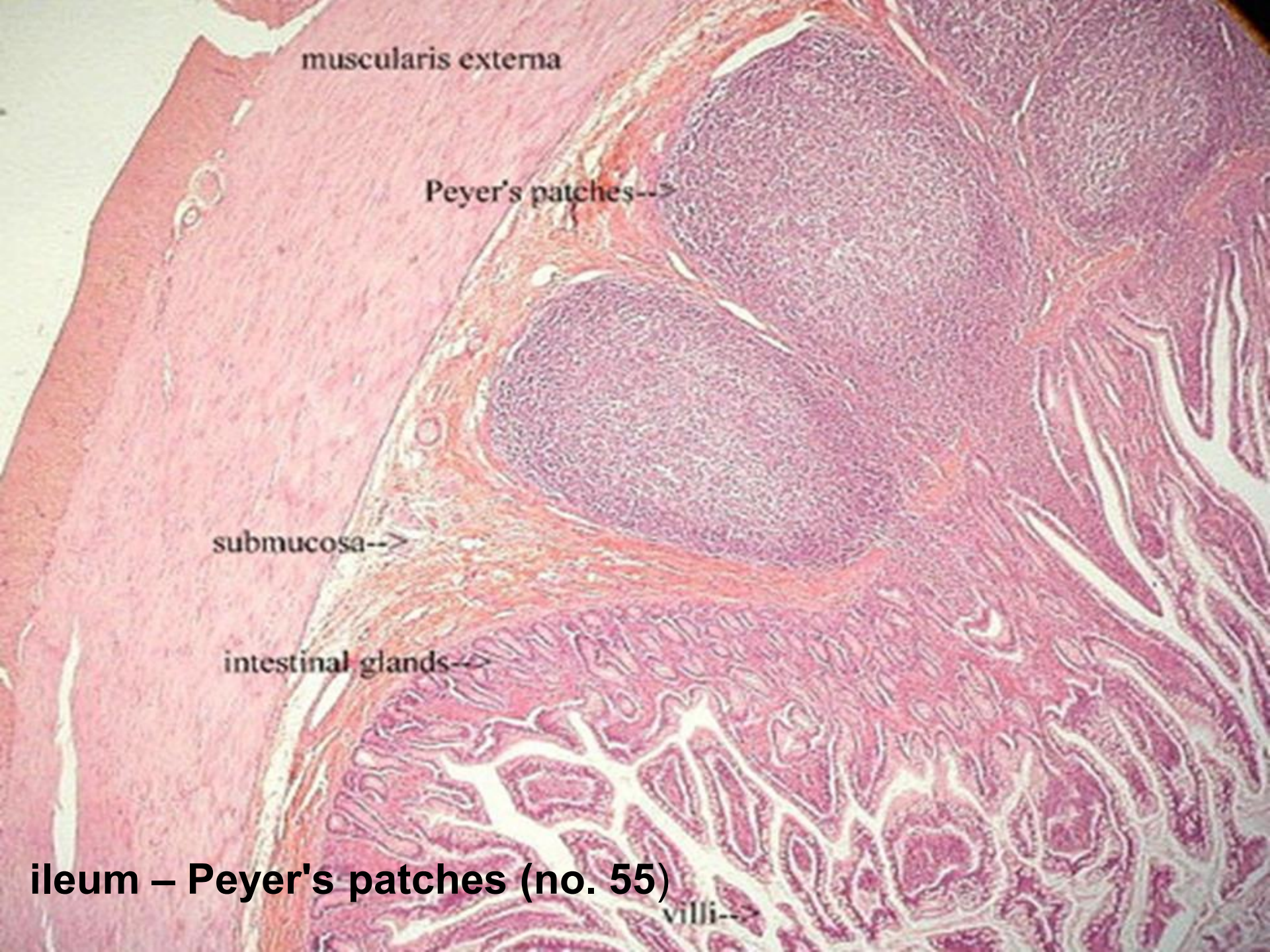
B lymphocytes - in the follicles' **germinal centers**.

T lymphocytes - between follicles

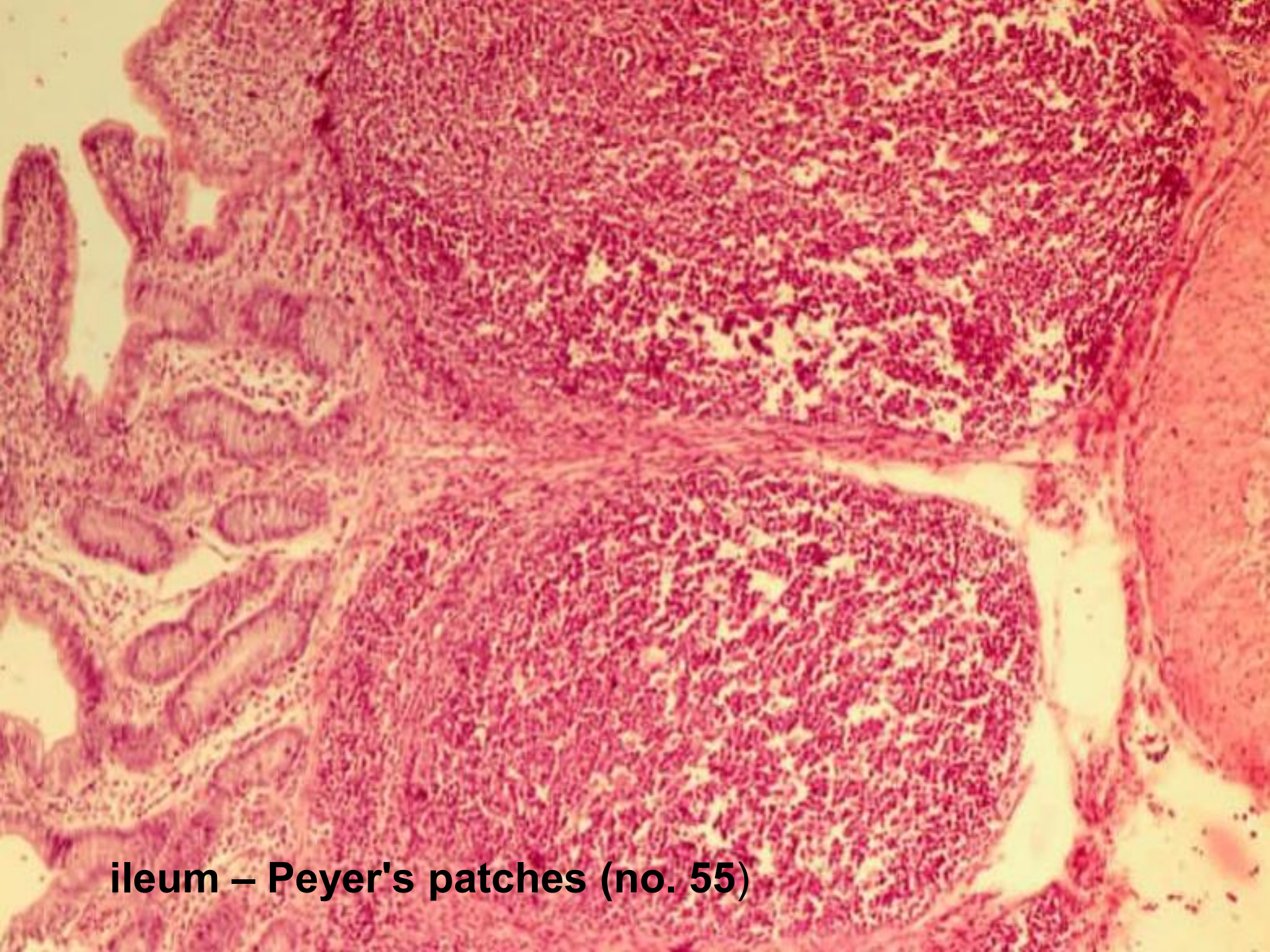




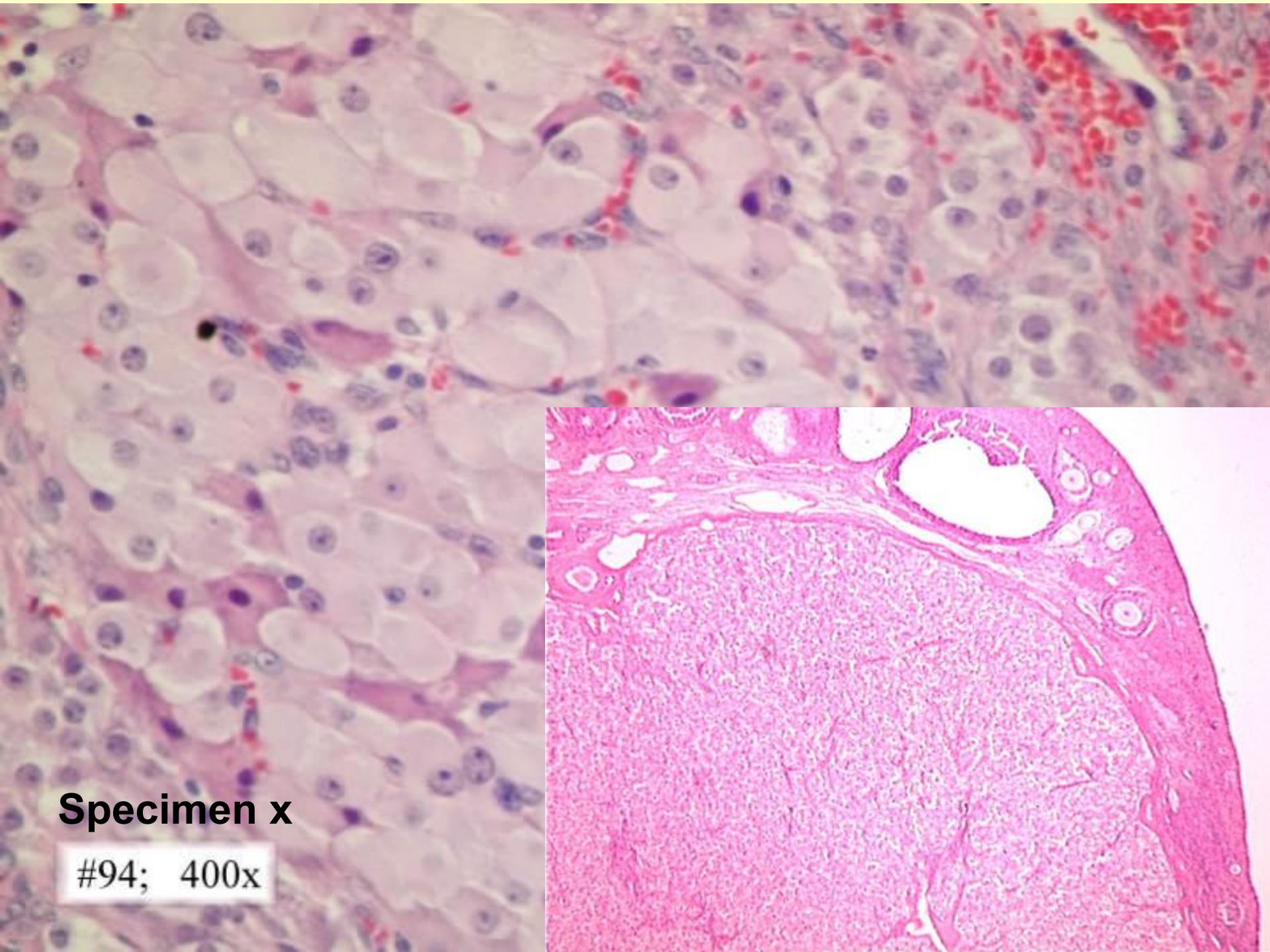
- M (Microfold) cells transport antigens (endocytosis) to APC (presentation) – activation of T cells
- B cells differentiate into plasma cells and produce **IgA**.



ileum – Peyer's patches (no. 55)



ileum – Peyer's patches (no. 55)


Specimen x
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