



# Digestive System

## Introduction to Anatomy and Embryology

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## The functions of the digestive system

**Ingestion.** Food must be placed into the mouth before it can be acted on; this is an active, voluntary process called ingestion.

**Propulsion.** Food must be propelled from one organ to the next; swallowing is one example of food movement that depends largely on the propulsive process. **Peristalsis** is involuntary, alternating waves of contraction and relaxation of the muscles in the organ wall.

**Food breakdown: mechanical digestion.** Mechanical digestion prepares food for further degradation by enzymes by physically fragmenting the food into smaller pieces, and examples of mechanical digestion are: mixing of food in the mouth by the tongue, churning of food in the stomach, and segmentation in the small intestine.

**Food breakdown: chemical digestion.** The sequence of steps in which the large food molecules are broken down into their building blocks by enzymes is called chemical digestion.

**Absorption.** Transport of digested end products from the lumen of the GI tract to the blood or lymph is absorption, and for absorption to happen, the digested foods must first enter the mucosal cells by active or passive transport processes.

**Defecation.** Defecation is the elimination of indigestible residues from the GI tract via the anus in the form of feces.

# The Digestive System

- **The GI tract** (gastrointestinal tract)

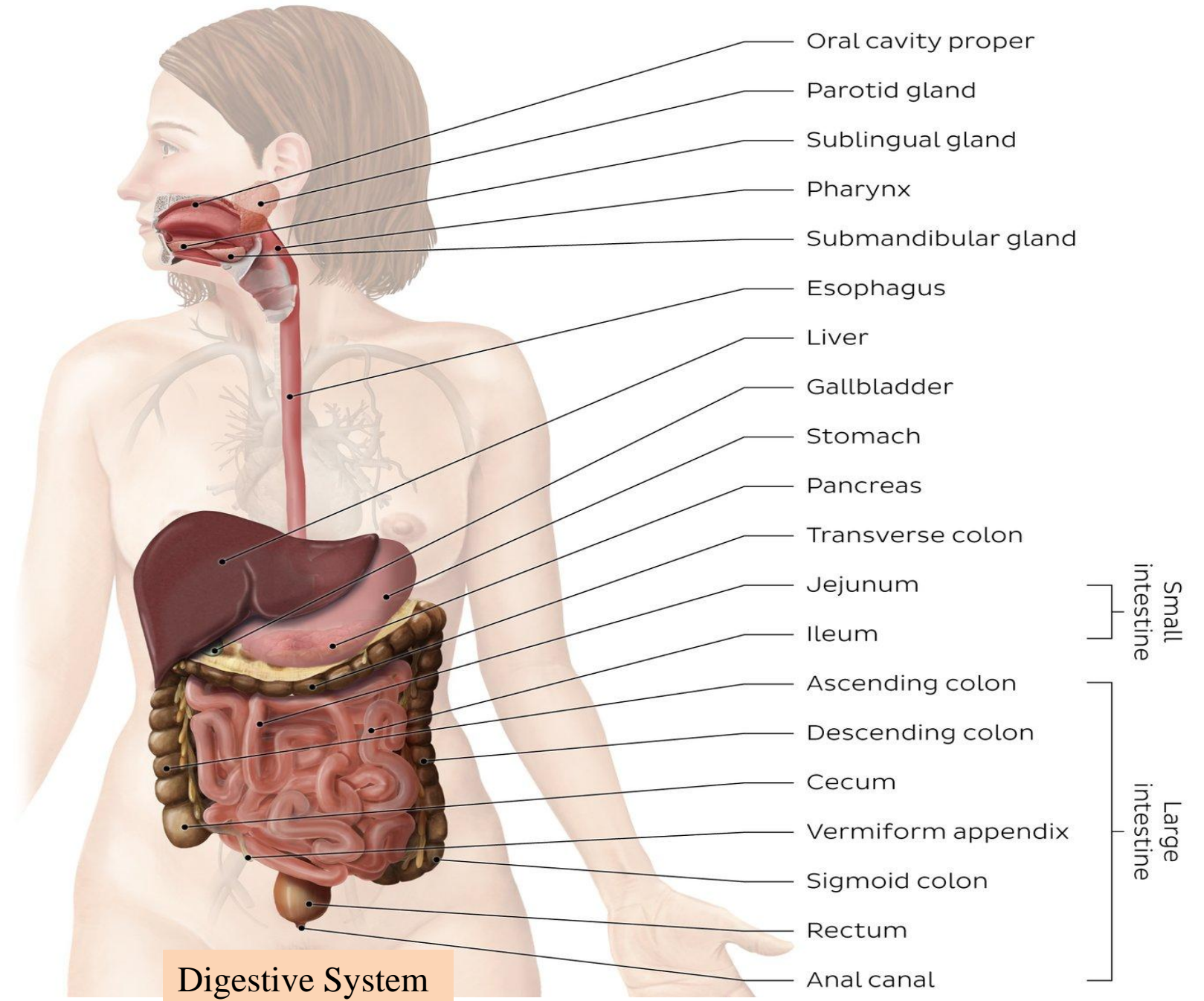
*The muscular alimentary canal*

- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

- **The accessory digestive organs**

- Teeth & tongue
- Salivary glands
- Gallbladder
- Liver
- Pancreas

*Supply secretions  
contributing to the  
breakdown of food*



# The Mouth (oral cavity)

**Palate.** Roof of mouth  
Hard plate anteriorly  
Soft palate posteriorly

**Uvula.** The uvula is a finger-like projection of the soft palate, which extends inferiorly from the soft palate. During swallowing, uvula is drawn superiorly, closing off the nasopharynx

**Vestibule.** The space between the lips and the cheeks externally and the teeth and gums internally is the vestibule. *(Its where you put the tooth brush)*

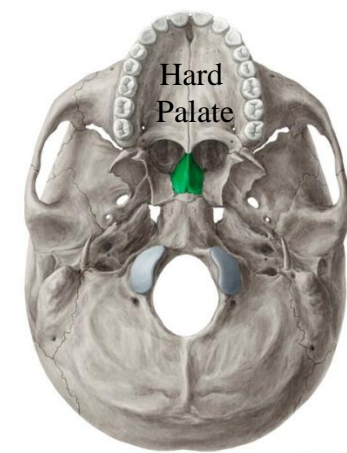
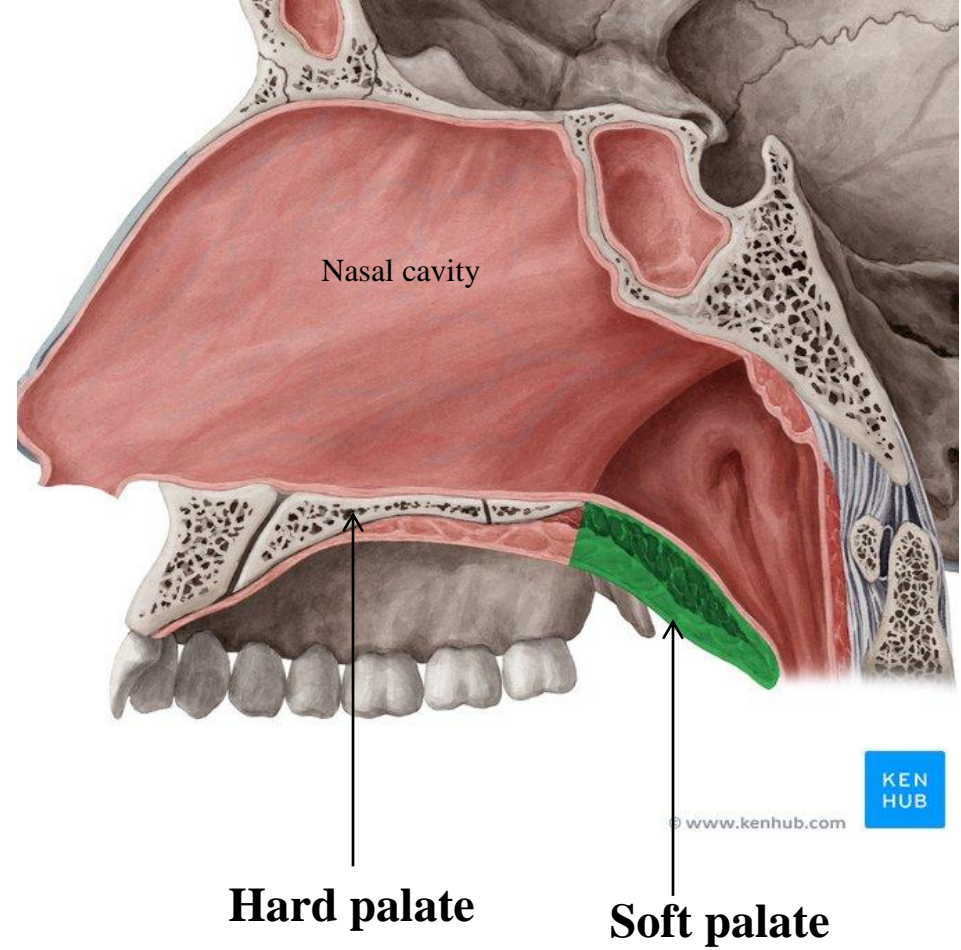
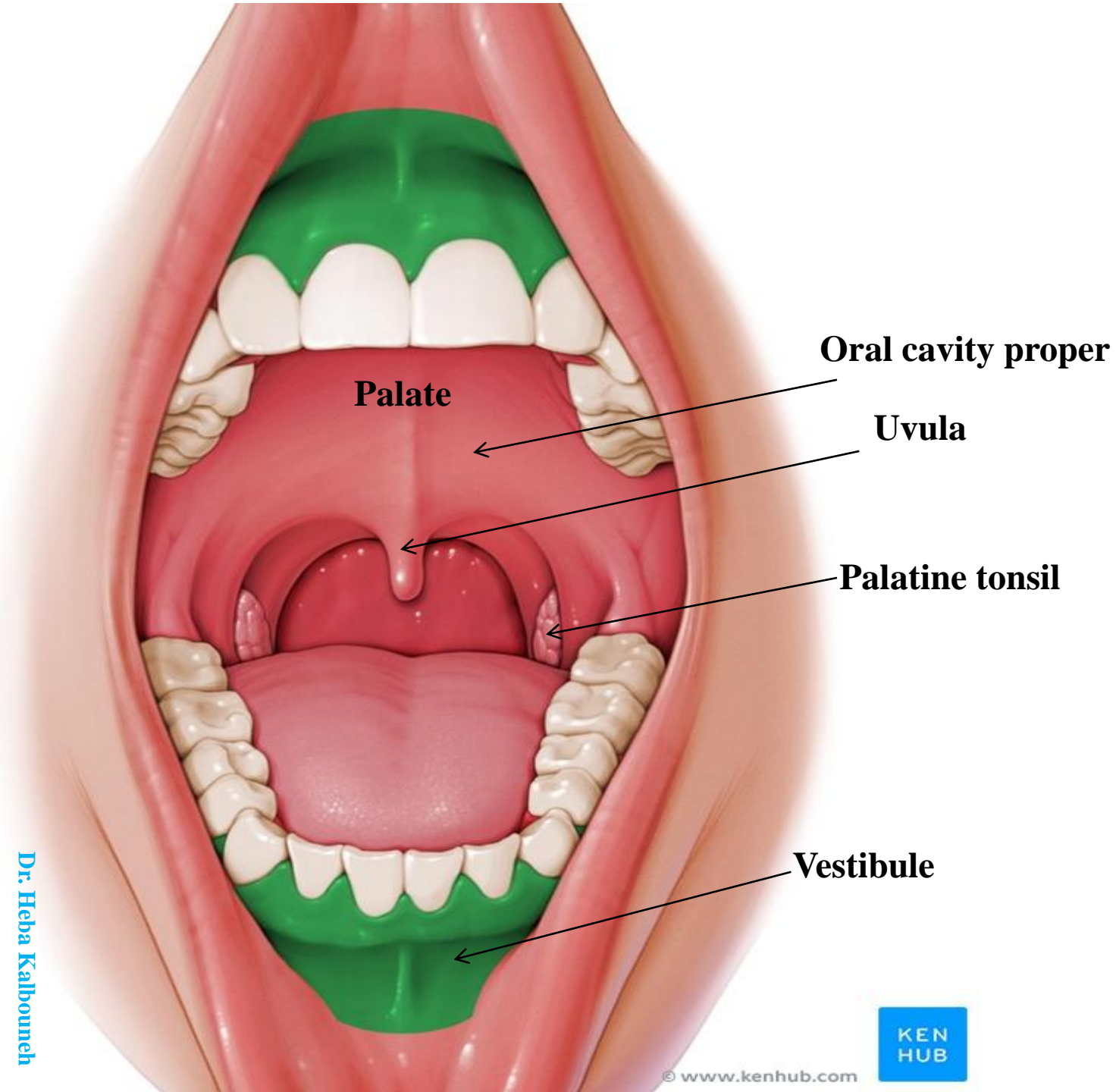
**Oral cavity proper.** The area contained by the teeth is the oral cavity proper.

**Tongue.** The muscular tongue occupies the floor of the mouth and has several bony attachments

**Palatine tonsils.** At the posterior end of the oral cavity are paired masses of lymphatic tissue, the palatine tonsils.

**Lingual tonsils.** The lingual tonsils cover the posterior 1/3 of the tongue.





# Tongue

Lingual tonsils

Epiglottis

Palatine tonsil

Posterior 1/3

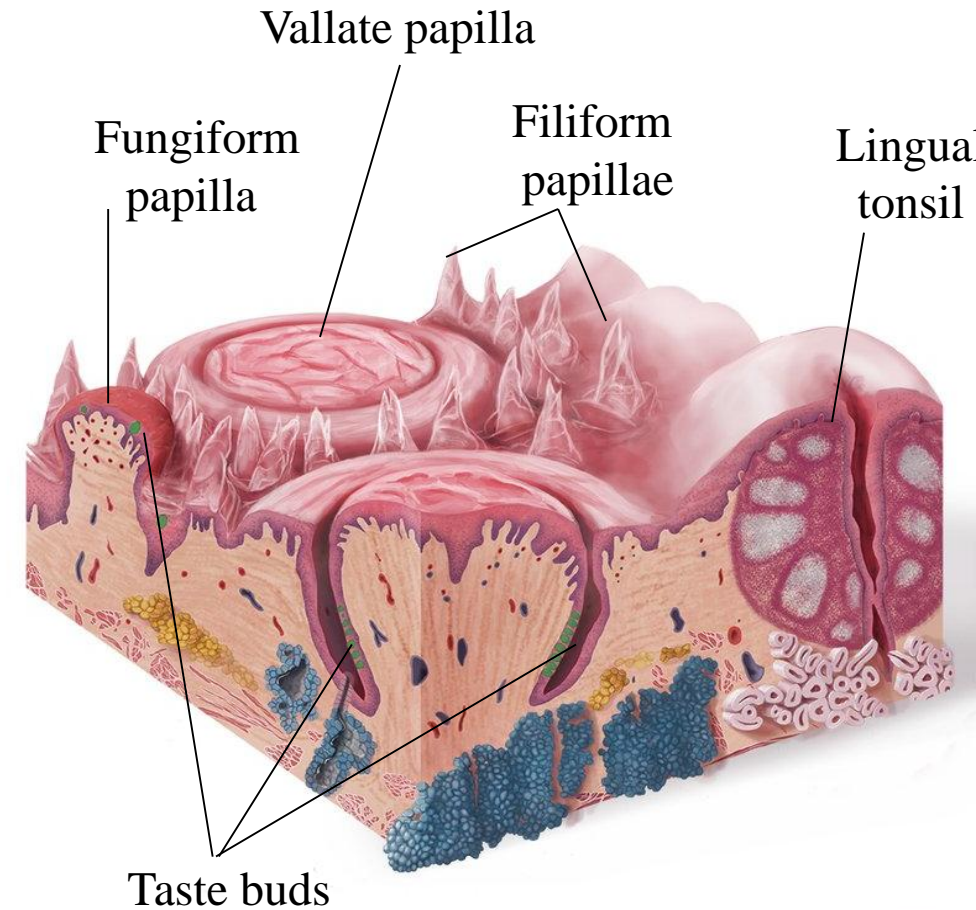
Anterior 2/3

Attached to the hyoid bone, styloid process of the temporal bone, and mandible.

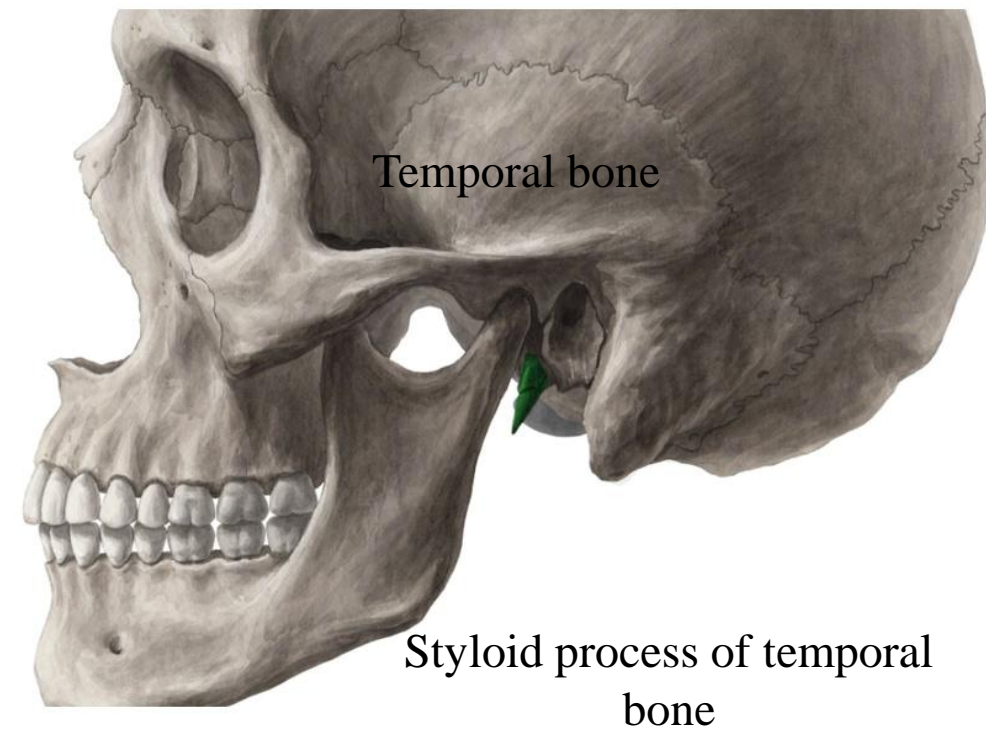
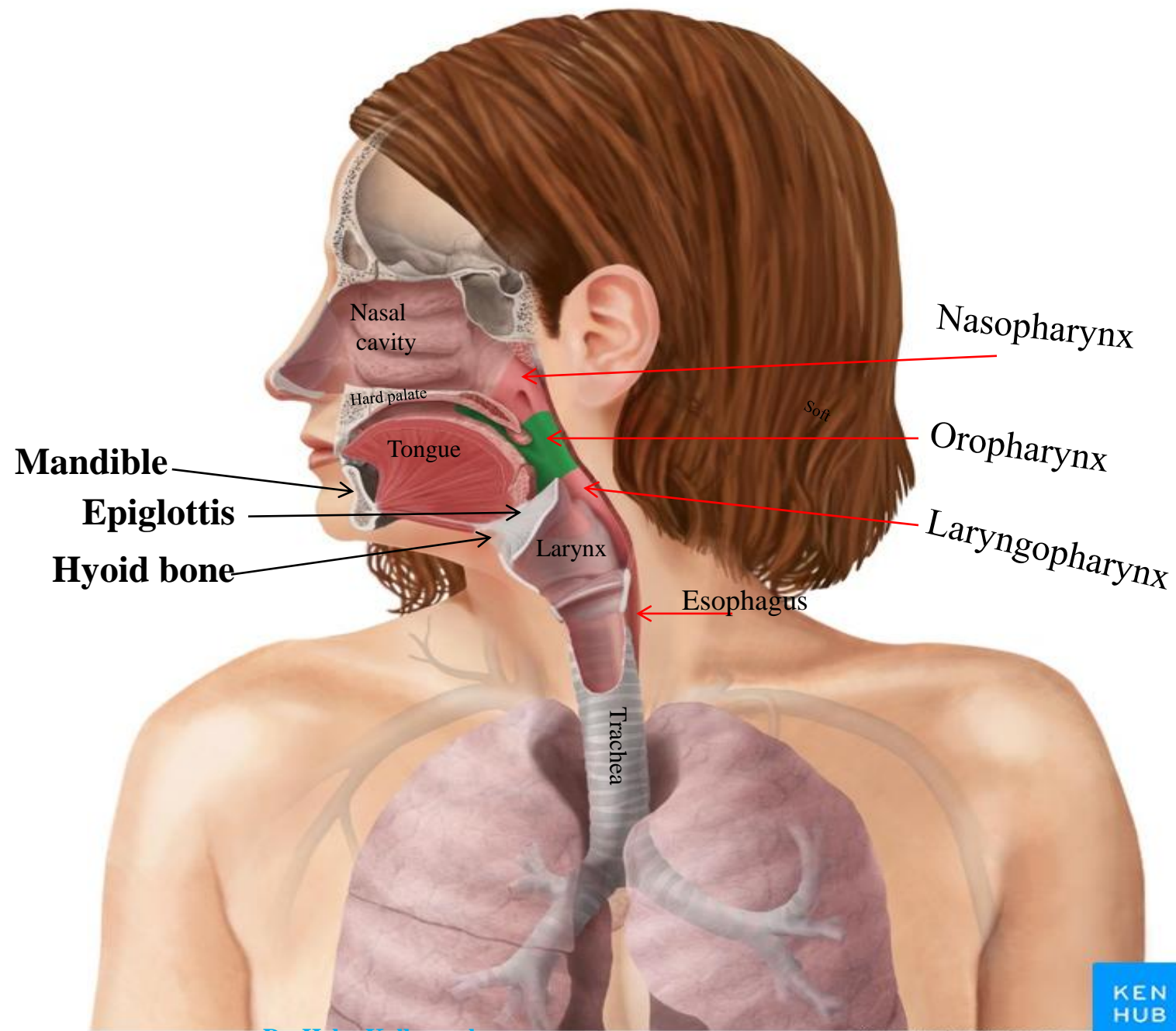
Two groups of skeletal muscles  
**Extrinsic muscles:** originate outside the tongue and insert into the tongue.  
**Intrinsic muscles:** originate in and insert within the tongue.

**Lingual papillae** are the small, nipple-like structures on the upper surface of the tongue that give it its characteristic rough texture. The four types of papillae are circumvallate (or vallate), fungiform, filiform, and foliate.

All except the filiform papillae are associated with taste buds





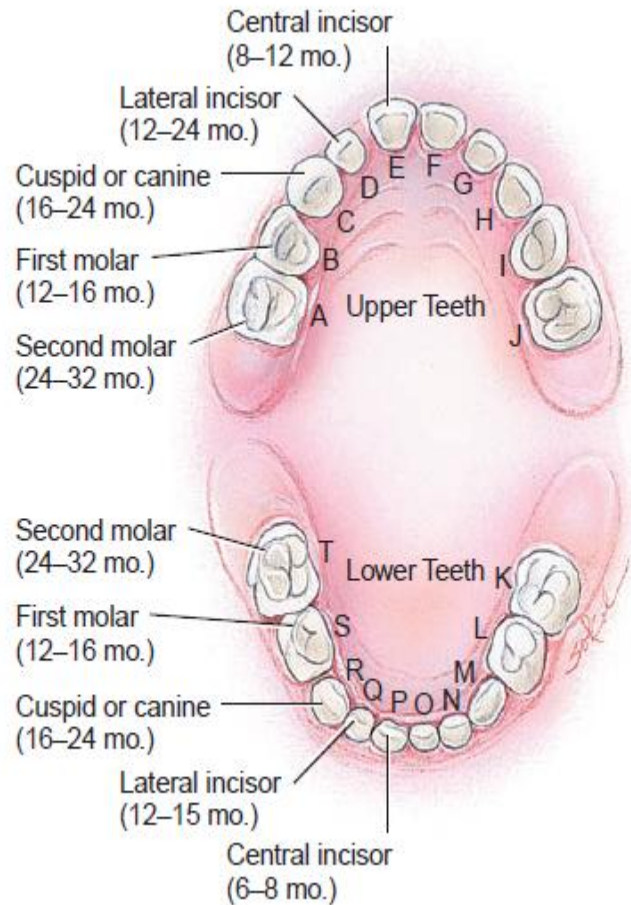


# Teeth

- 1) Primary or deciduous
- 2) Permanent

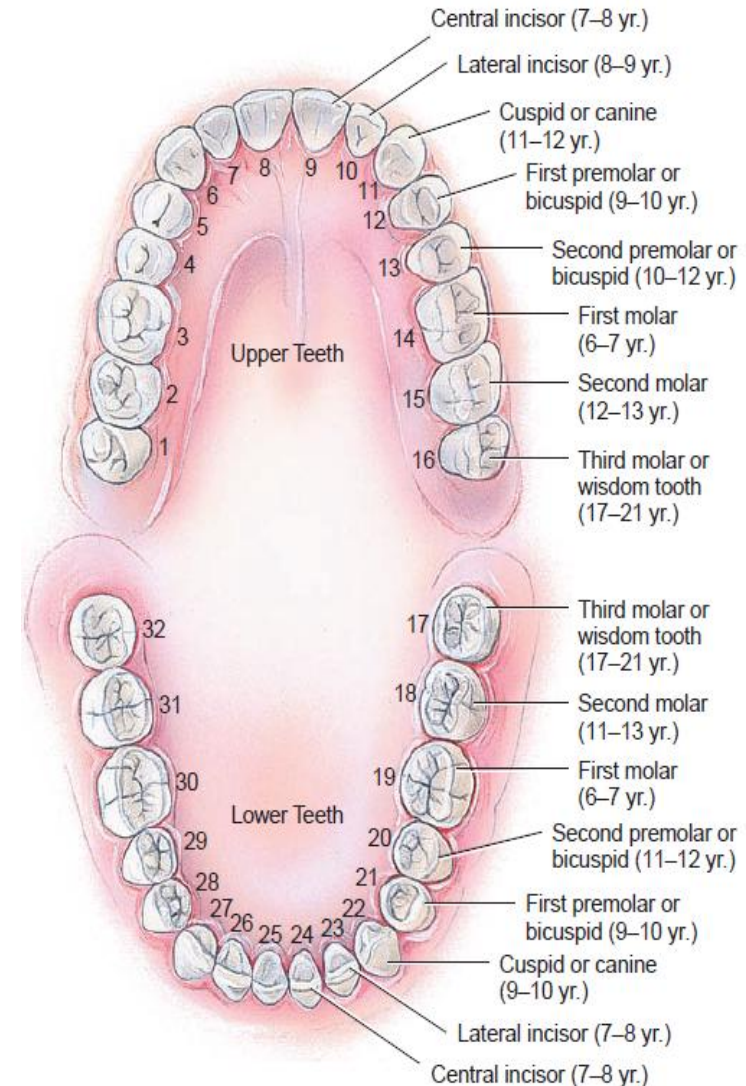
## Primary or deciduous

- ✓ Start at 6 months
- ✓ 20 are out by about 2 years
- ✓ Fall out between 2-6 years



## Permanent: 32 total

- ✓ Incisors
- ✓ Canines
- ✓ Premolars
- ✓ Molars

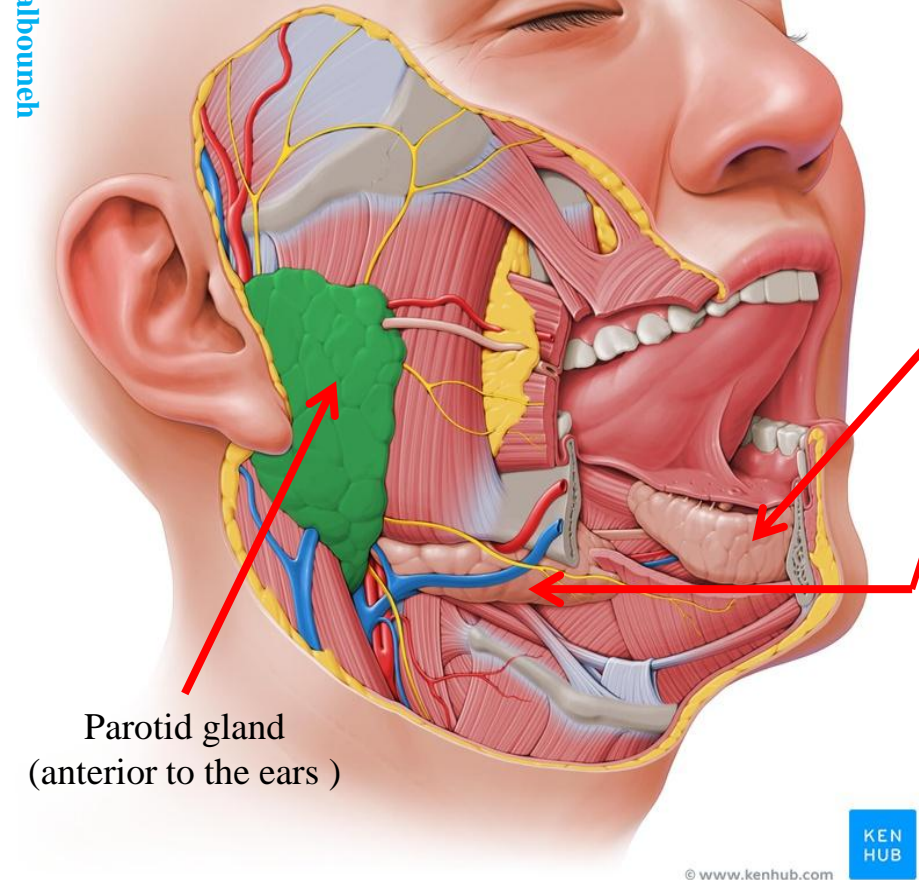




# Salivary glands

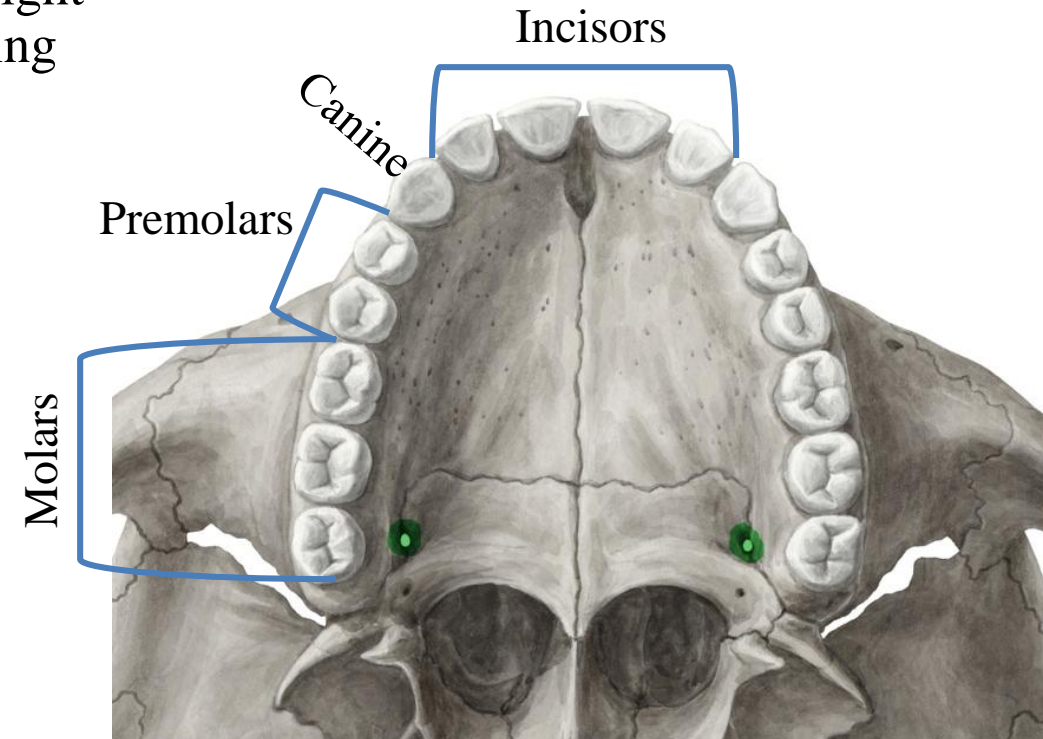
## Major salivary glands

- Paired (2 each)
  - Parotid
  - Sublingual
  - Submandibular
- External to mouth
- Ducts open inside the mouth
- Secrete saliva only right before or during eating



**Saliva:** mixture of water, ions, mucus, and enzymes

- ✓ keeps mouth moist, dissolves food so can be tasted, moistens food, starts enzymatic digestion, antibacterial

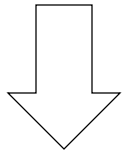


# Pharynx

✓ From the mouth, food passes posteriorly into the oropharynx and laryngopharynx.

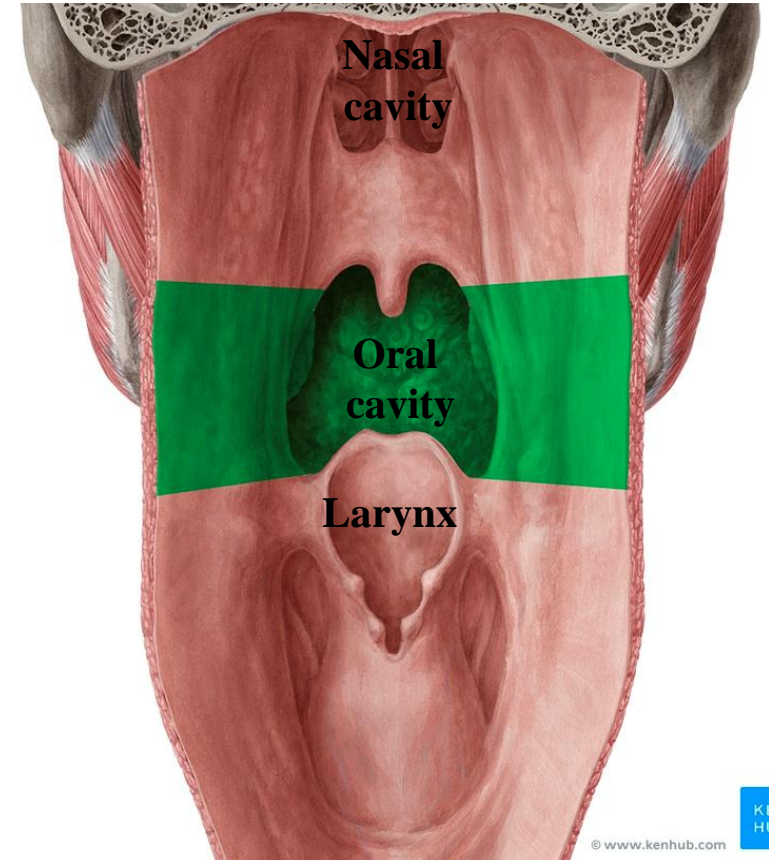
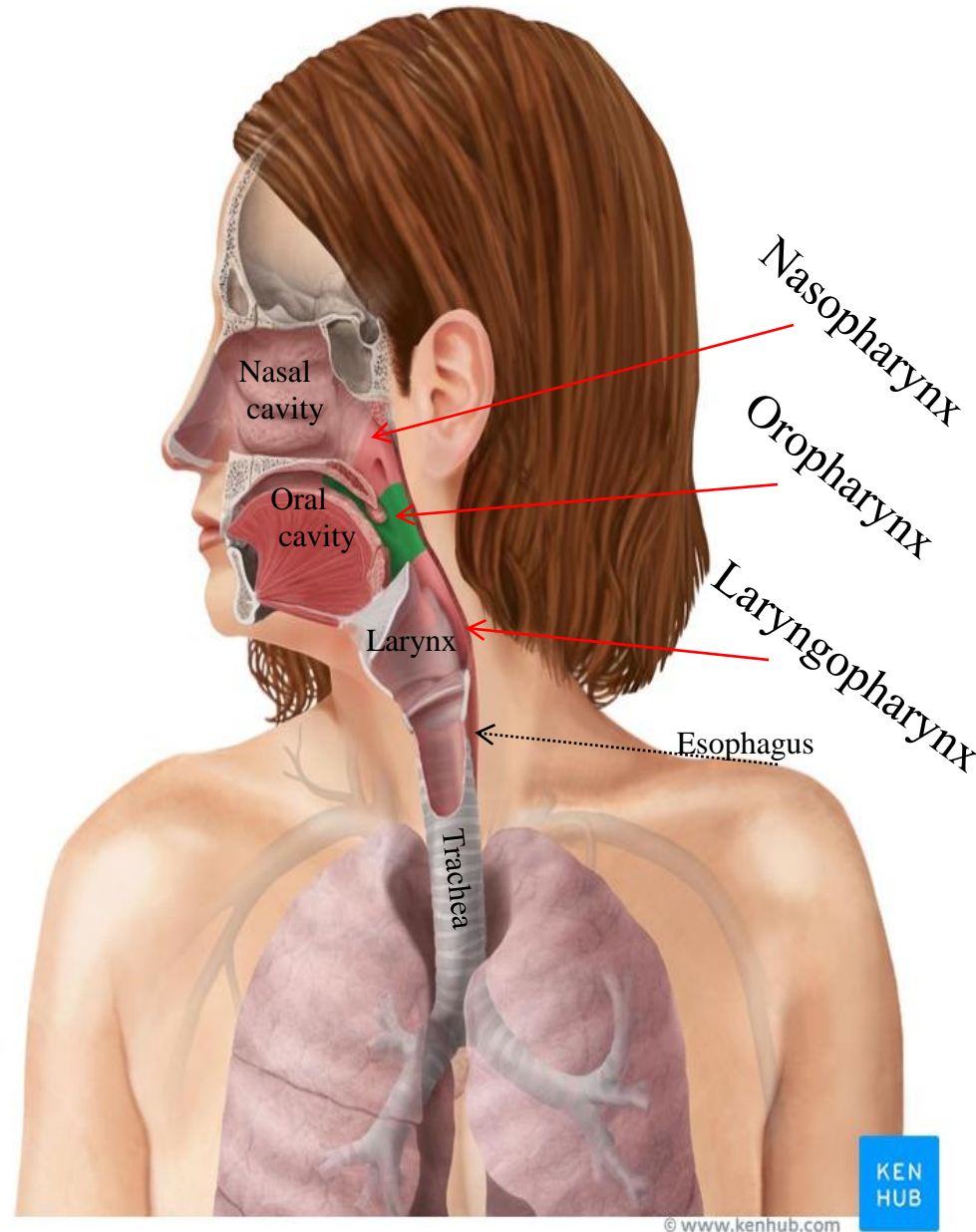
✓ **Oropharynx.** The oropharynx is posterior to the oral cavity.

✓ **Laryngopharynx.** The laryngopharynx is posterior to larynx and continuous with the esophagus below



Both are common passageways for food, fluids, and air.

Three constrictor muscles  
(skeletal) Sequentially squeeze  
bolus of food into esophagus



Posterior view



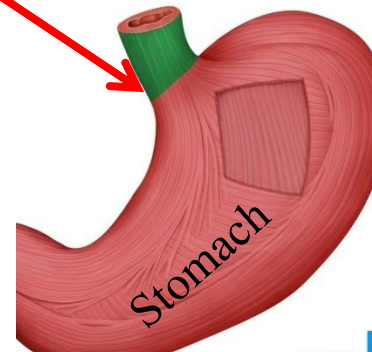
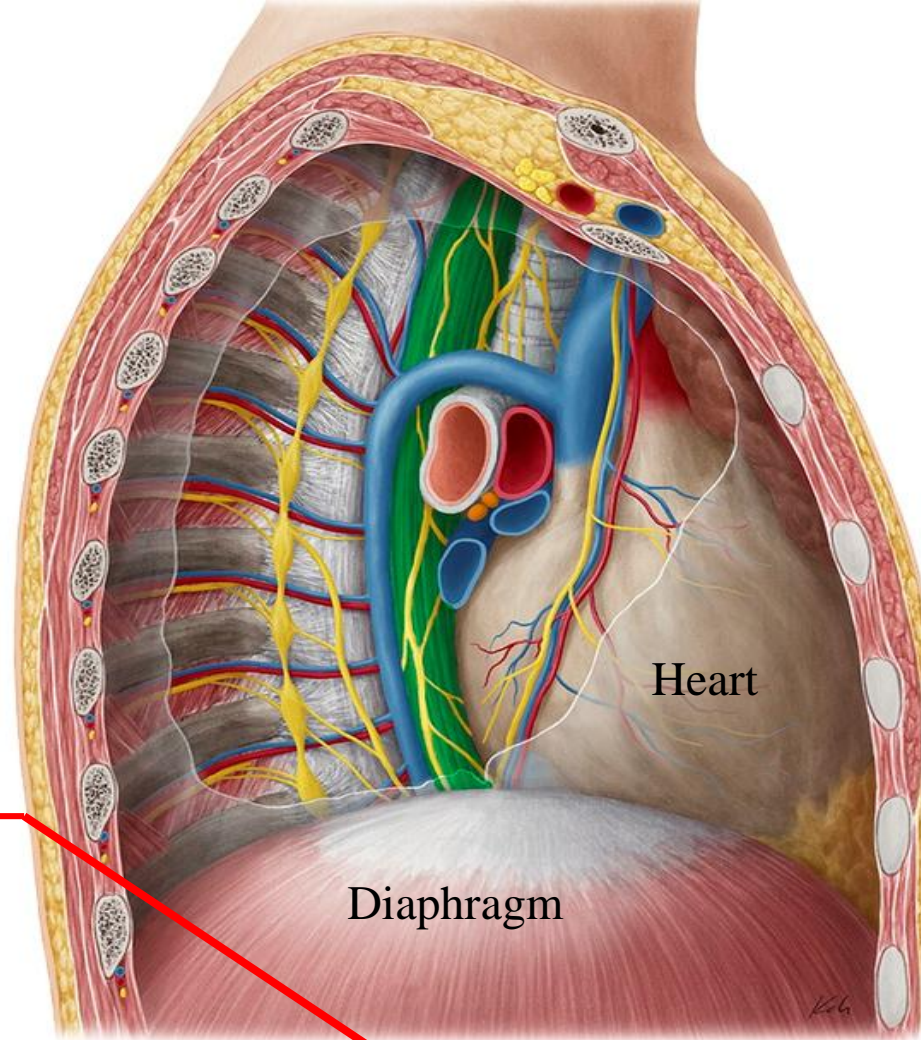
# Esophagus

- Begins at the inferior end of the laryngopharynx (C6)
- Muscular tube
- Collapsed when lumen is empty
- Descends through thorax, enters the mediastinum
  - Anterior to vertebral column
  - Posterior to trachea
- Passes through **esophageal hiatus (T10)** in the diaphragm to enter the abdomen
- Abdominal part only 2 cm long
- Joins stomach at cardiac orifice
- **Lower oesophageal sphincter** (gastroesophageal or the cardiac sphincter)



to prevent regurgitation  
(food coming back up  
into esophagus)

hiatus = opening



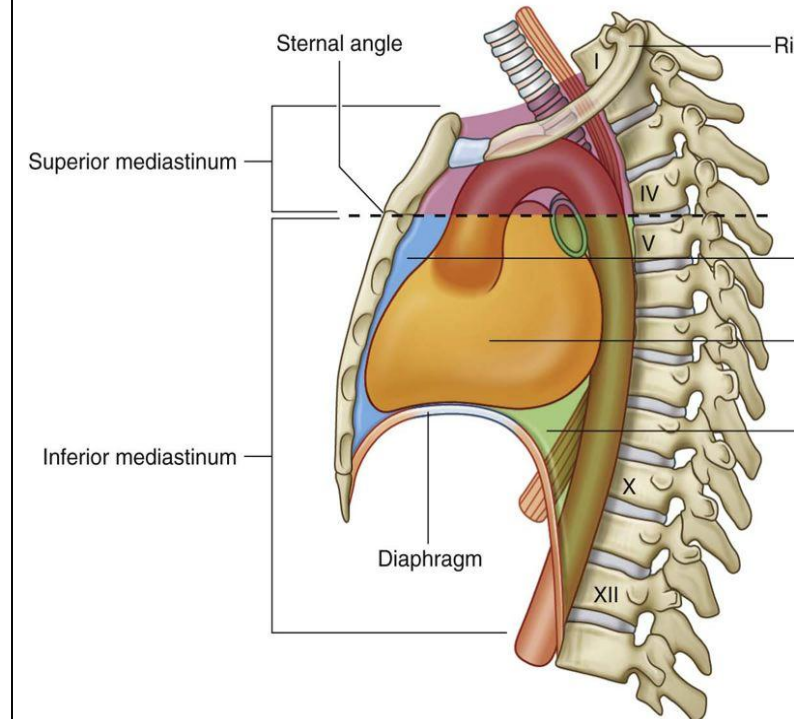
Anterior

Side view:  
diaphragm

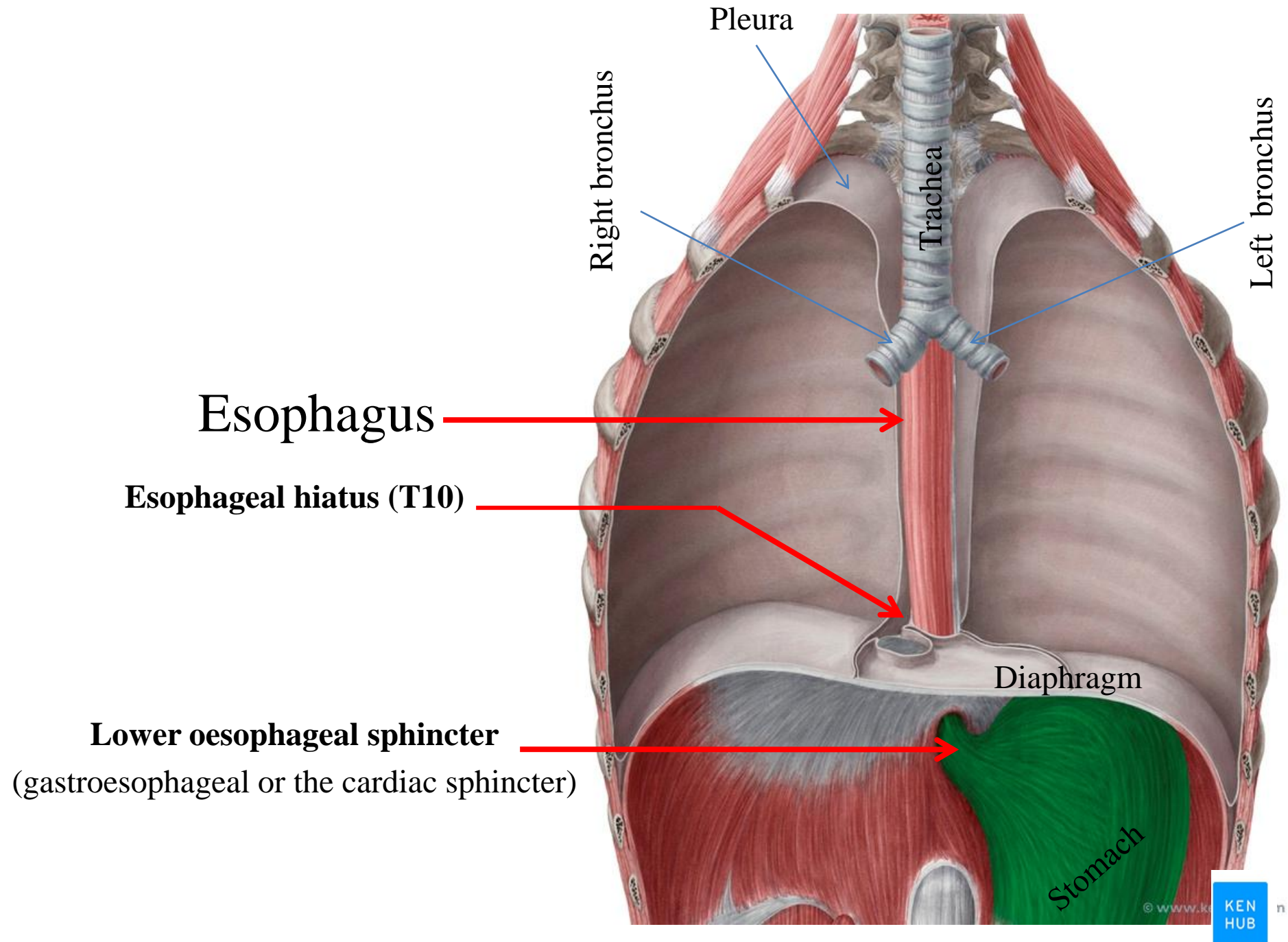
Opening for  
IVC (T8)

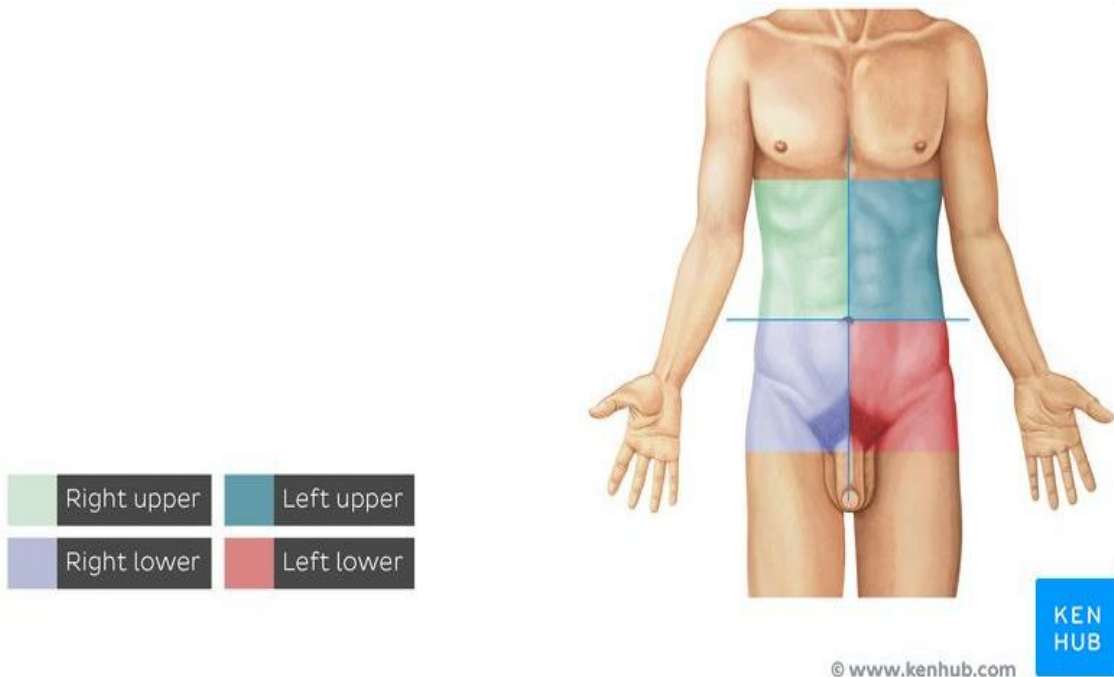
Opening for  
esophagus (T10)

Opening for  
aorta (T12)







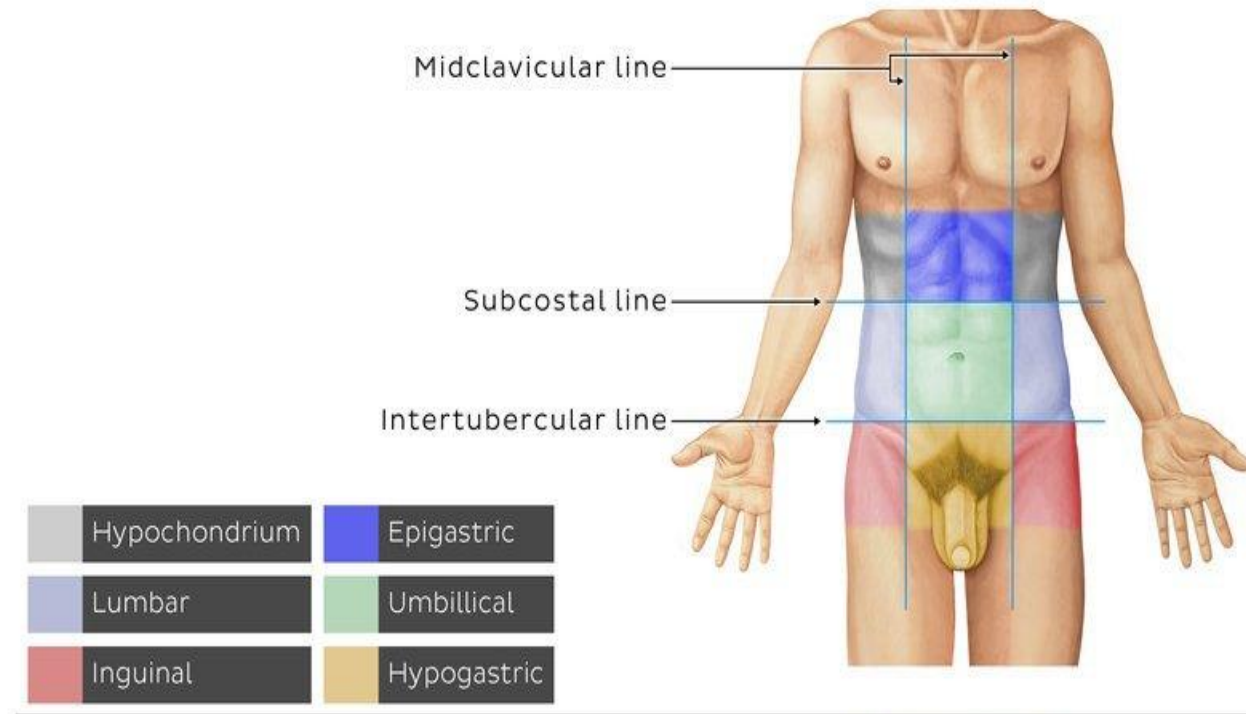


### Four quadrants

which are divided by the horizontal transumbilical and vertical median planes.

The four resulting areas are called right upper, left upper, right lower and left lower quadrants.

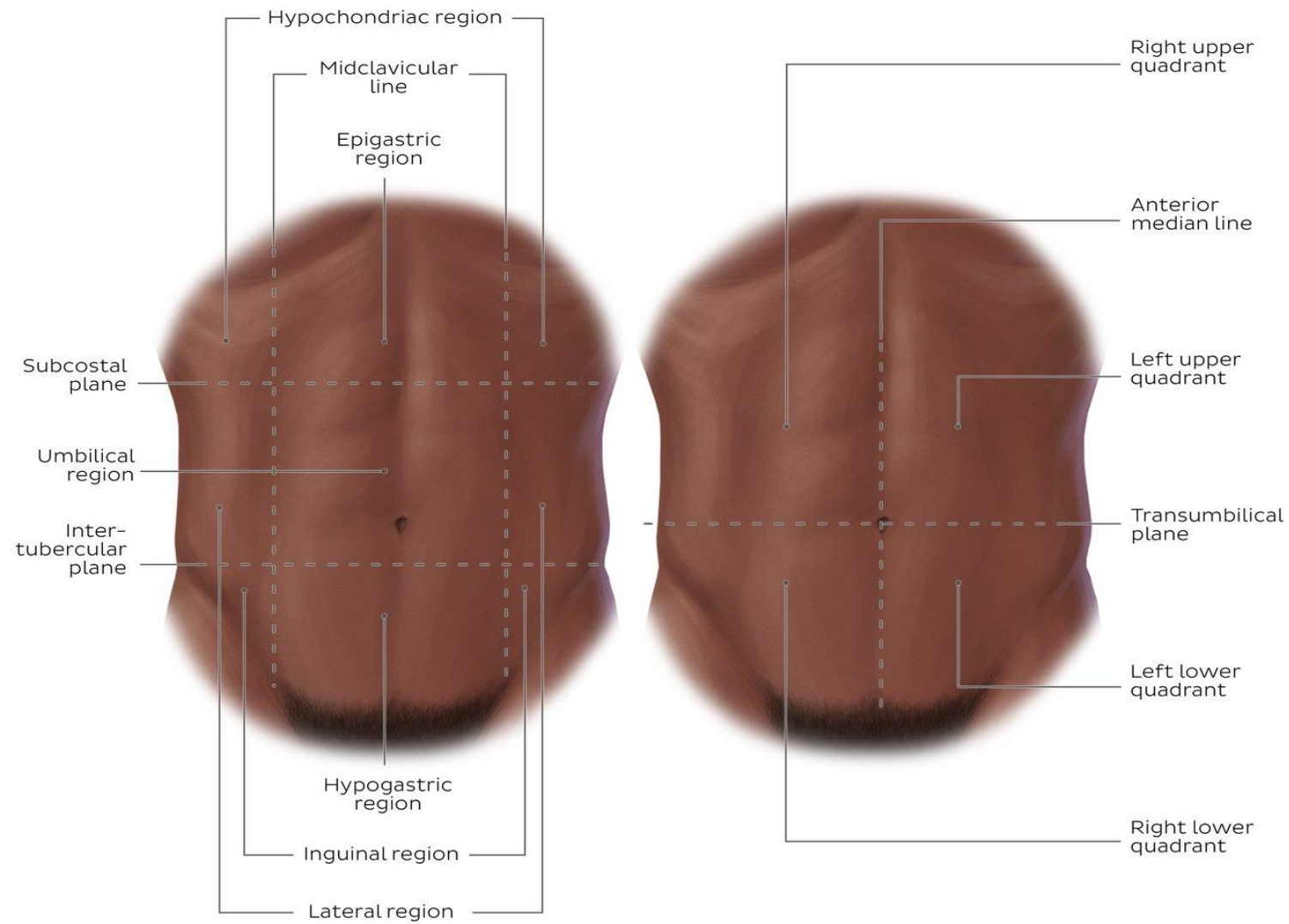
*The anterolateral abdominal wall can be divided into several topographical areas, which are used to describe the location of abdominal organs and the pain associated with them:*



### Nine abdominopelvic regions

which are divided horizontally by the superior subcostal plane, which passes right under the costal margins of the 10th ribs, and the inferior intertubercular plane, which connects the tubercles of the iliac crest.

Vertically they are divided by the two midclavicular planes which pass through the midpoint of each clavicle and halfway between the pubic symphysis and the anterior superior iliac spine. The four planes create nine abdominal regions as you see in the picture: hypochondriac (right, left) and epigastric regions superiorly, flanks (right, left) and umbilical region in the middle, groin (right, left) and hypogastric region inferiorly.





# Stomach

The stomach is a hollow muscular organ positioned between the esophagus and duodenum. It has a characteristic J-shape created by two unequal curvatures (greater and lesser curvatures). The four main anatomical parts include the **cardia, fundus, body, and pyloric part**. Similar to the other parts of the gastrointestinal tract, the stomach also comprises four histological layers. From interior to exterior, these layers include the mucosa, submucosa, muscular coat and serosa.

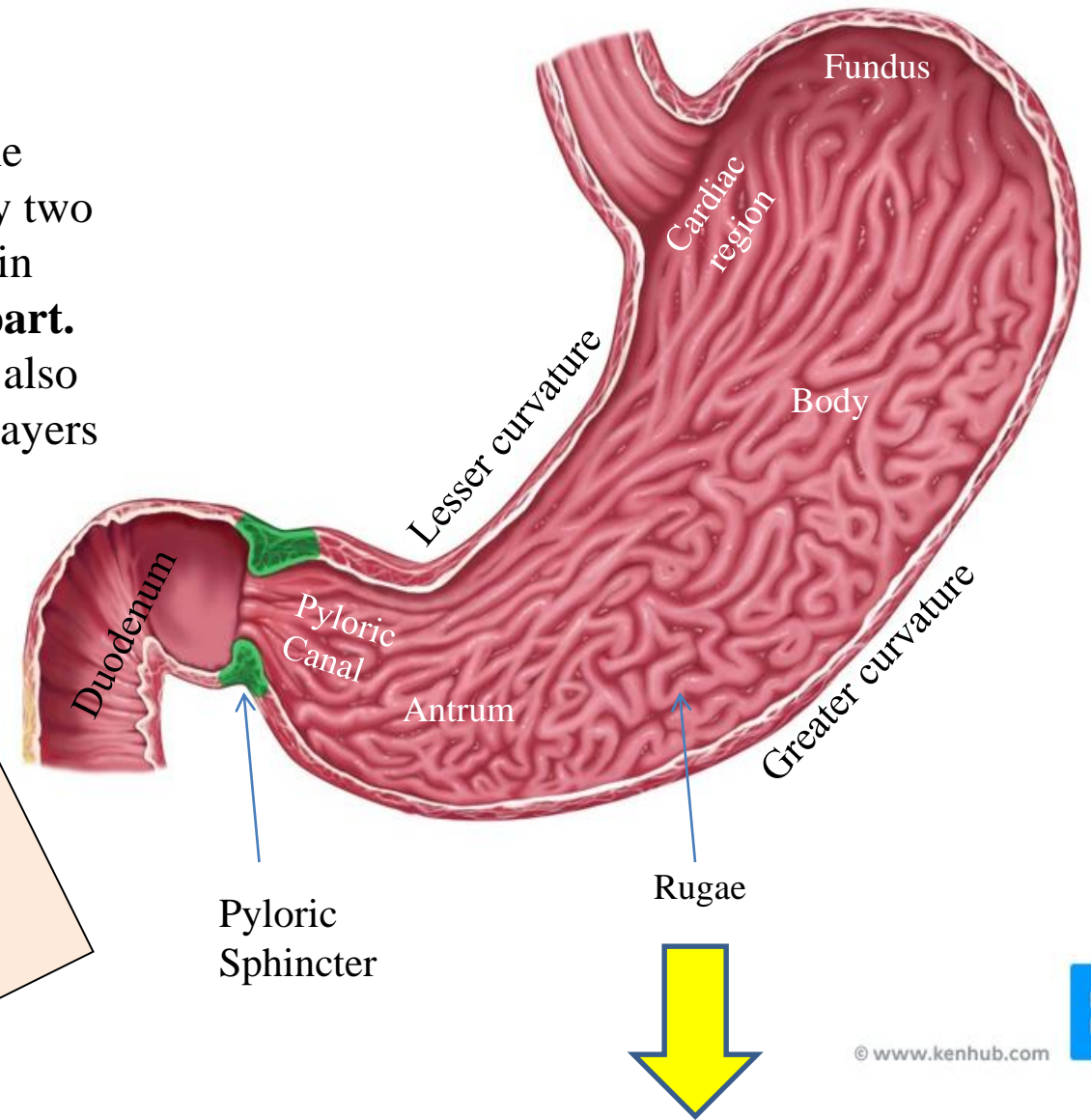
\* J-shaped; widest part of alimentary canal

## Stomach regions

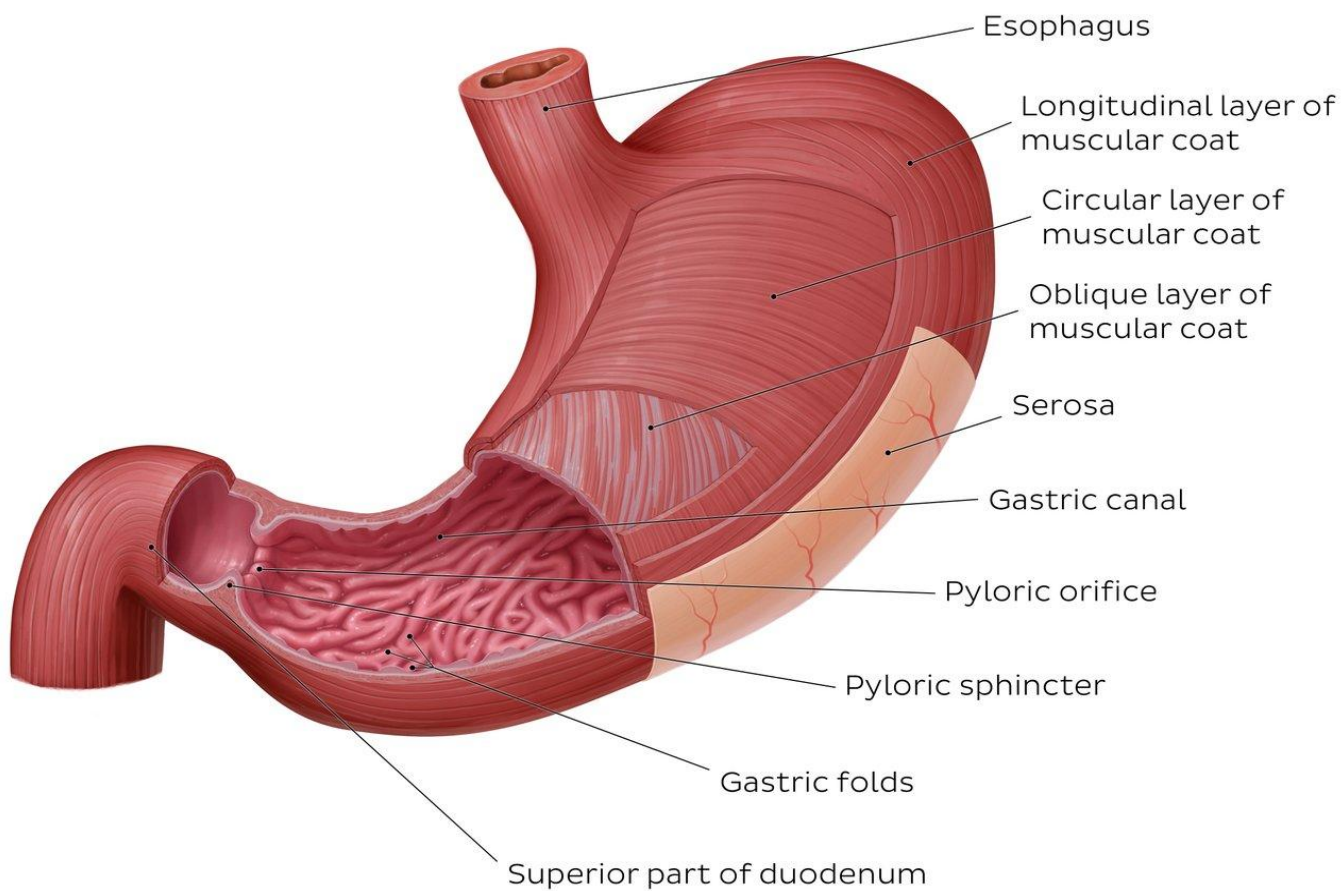
- Cardiac region
- Fundus (dome-shaped)
- Body
  - Greater curvature
  - Lesser curvature
- Pyloric region
  - Antrum
  - Canal
  - Sphincter

Stomach lies mostly in epigastric, umbilical, and left hypochondriac regions, inferior to diaphragm, anterior to spleen and pancreas

Capacity: max 2 L



**Rugae** are longitudinal folds on internal surface when stomach is empty (helps distensibility)

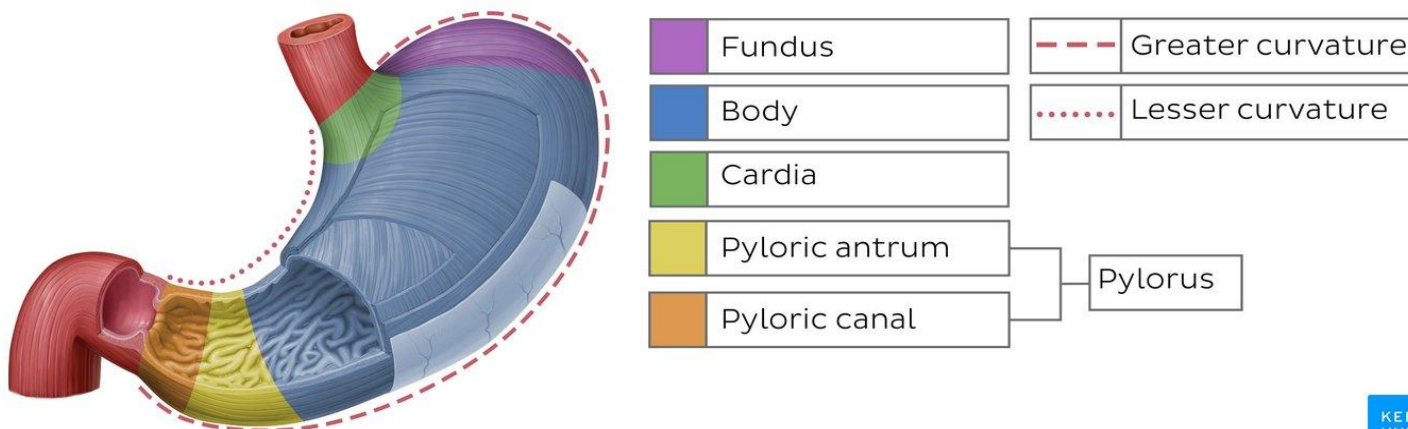


**Note:**

The muscular coat is further divided into three separate layers: oblique, circular and longitudinal layers. The main function of the stomach involves the mechanical and chemical digestion of ingested food.

Stomach acts in mechanical and chemical digestion, the cells work together to produce gastric juice which breaks down proteins into small polypeptides

The mixing of gastric juice and food produces a fluid like substance called **chyme**





# Small intestine

- ✓ **Location.** The small intestine is a muscular tube extending from the pyloric sphincter to the ileocecal junction
- ✓ **Size.** 6-7 m
- ✓ Most enzymes are secreted by *pancreas*, not small intestine
- ✓ The main functions of the small intestine are to complete digestion of food and to absorb nutrients.
- ✓ 3-6 hour process

The small intestine has three subdivisions:

**Duodenum** (5 percent)

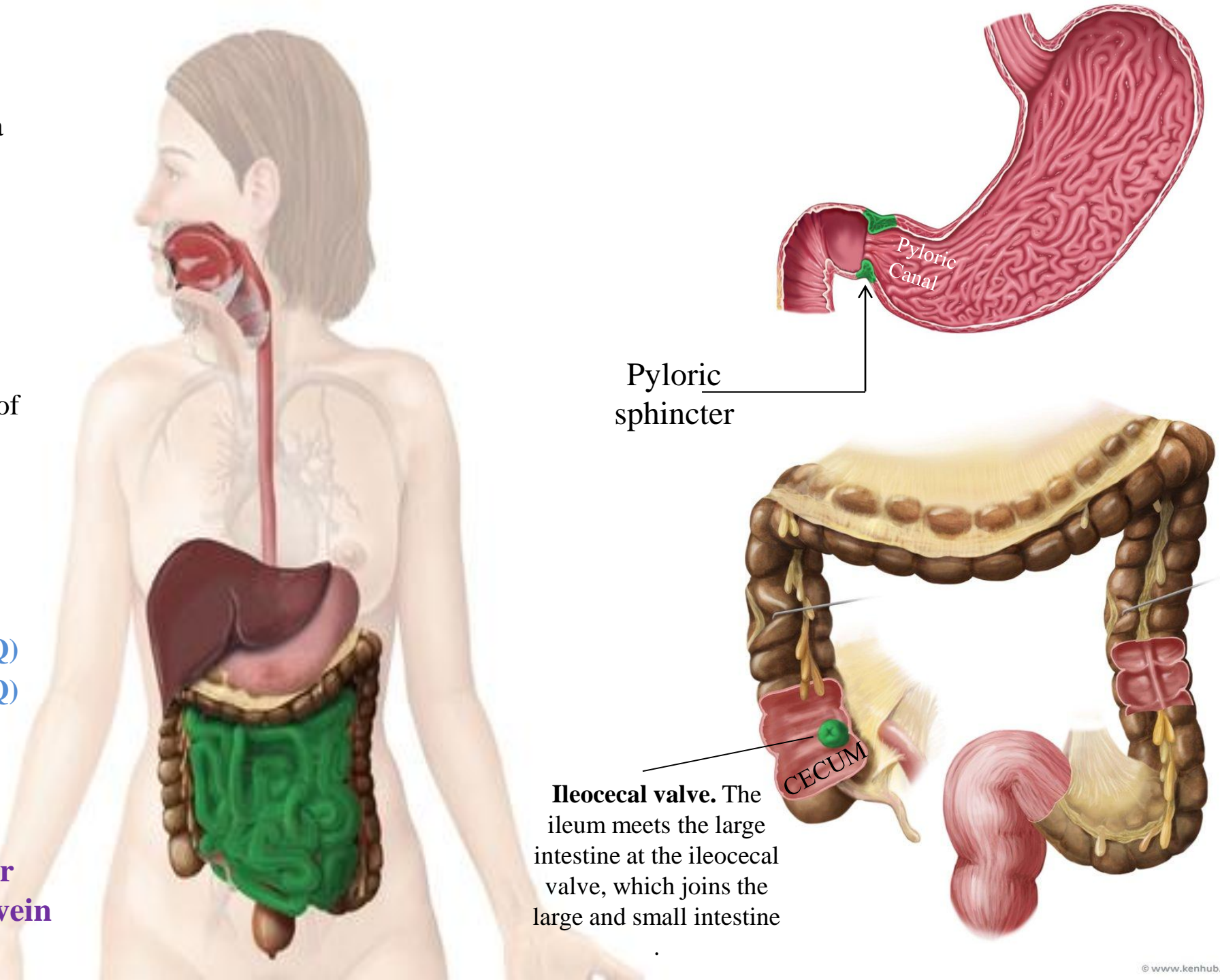
**Jejunum** (nearly 40 percent) (LUQ)

**Ileum** (nearly 60 percent) (RLQ)

**Blood supply:** **Superior mesenteric artery**

**Venous drainage:** **Superior mesenteric vein** → **portal vein**

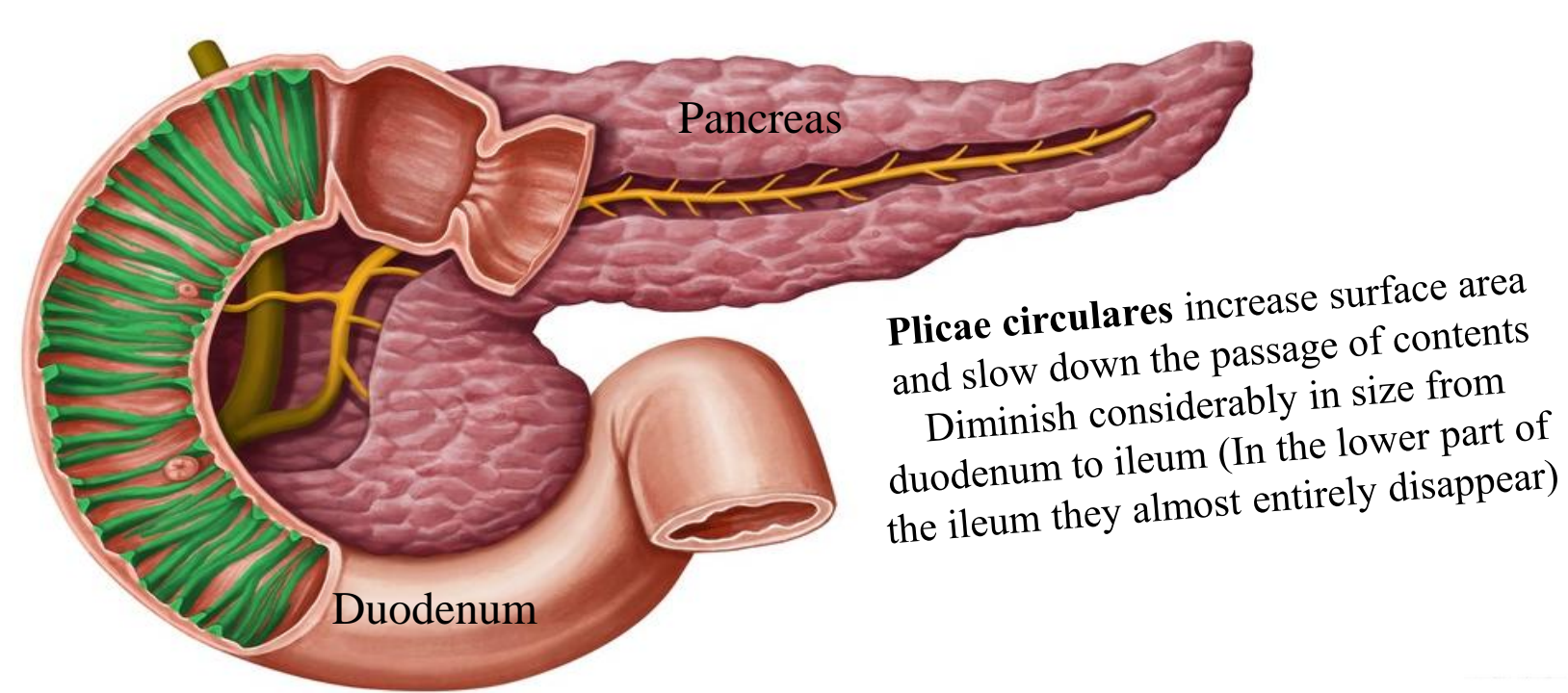
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Pyloric  
sphincter

**Ileocecal valve.** The ileum meets the large intestine at the ileocecal valve, which joins the large and small intestine





**Villi**

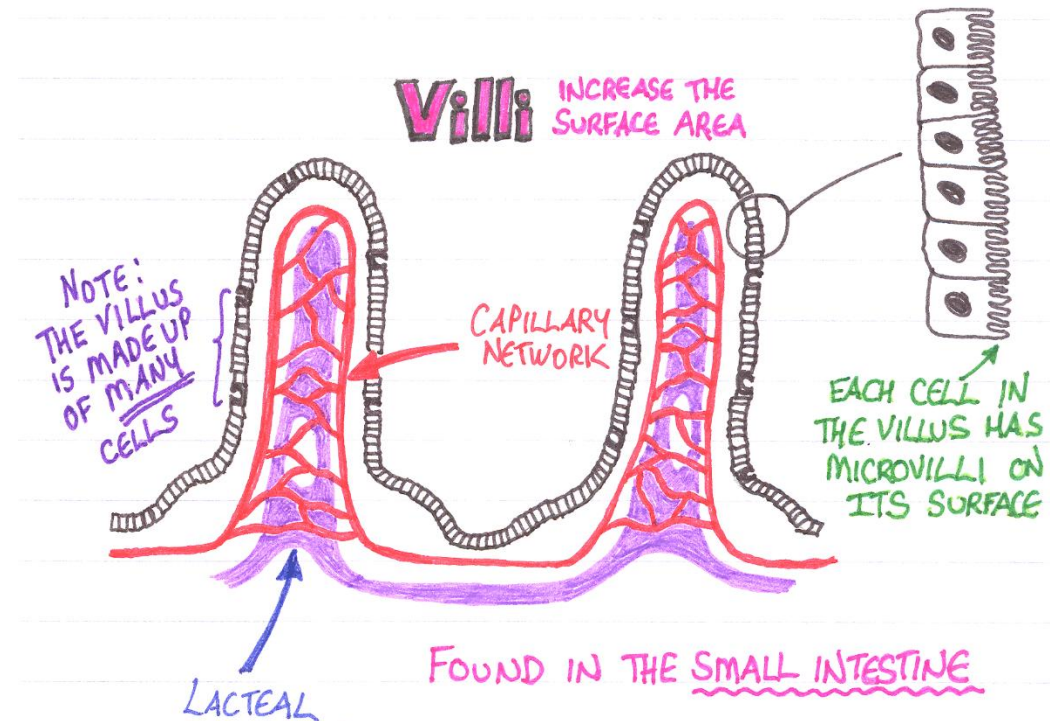


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**Microvilli.** Microvilli are tiny projections of the plasma membrane of the mucosa cells that give the cell surface a fuzzy appearance (**brush border**); the plasma membranes bear enzymes (brush border enzymes) that complete the digestion of proteins and carbohydrates in the small intestine

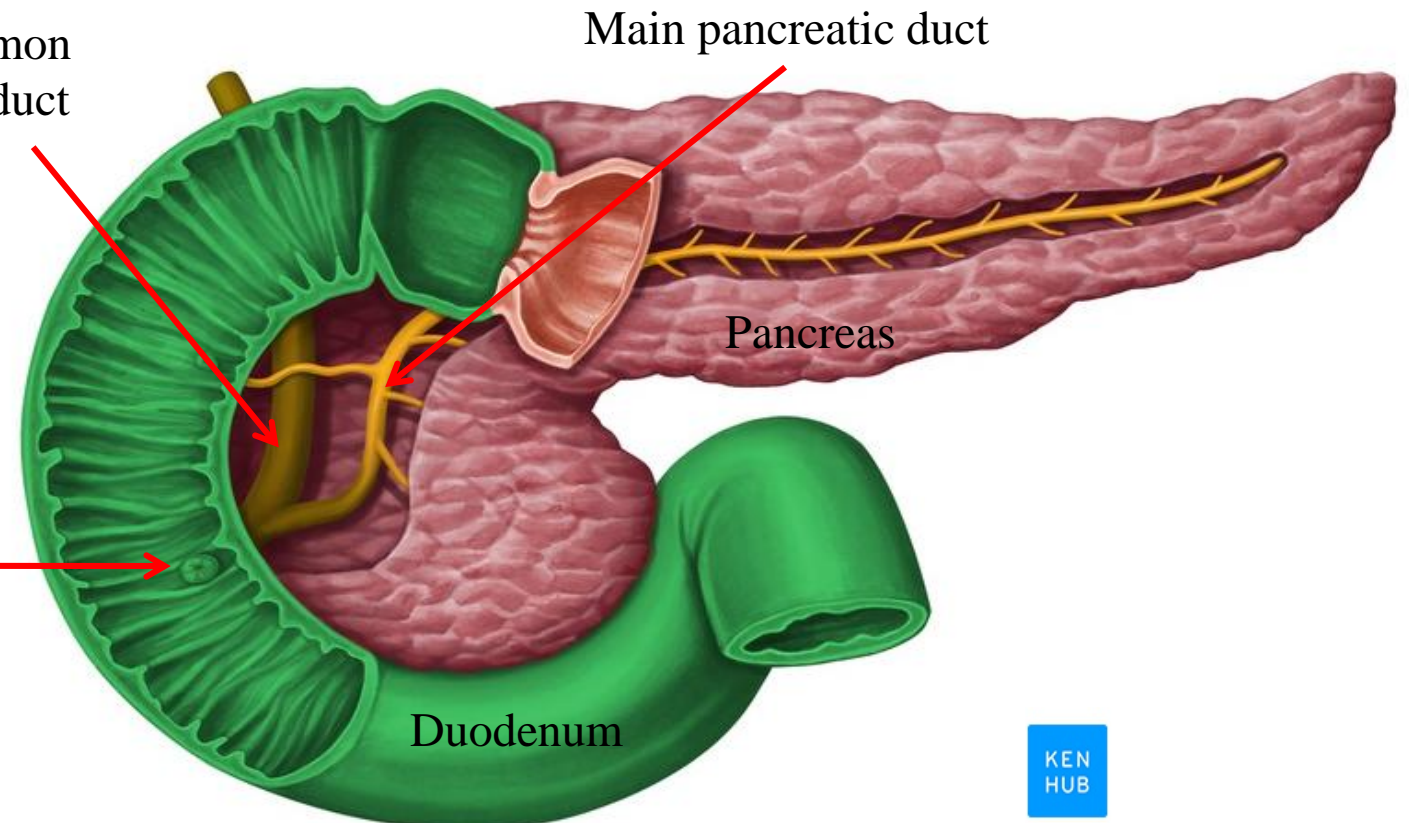
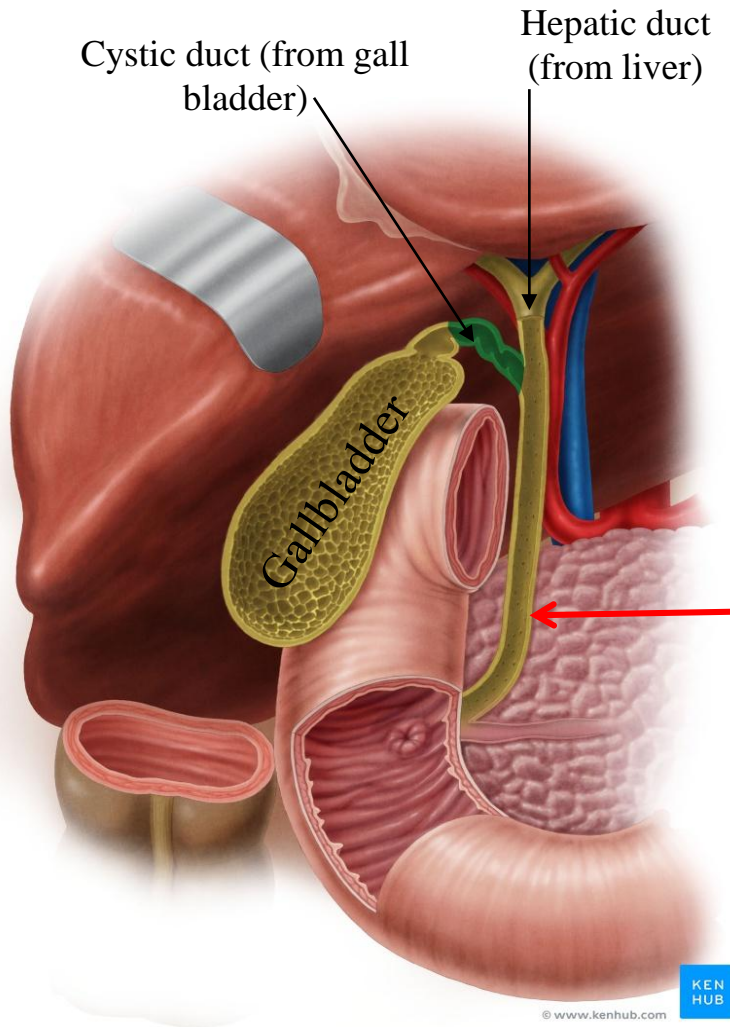
**Villi.** Villi are fingerlike projections of the mucosa (epithelium and lamina propria) that give it a velvety appearance and feel (*much like the soft nap of a towel*)

**Circular folds (plicae circulares)** are deep folds of both mucosa and submucosa layers, and they do not disappear when food fills the small intestine (permanent folds).



**Bile:** from liver and gallbladder via common bile duct  
**Digestive Enzymes:** from pancreas via main pancreatic duct

The main pancreatic and common bile ducts join. From there, the bile and pancreatic juice travel through the **duodenal papilla** and enter the duodenum together

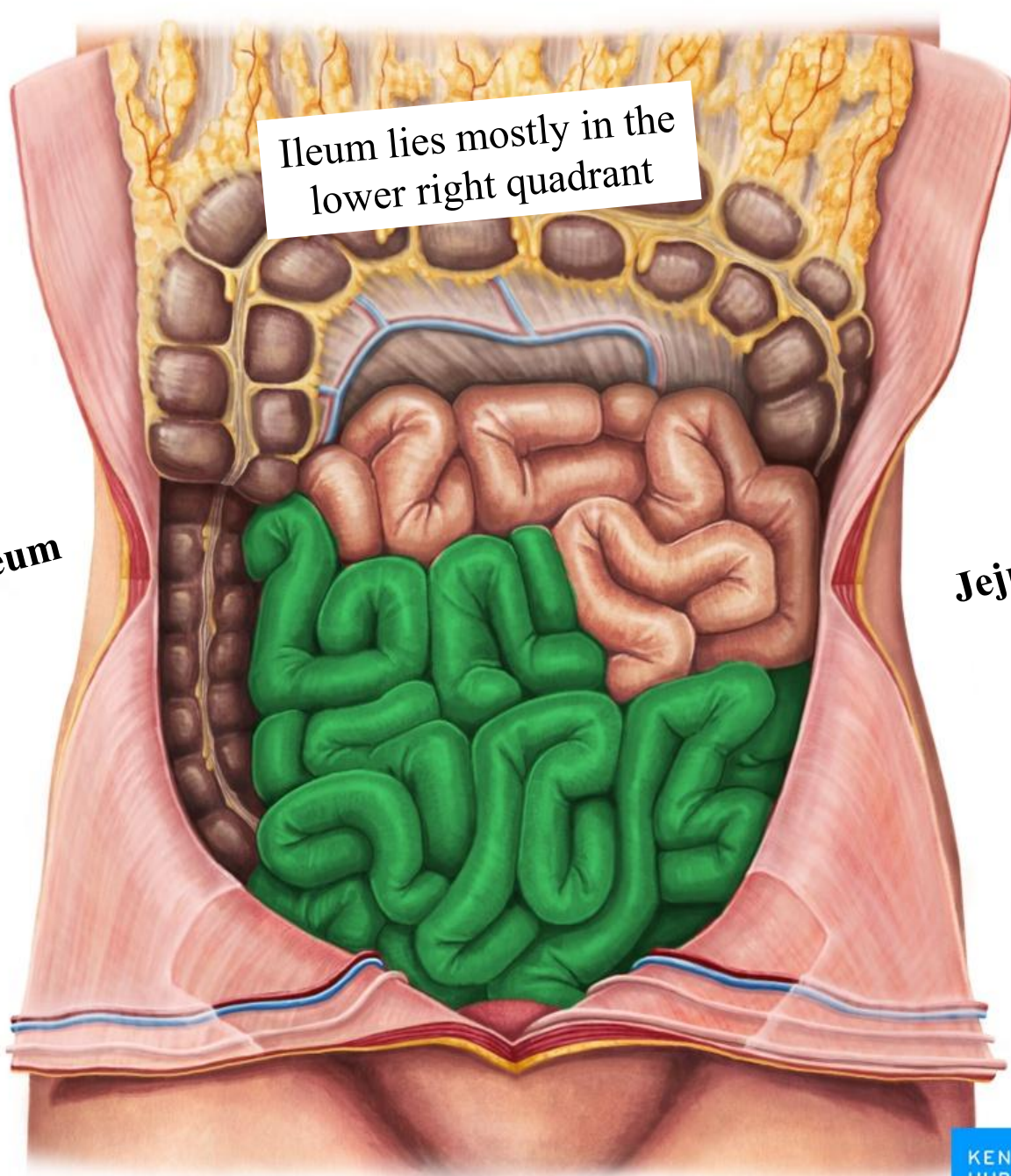


Duodenum is retroperitoneal C-shaped tube



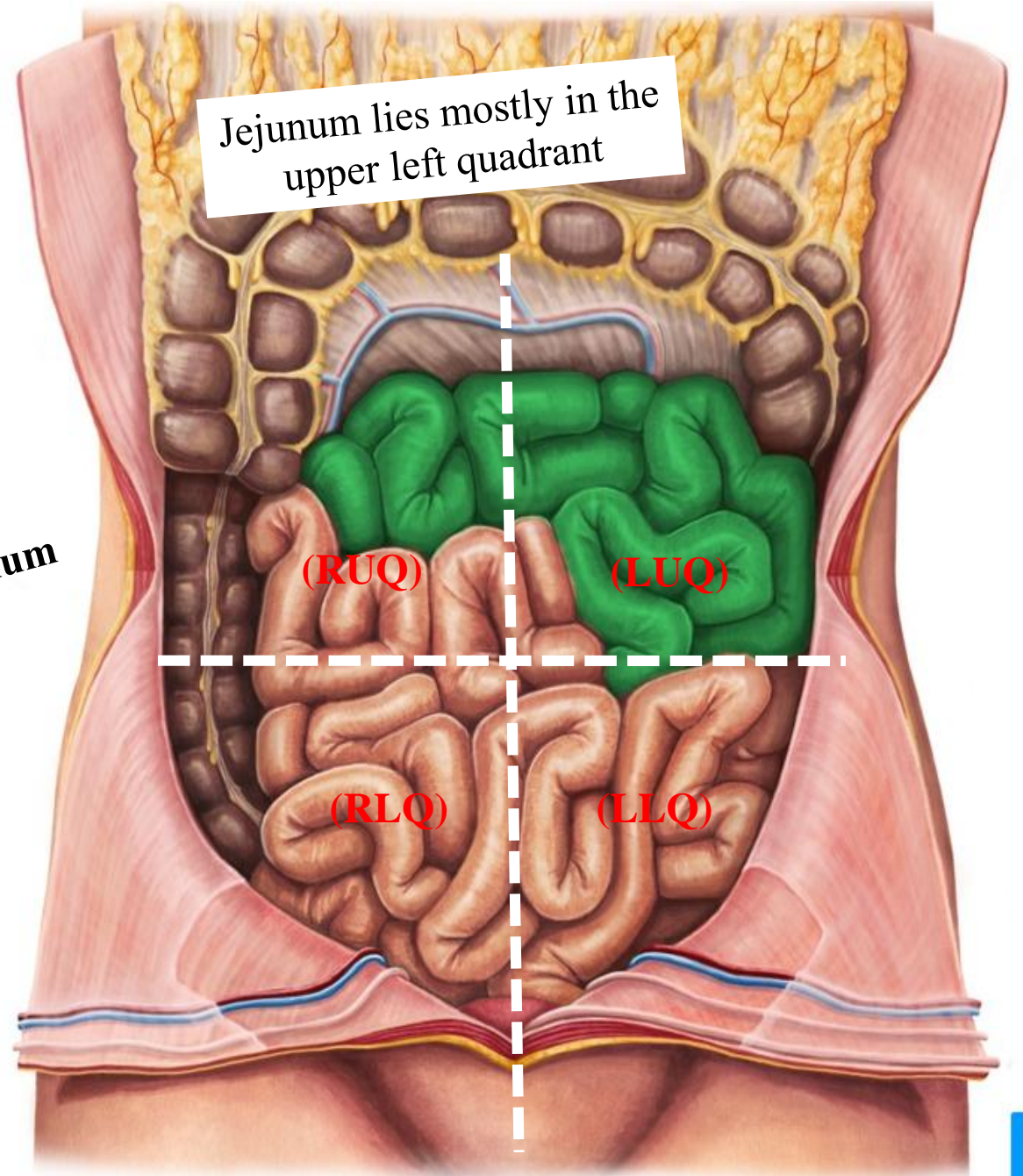
Ileum lies mostly in the lower right quadrant

Ileum



Jejunum lies mostly in the upper left quadrant

Jejunum





# Large intestine

- ✓ Situated between the terminal end of ileum and anus
- ✓ About **1.5 m** (5 feet) long
- ✓ Shorter and less convoluted than small intestine
- ✓ Consists of:

**Cecum**

**Ascending colon**

**Transverse colon**

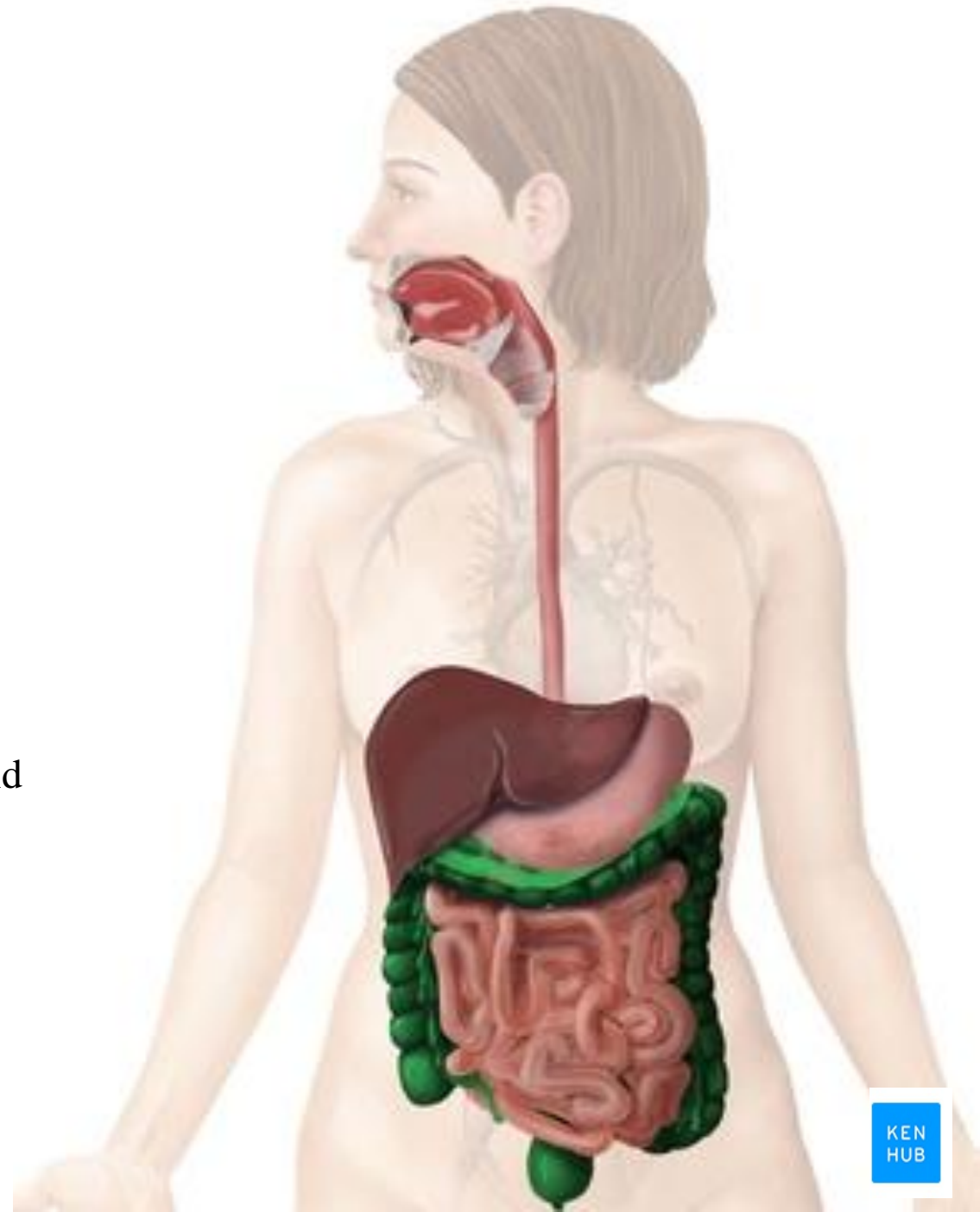
**Descending colon**

**Sigmoid colon**

**Rectum**

**Anal canal**

- ✓ Semifluid chyme enters through ileocecal valve
- ✓ At terminal end, semifluid residues become semisolid feces
- ✓ Main function is the absorption of water and electrolytes



**Cecum.** The saclike cecum is the first part of the large intestine.

**Appendix.** Hanging from the cecum is the wormlike appendix, high concentration of lymphatic nodules (a potential trouble spot because it is an ideal location for bacteria to accumulate and multiply).

**Ascending colon.** The ascending colon travels up the right side of the abdominal cavity and makes a turn, the **right colic (or hepatic) flexure**.

**Transverse colon.** The ascending colon makes a turn and continue to be the transverse colon as it travels across the abdominal cavity.

**Descending colon.** It then turns again at the **left colic (or splenic) flexure**, and continues down the left side as the descending colon.

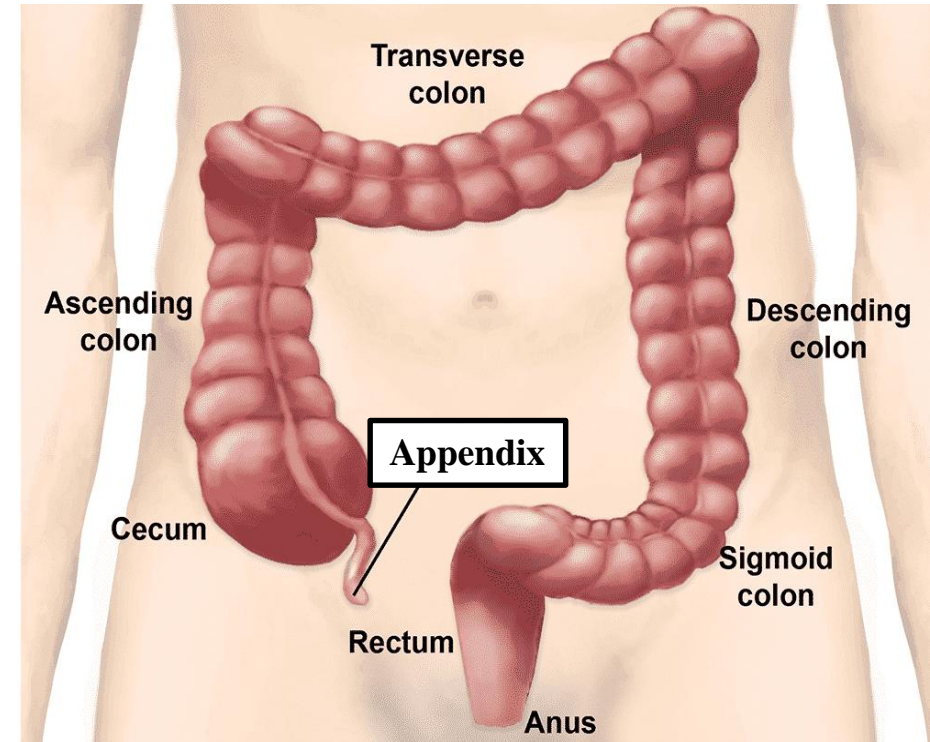
**Sigmoid colon.** The intestine then enters the pelvis, where it becomes the S-shaped sigmoid colon.

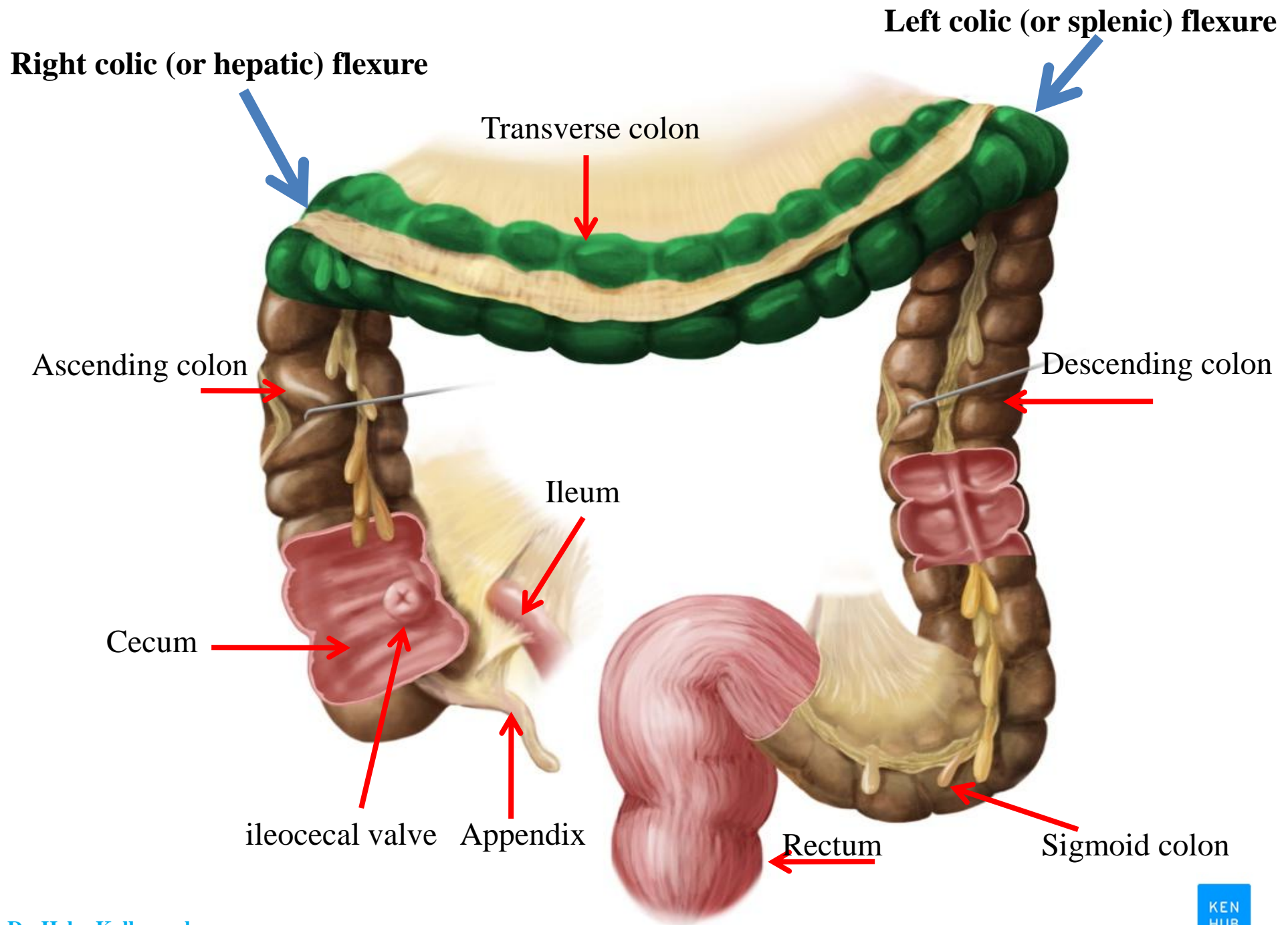
**Rectum:** anterior to the sacrum and coccyx. The terminal 2–3 cm of the rectum is called the **anal canal**

**Anal canal.** The anal canal ends at the anus which opens to the exterior.

**Internal anal sphincter.** The internal involuntary sphincter is formed by **smooth muscles**

**External anal sphincter.** The anal canal has an external voluntary sphincter, the external anal sphincter, composed of **skeletal muscle**.

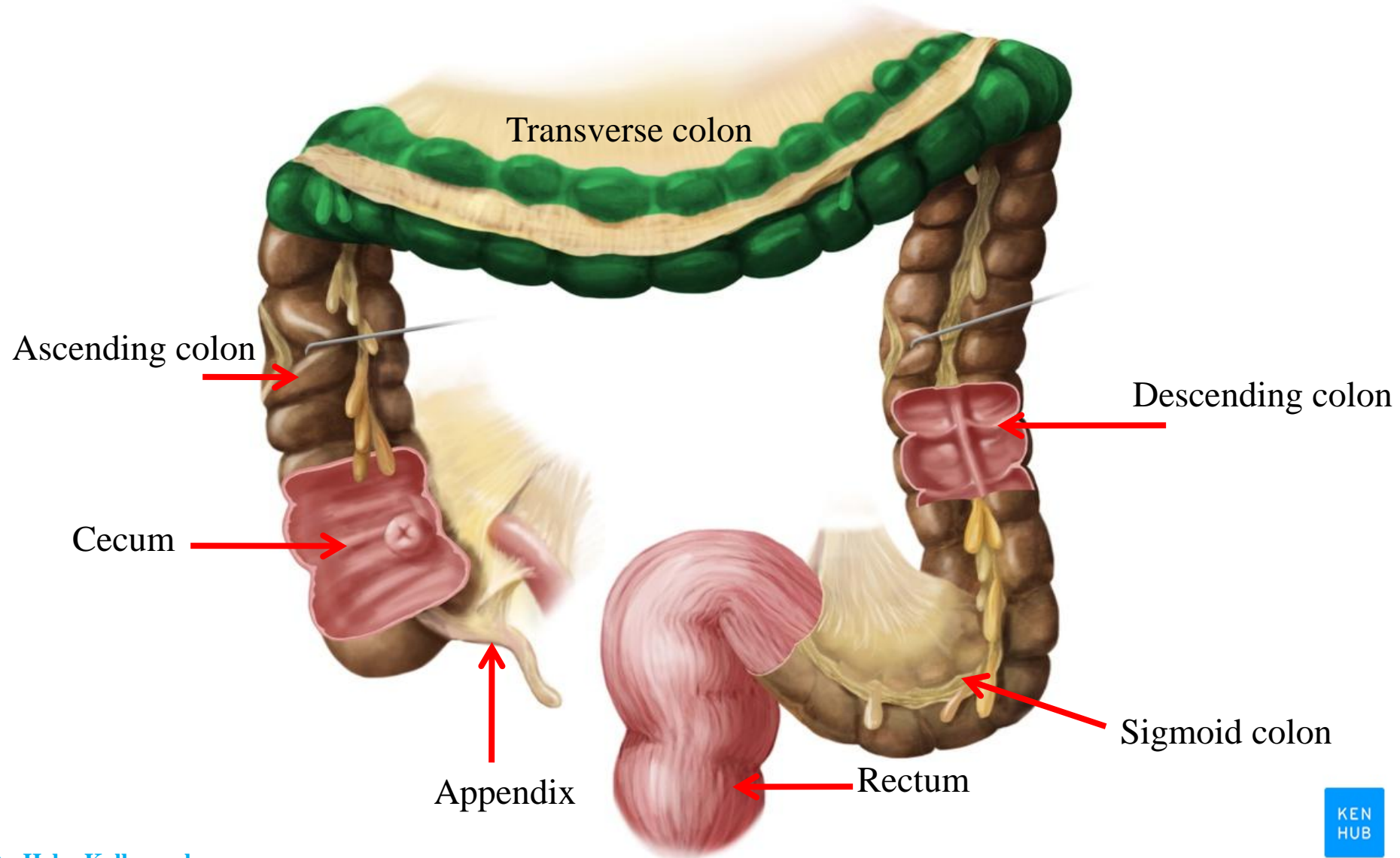






**Retroperitoneal organs** in general do not have a complete covering of peritoneum, so they are fixed in location. **Intraperitoneal organs** are completely surrounded by peritoneum and are therefore mobile

The ascending colon, descending colon and rectum **are retroperitoneal**, while the cecum, appendix, transverse colon and sigmoid colon **are intraperitoneal**

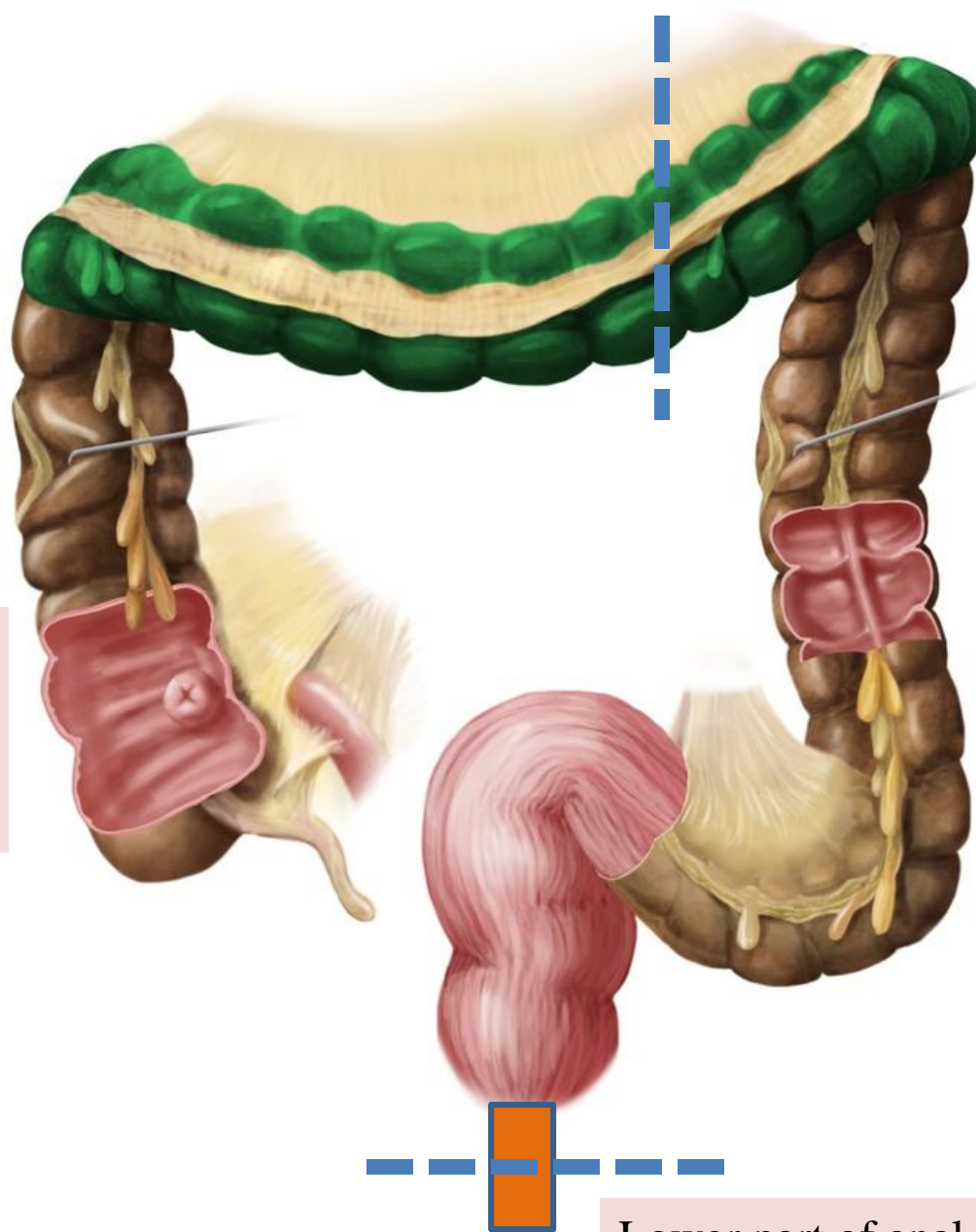


Blood supply:  
**superior mesenteric  
artery**

Veins drain into  
Superior mesenteric  
vein

↓  
portal vein  
(Portal circulation)

From the distal ½ of  
the duodenum to the  
proximal 2/3 of the  
transverse colon



Blood supply:  
**inferior mesenteric  
artery**

Veins drain into  
Inferior mesenteric  
vein

↓  
portal vein  
(Portal circulation)

The distal 1/3 of the  
transverse colon, splenic  
flexure, descending colon,  
sigmoid colon, rectum,  
upper part of anal canal

Lower part of anal canal

Blood supply: **branches from internal iliac artery**

Veins drain into **internal iliac vein—common iliac vein---IVC (Systemic circulation)**



**Rectum** begins in front of the third sacral vertebra as a continuation of the sigmoid colon

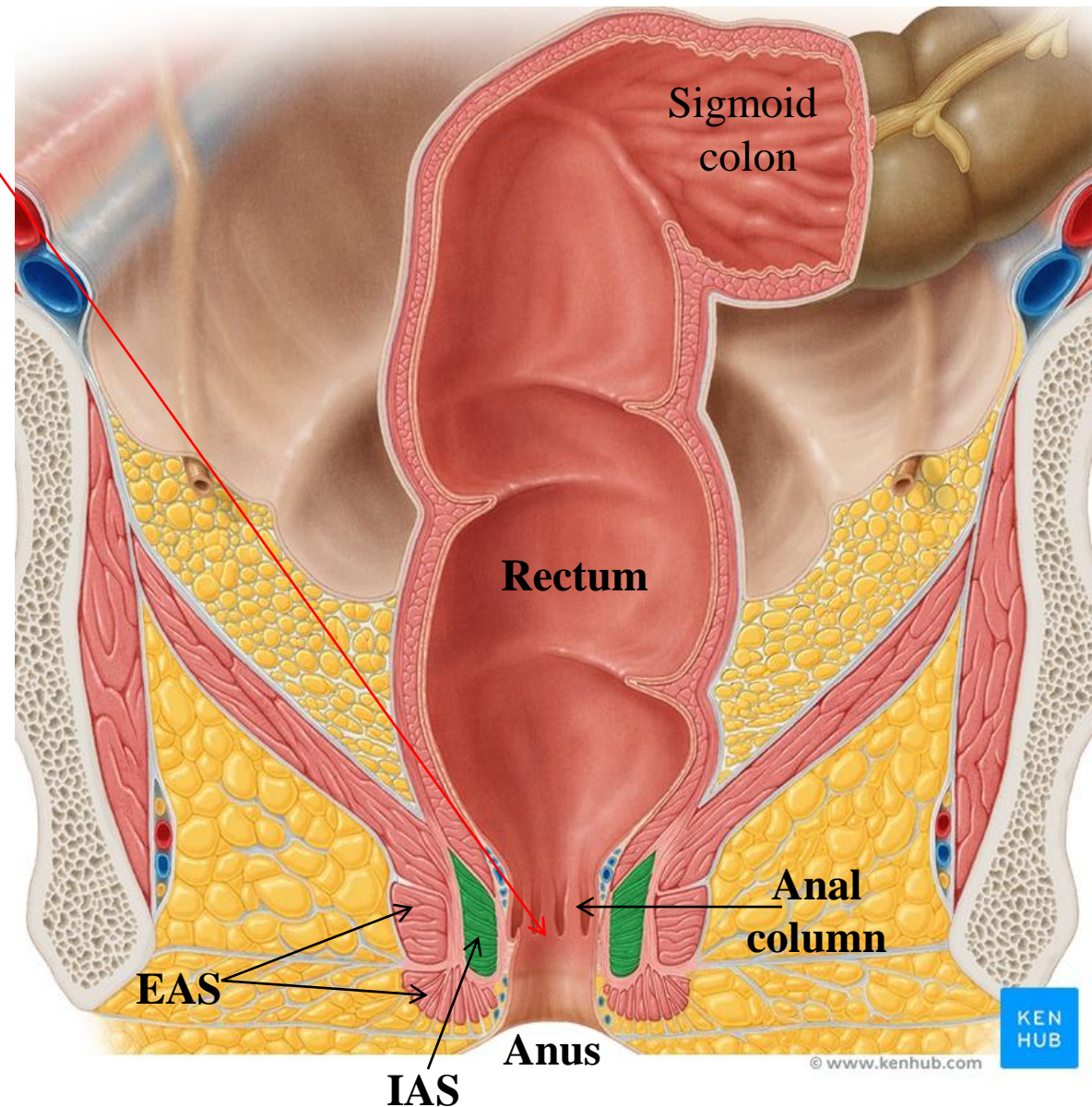
**Anal canal.** The mucous membrane of the anal canal is arranged in longitudinal folds called **anal columns** that contain a network of arteries and veins

**Anus:** opening of the anal canal to the exterior, guarded by an **internal anal sphincter** and an **external anal sphincter**

**Clinical notes:**

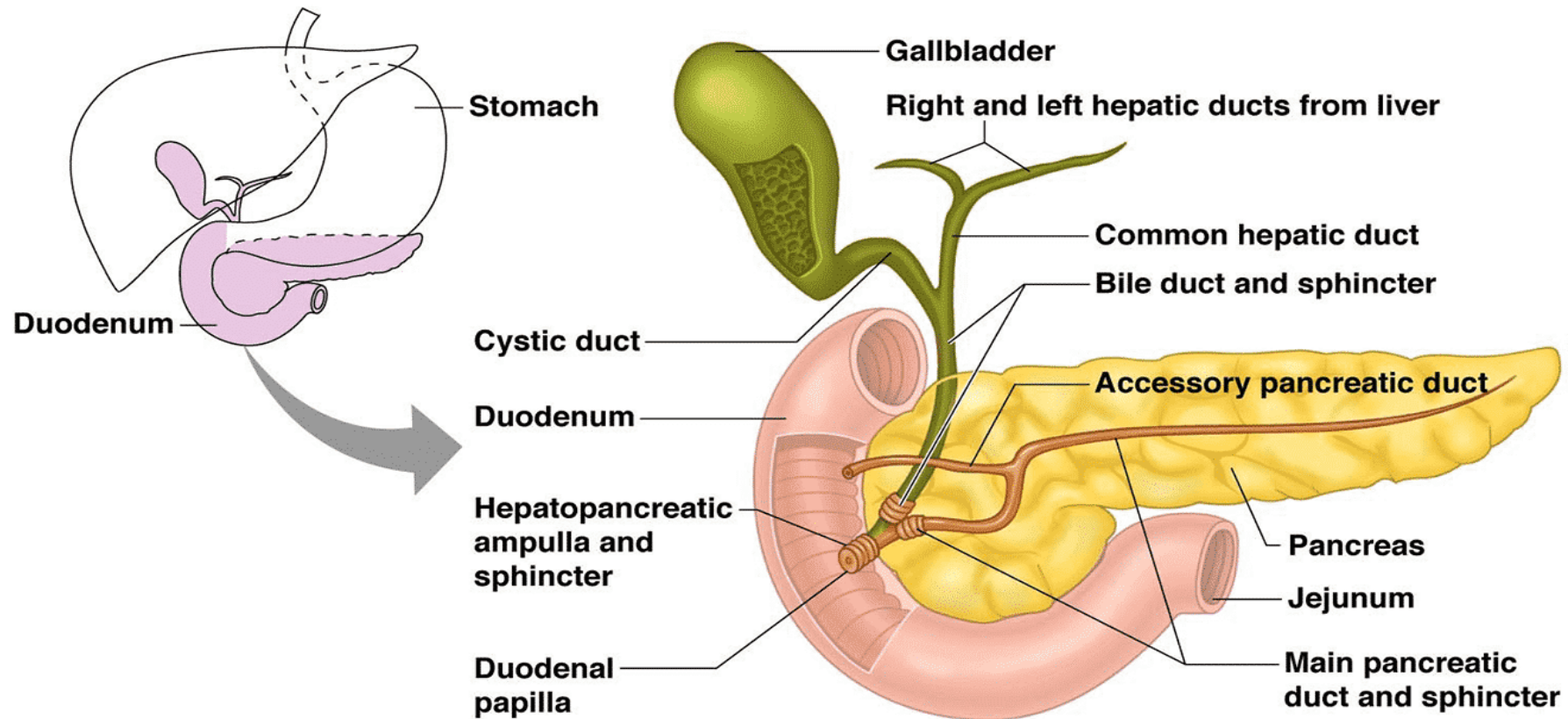
**Hemorrhoids** (piles) are swollen veins in anus and lower rectum, similar to varicose veins.

**Hemorrhoids** can develop inside the rectum (internal **hemorrhoids**) or under the skin around the anus (external **hemorrhoids**).



Except during defecation, the anal canal is collapsed by the internal and external anal sphincters to prevent the passage of faecal material.

# Pancreas, Gallbladder, and Liver

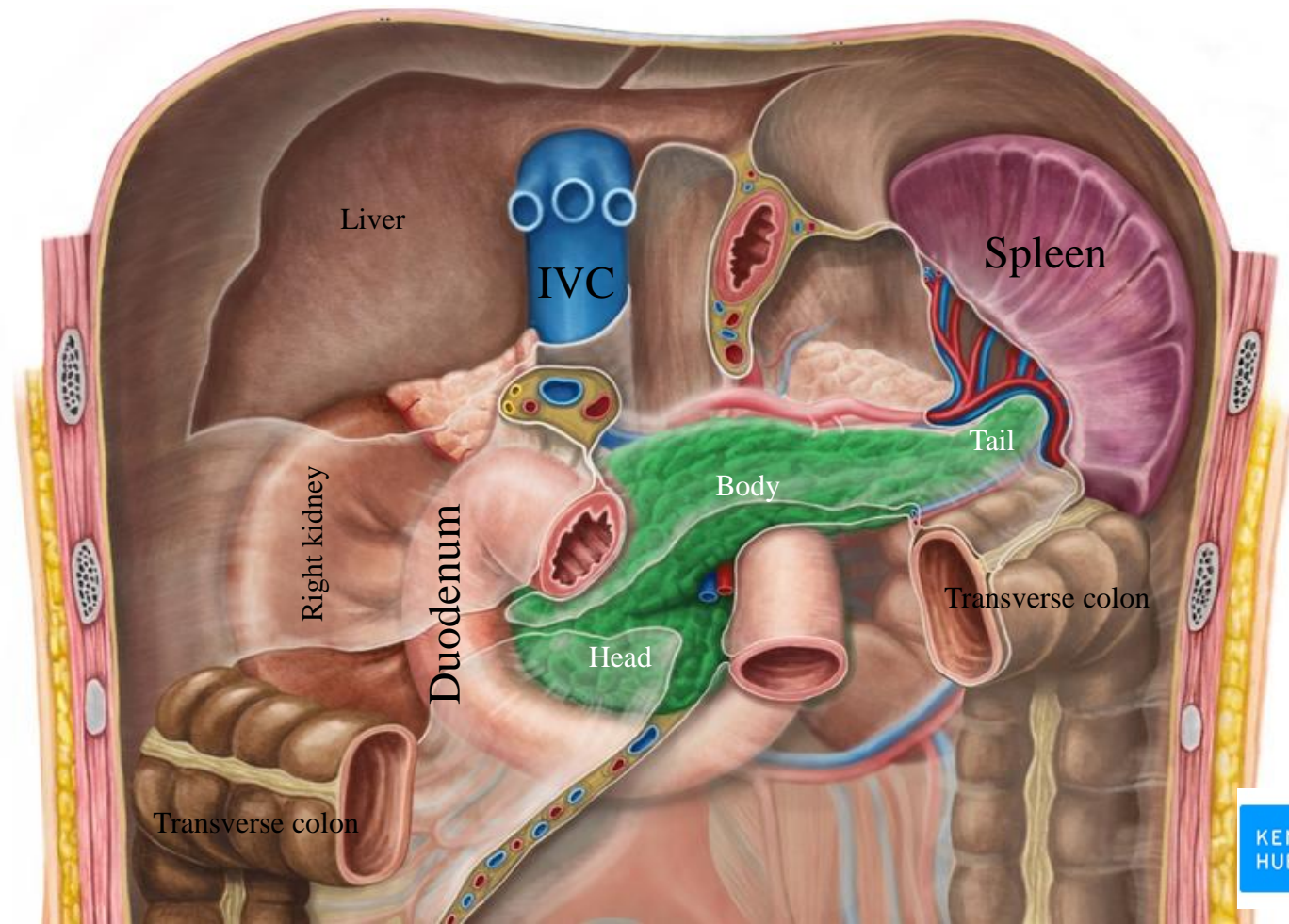




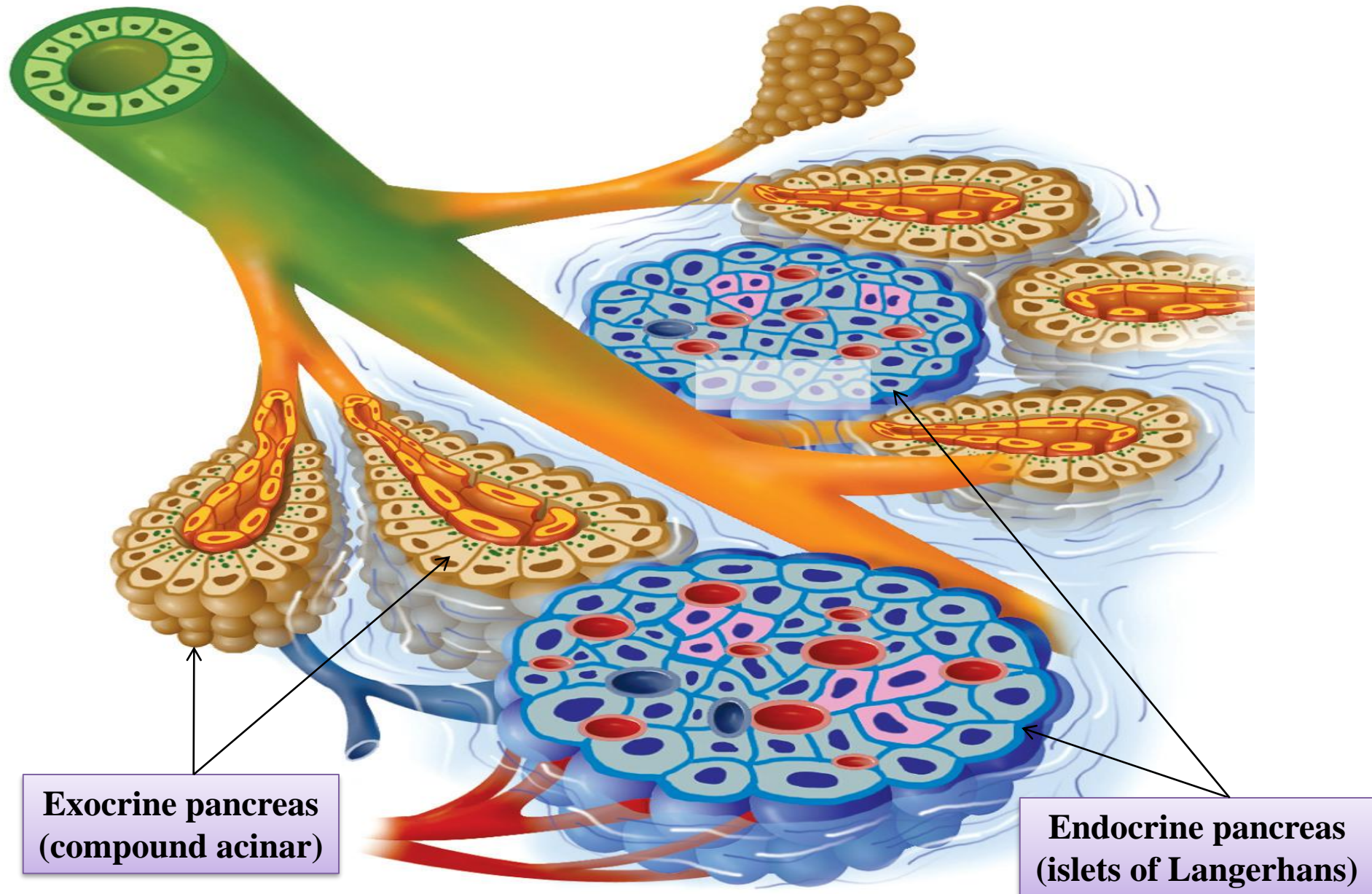
# Pancreas

**Location.** The pancreas is a soft, triangular gland that extends across the abdomen from the spleen to the duodenum; but most of the pancreas lies posterior to the parietal peritoneum, hence its location, it is referred to as **retroperitoneal**.

Has a head, body and tail

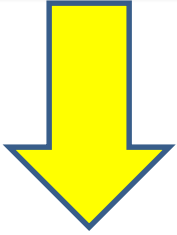


The pancreas is a mixed organ; it contains both endocrine and exocrine components.



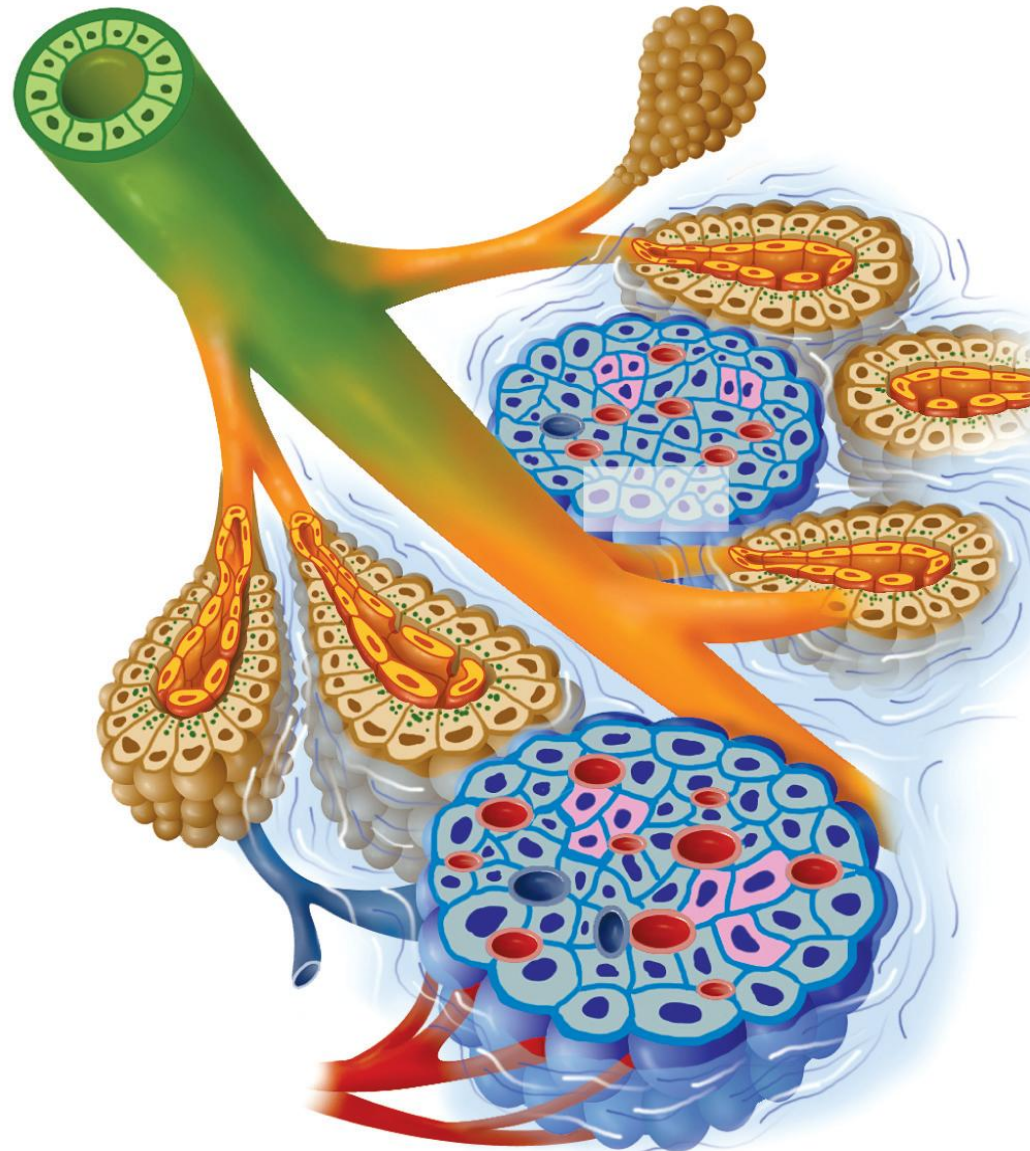


## Exocrine pancreas

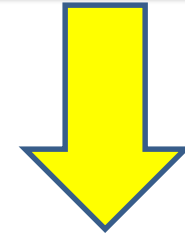


**Produces numerous digestive enzymes that exit the gland through an excretory duct (main pancreatic duct)**

The pancreatic enzymes are secreted into the duodenum in an alkaline fluid that neutralizes the acidic chyme coming in from the stomach.



## Endocrine pancreas (pancreatic islets)



**Produces different hormones which are transported from the pancreas via numerous blood vessels  
(**Insulin & Glucagon**)**

# The liver

The liver is the largest gland in the body (about 1.4 kg)

**Location.** Inferior to diaphragm in RUQ protected by ribs

**Hepatocytes.** Liver cells

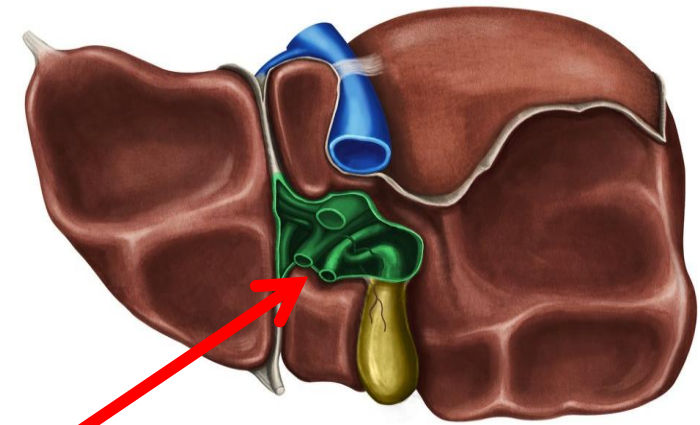
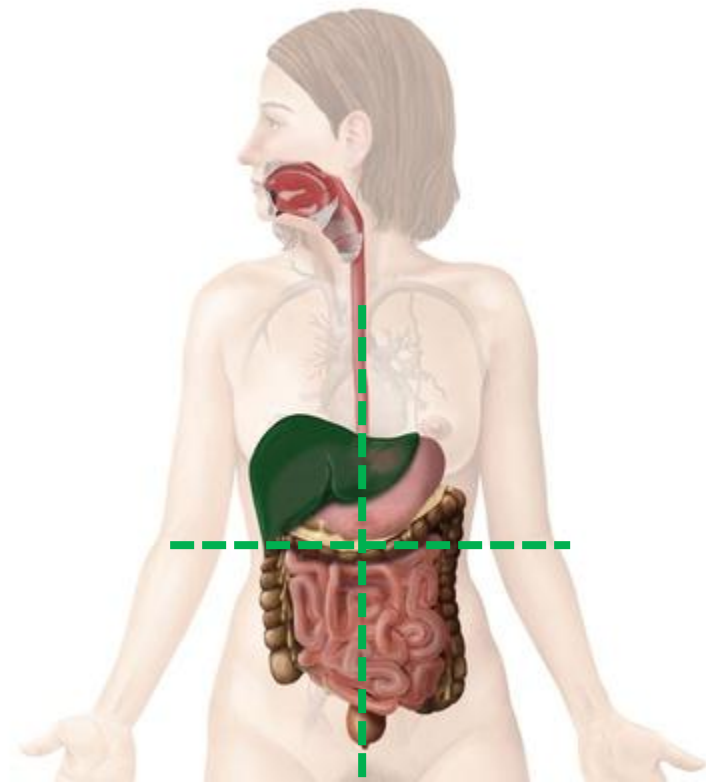
**Falciform ligament.** The liver has four lobes and is suspended from the diaphragm and abdominal wall by the falciform ligament.

**Function.** The liver's digestive function is to produce bile.

**Bile.** Bile is a yellow-to-green, watery solution containing bile salts, bile pigments, cholesterol, phospholipids, and a variety of electrolytes.

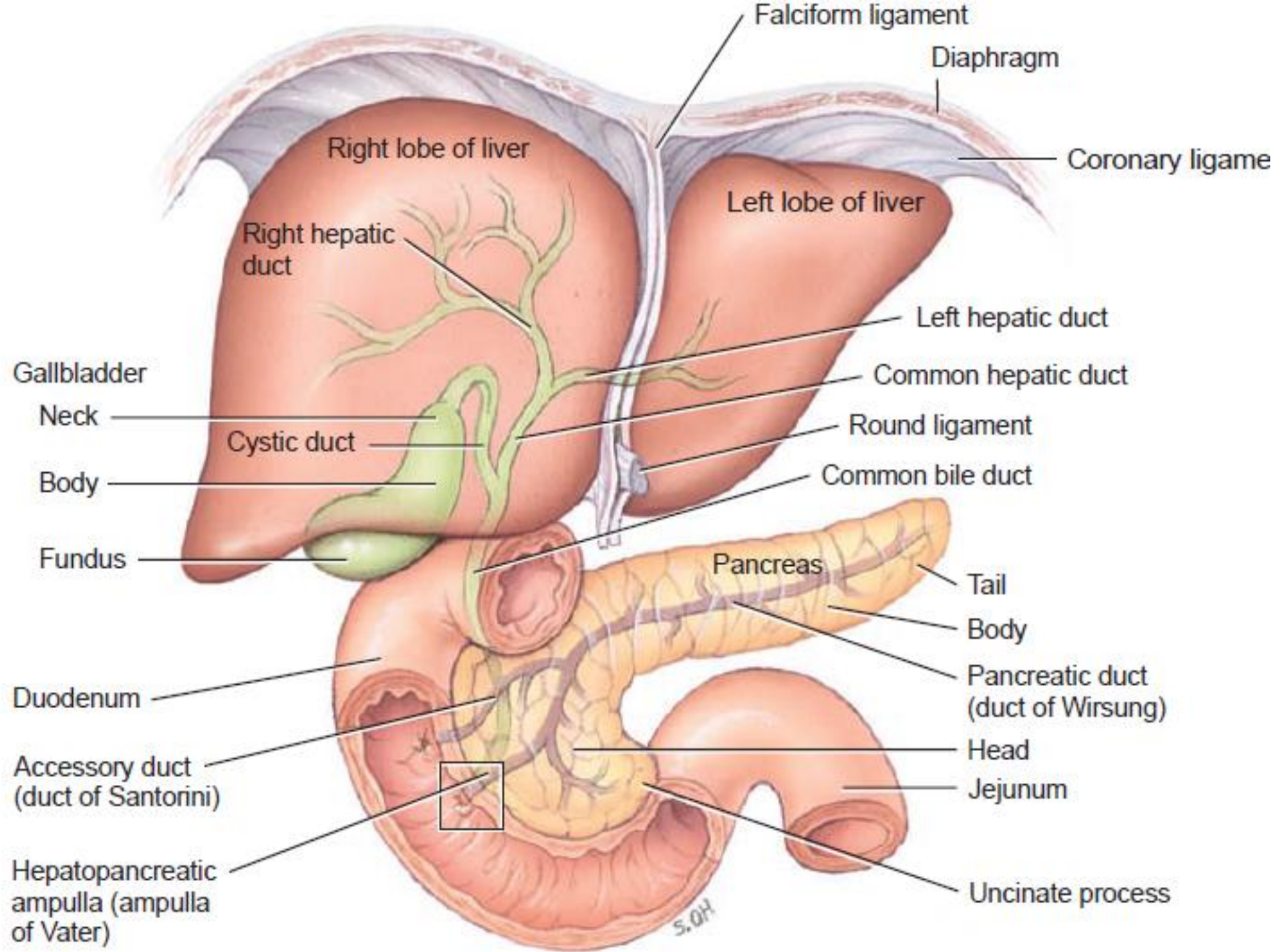
**Bile salts.** Bile does not contain enzymes but its bile salts emulsify fats by physically breaking large fat globules into smaller ones, thus providing more surface area for the fat-digesting enzymes to work on.

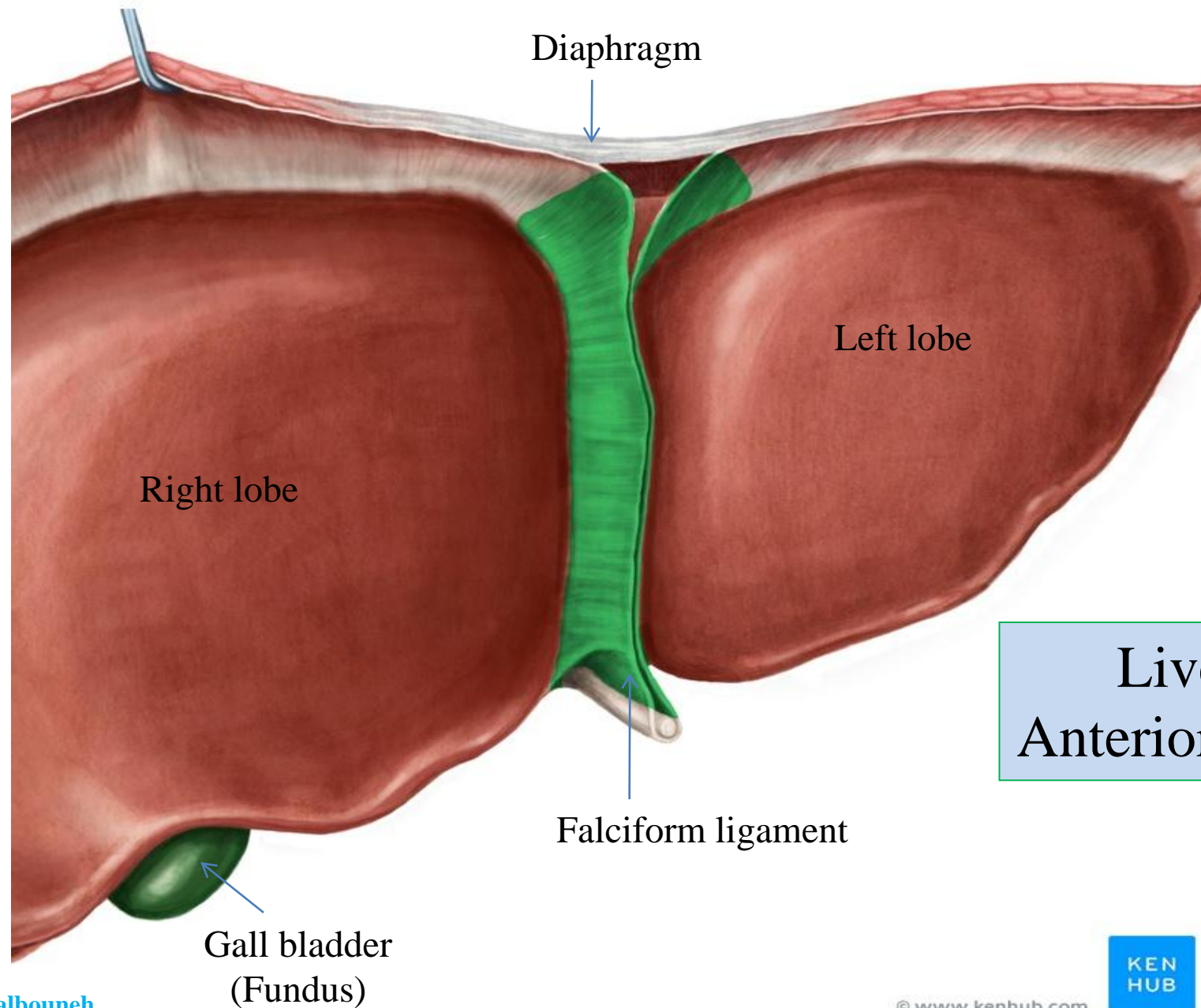
**Porta hepatis:** major vessels, lymphatics and nerves enter and leave the liver



**Porta hepatis**









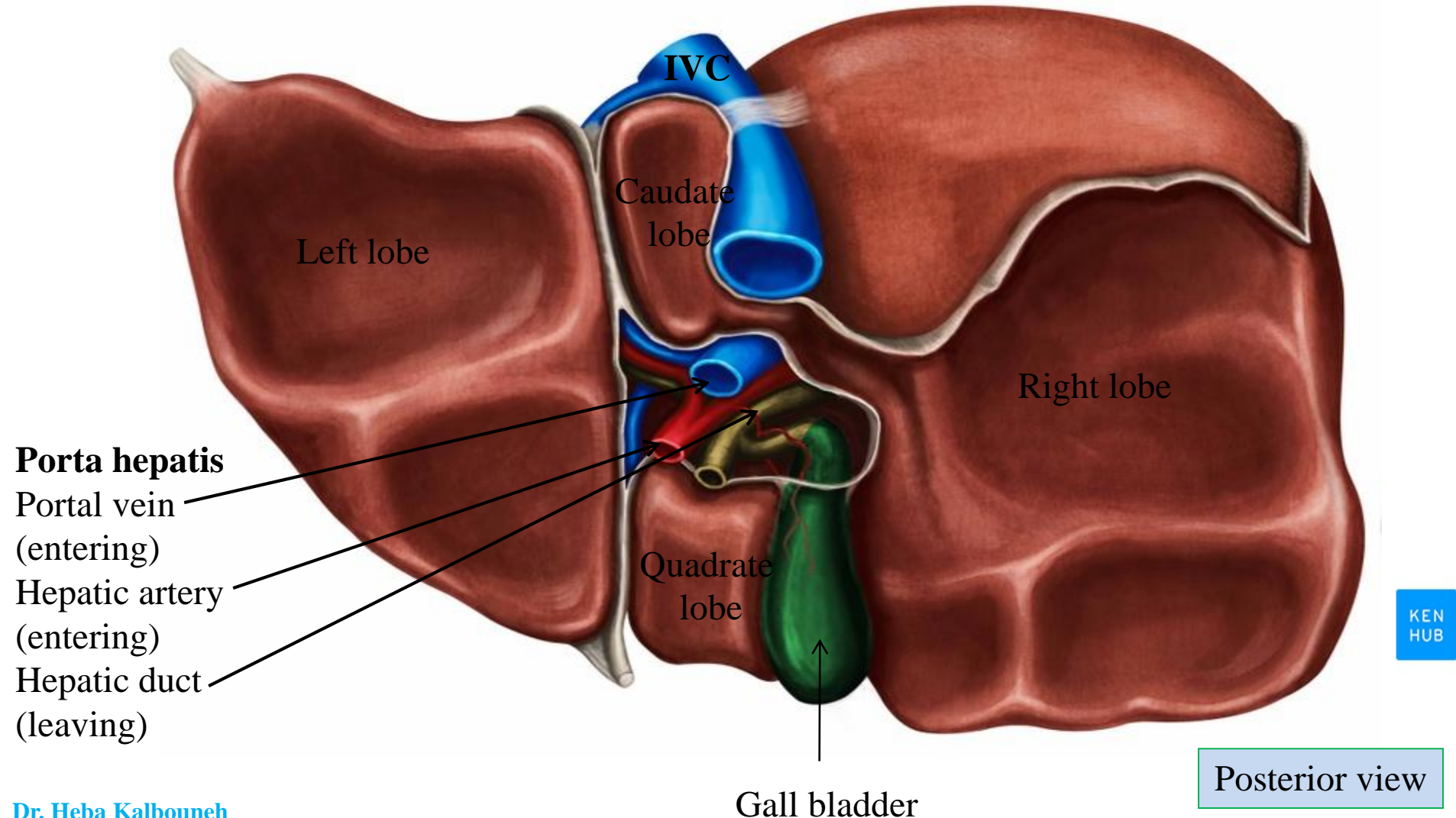
## Hepatic artery

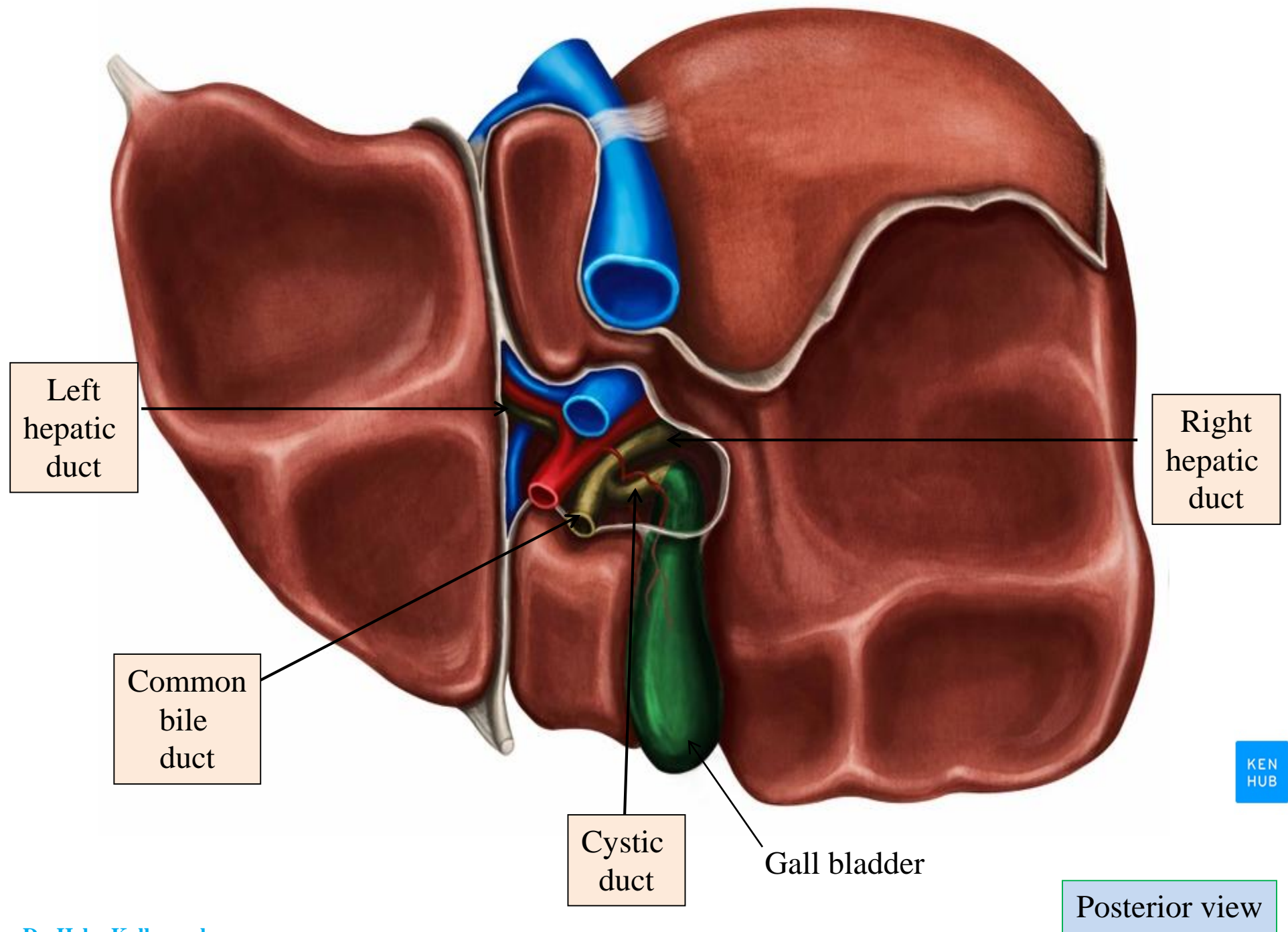
Supplies  
hepatocytes with  
oxygen rich blood

Liver receives a  
dual blood supply

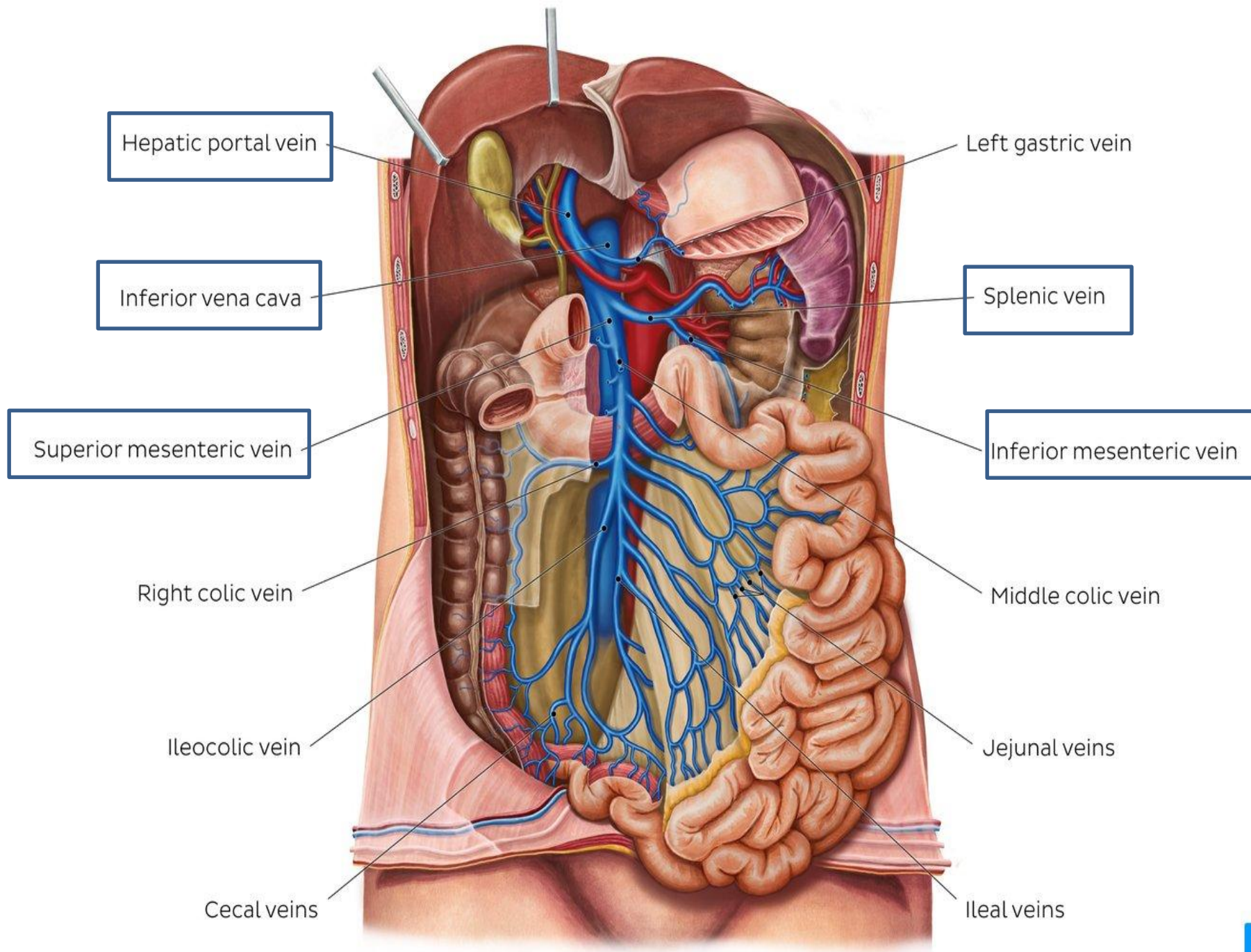
## Portal vein

Supplies  
hepatocytes with  
nutrients rich blood



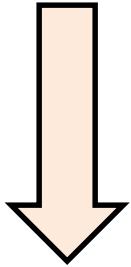




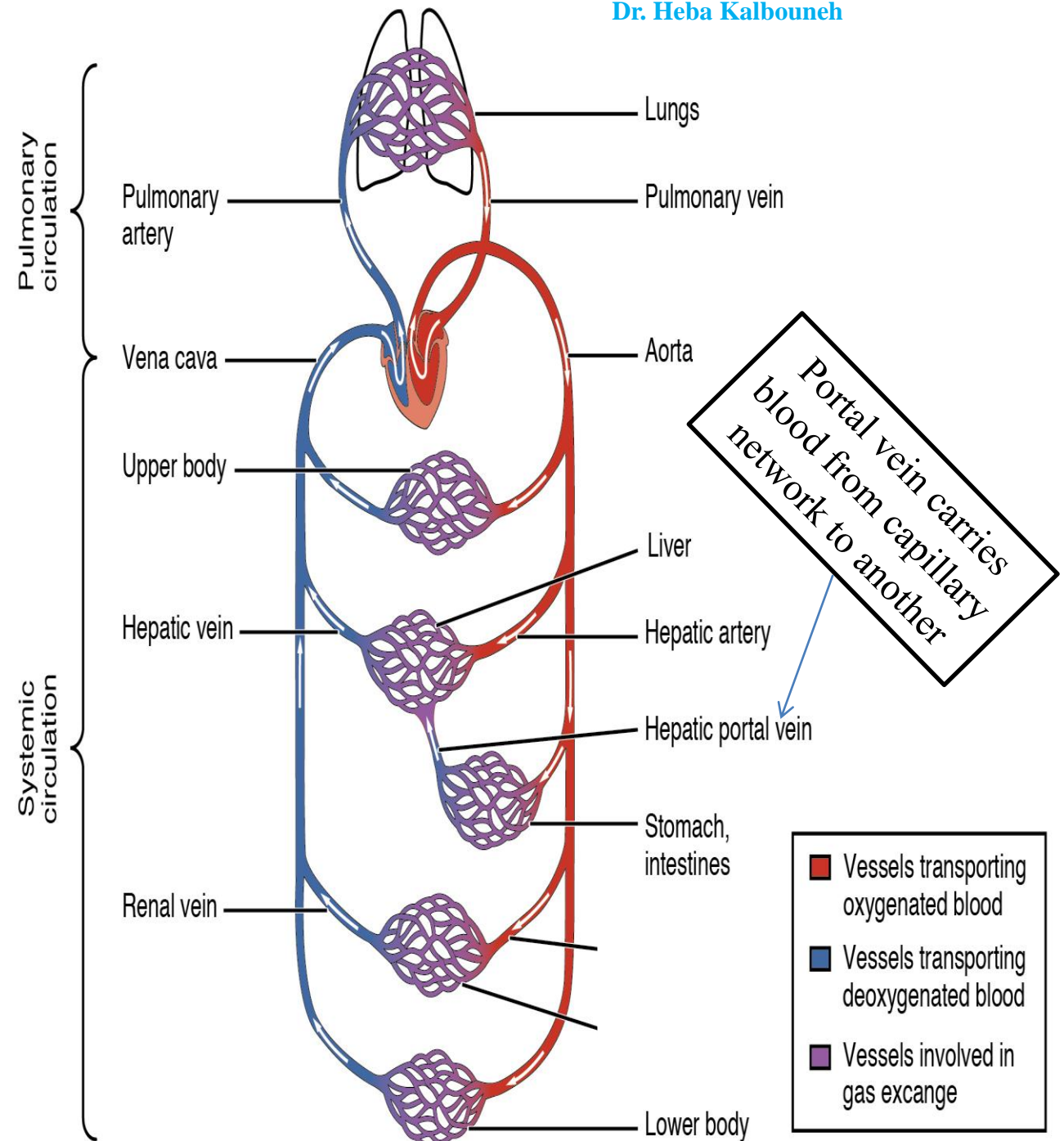


# Portal circulation

The **portal venous system** is responsible for directing blood from parts of the gastrointestinal tract (from the lower third of the esophagus to halfway down the anal canal), spleen and pancreas to the liver. Substances absorbed in the small intestine travel first to the liver for processing before continuing to the heart.

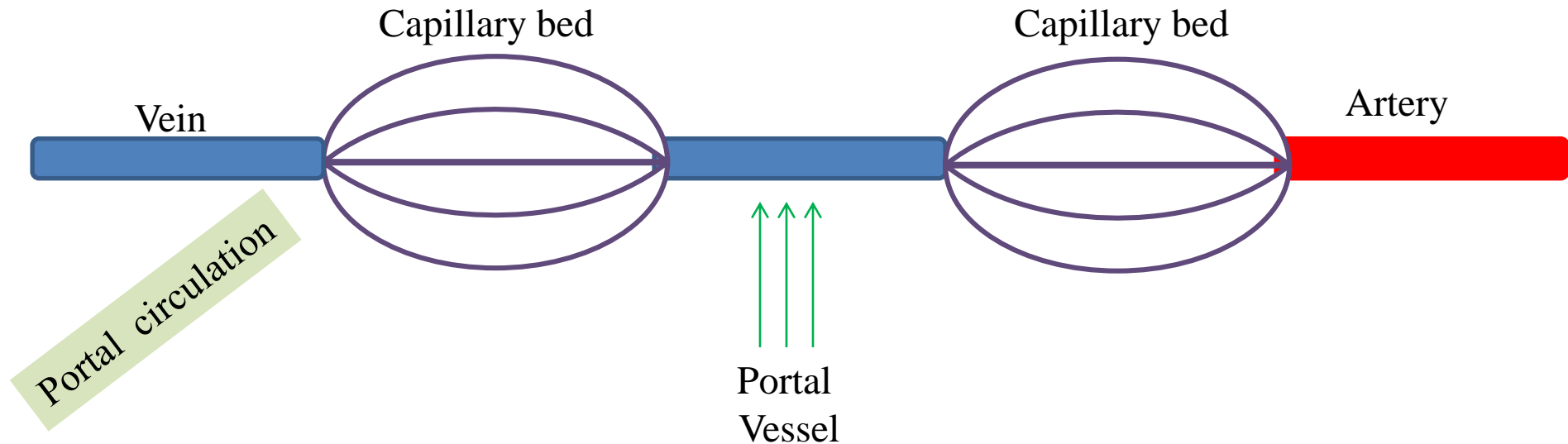
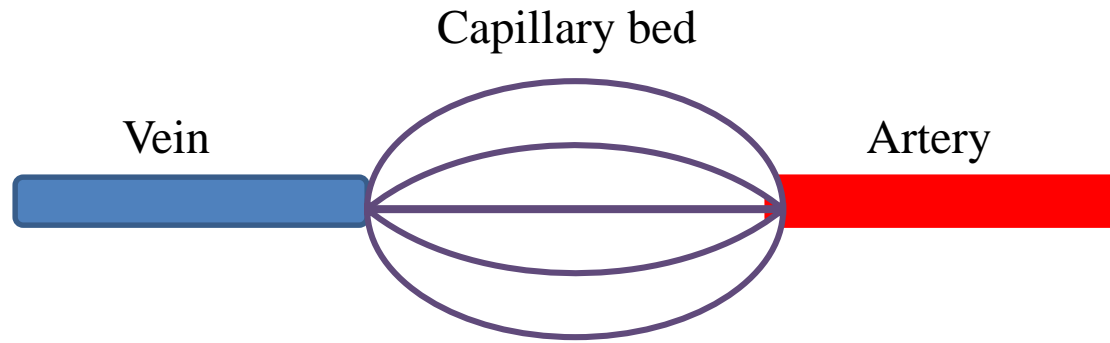


Therefore the portal vein is a blood vessel that sends nutrient-rich blood (but poor in oxygen) from the gastrointestinal tract, pancreas and spleen to the liver.





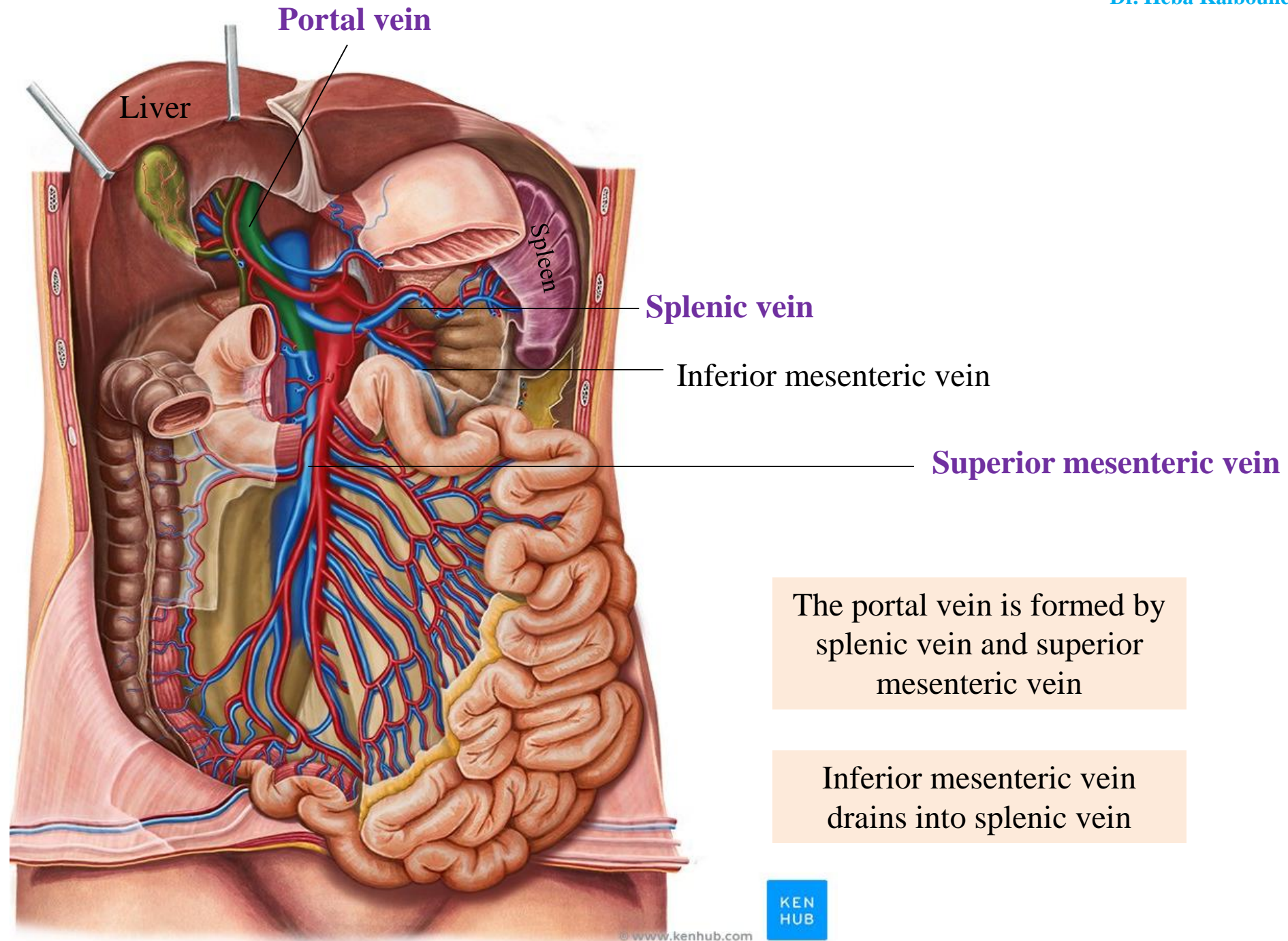
Systemic circulation



Portal vein in liver

Efferent arteriole in kidney

Portal venous system





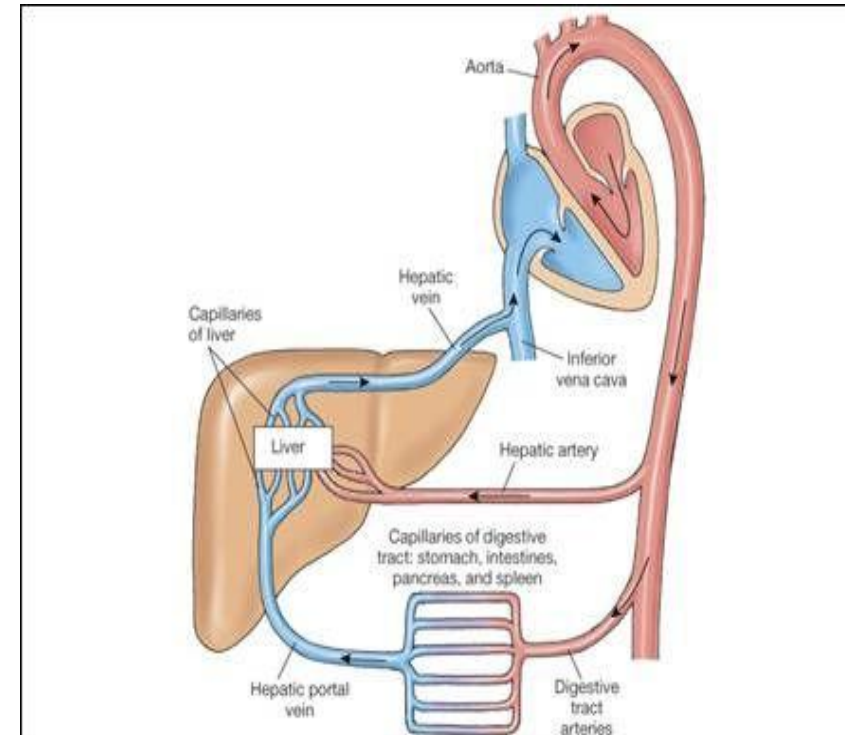
Many drugs that are absorbed through the GI tract are metabolized by the liver before reaching general circulation. As a consequence, certain drugs can only be taken via certain routes

Nitroglycerin cannot be swallowed because the liver would deactivate the medication, but it can be taken under the tongue or transdermally (through the skin) and thus is absorbed in a way that bypasses the portal venous system.

Dextromethorphan, a cough suppressor, is best taken orally because it needs to be metabolized by the liver into dextrophan in order to be effective.

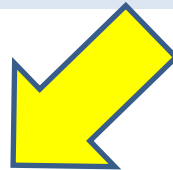
## Examples

The use of suppositories is a way to bypass partially the portal vein: the upper half of the anal canal is drained into the portal vein while the lower half is drained into the internal iliac vein that goes directly in the inferior vena cava (thus bypassing the liver).

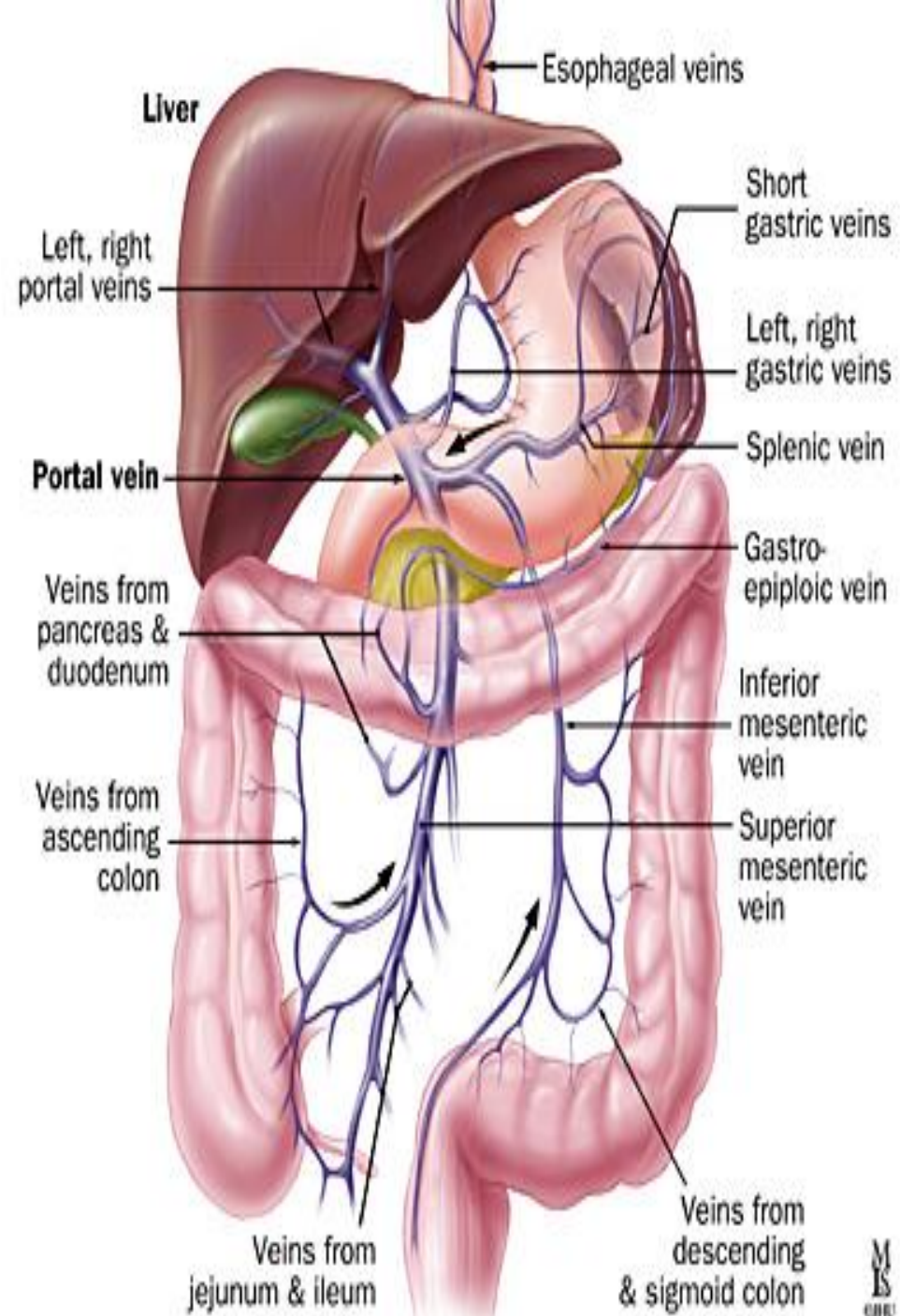


## Liver functions:

- Bile production and excretion.
- Storage of glycogen, vitamins, and minerals.
- Synthesis of plasma proteins, such as albumin, and clotting factors
- Detoxification of chemicals and metabolism of drugs (ex. Metabolism of alcohol)
- Processing hemoglobin to use its iron content (the liver stores iron)
- Change harmful ammonia to urea (urea is one of the end products of protein metabolism that is excreted in the urine)
- Clear bilirubin (too much bilirubin makes skin and eyes turn yellow)



- 1- Small intestine absorbs products of digestion
- 2- Nutrient molecules travel in portal vein to liver
- 3- Liver monitors blood content
- 4- Blood enters general circulation by way of hepatic vein (drains into inferior vena cava)





# Gallbladder

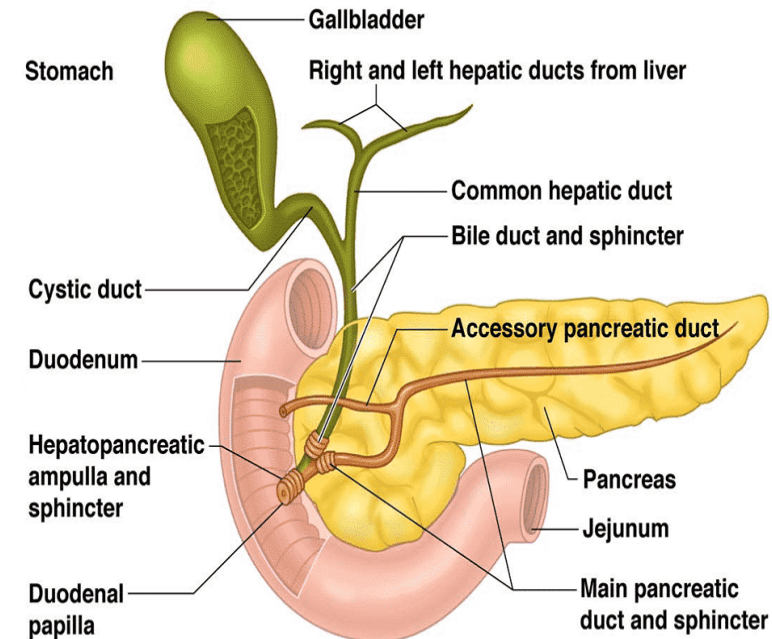
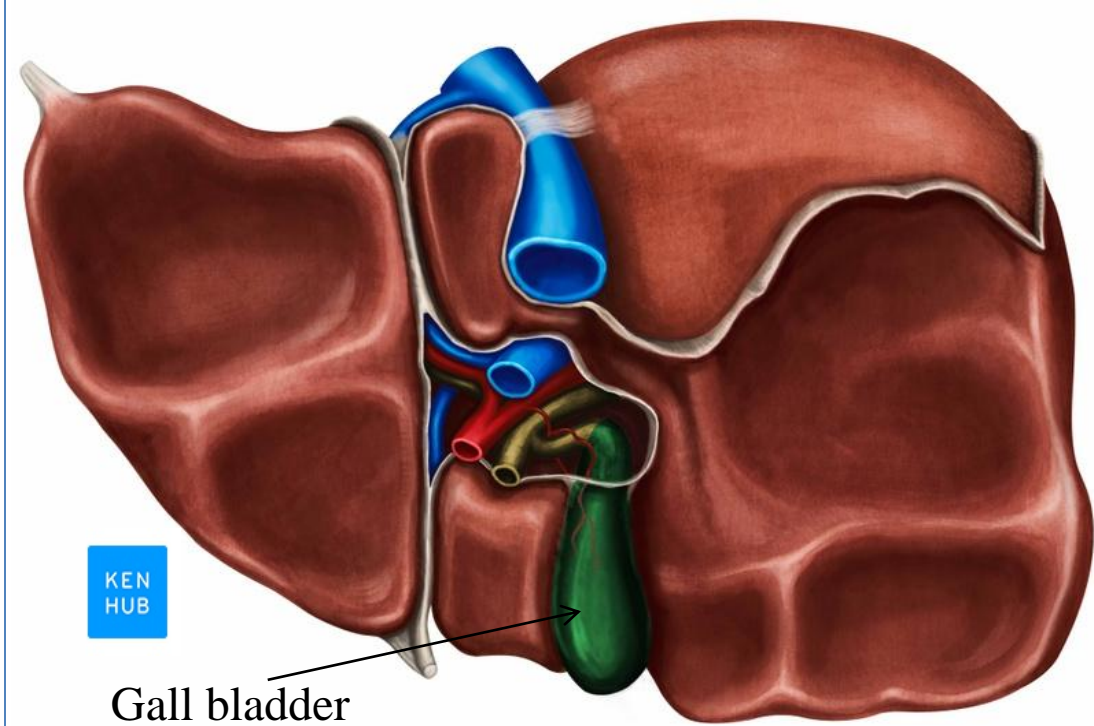
**Fundus:** projects downward beyond the inferior border of the liver

**Body:** the central portion

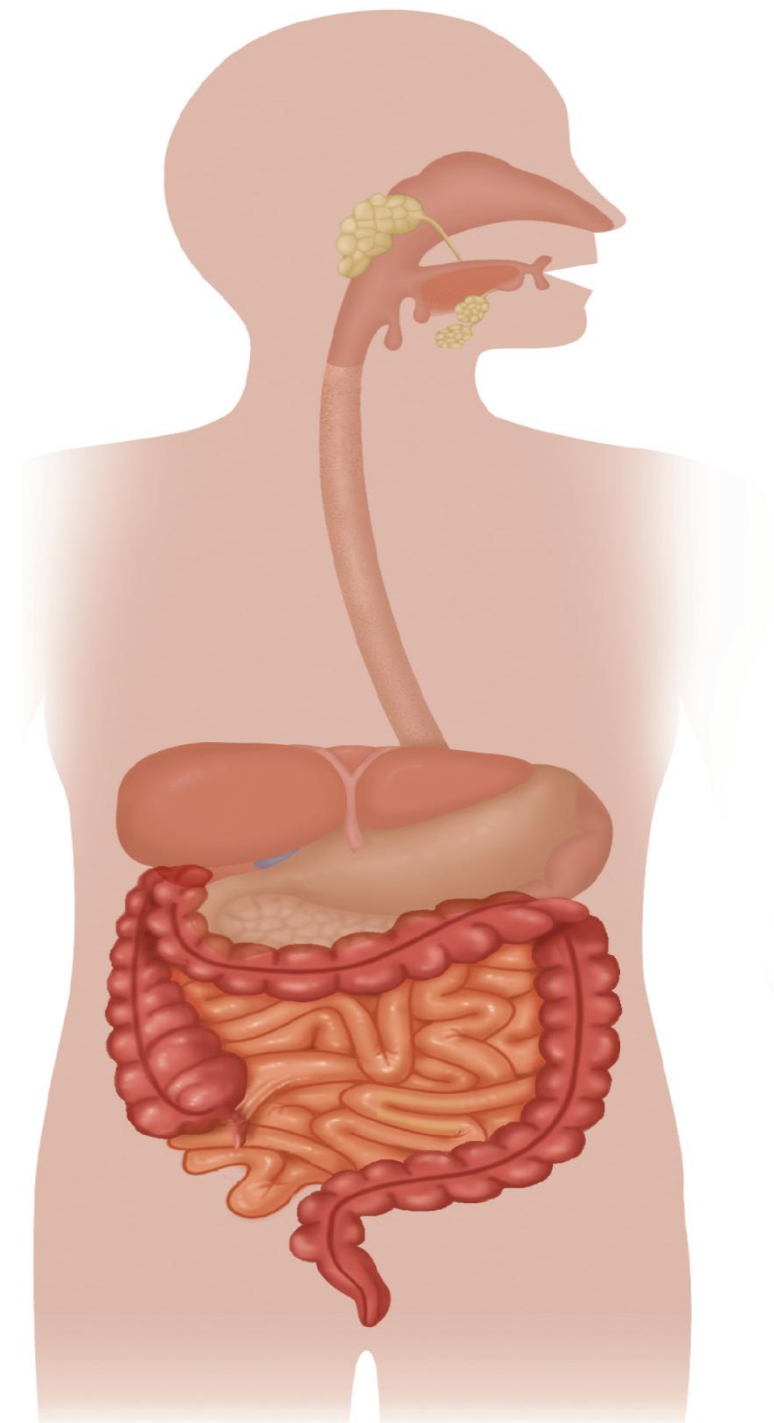
**Neck:** tapered portion

The body and neck project superiorly

- Bile is produced in the liver
- Bile is stored in the gallbladder
- Bile is concentrated by the removal of water
- Bile is excreted into the duodenum when needed (fatty meal)
- Bile helps dissolve fat and cholesterol
- If bile salts crystallize, gall stones are formed



**Note**  
**The vagus nerve CN X** carries  
parasympathetic fibers to the heart, lungs, and  
digestive tract.





Epithelial Membranes = epithelial layer of cells plus the underlying connective tissue.

Three Types:

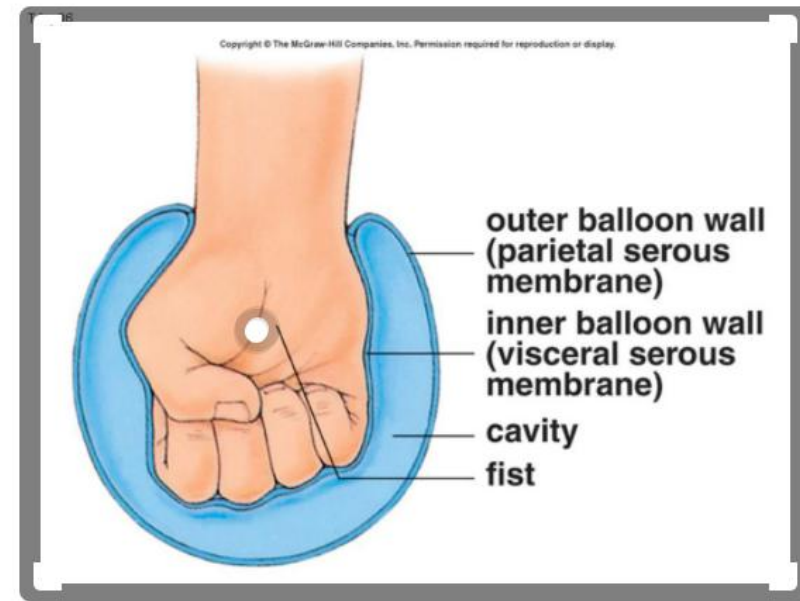
1. Mucous membranes
2. Serous membranes
3. Cutaneous membranes

**Remember**

**Mucous membrane = mucosa**; it lines cavities that open to the exterior, such as the GI tract.

The epithelial layer of the mucous membrane acts as a barrier to disease organisms.

The connective tissue layer of the mucous membrane is called the **lamina propria**. Found as the lining of the mouth, vagina, and nasal passage.....

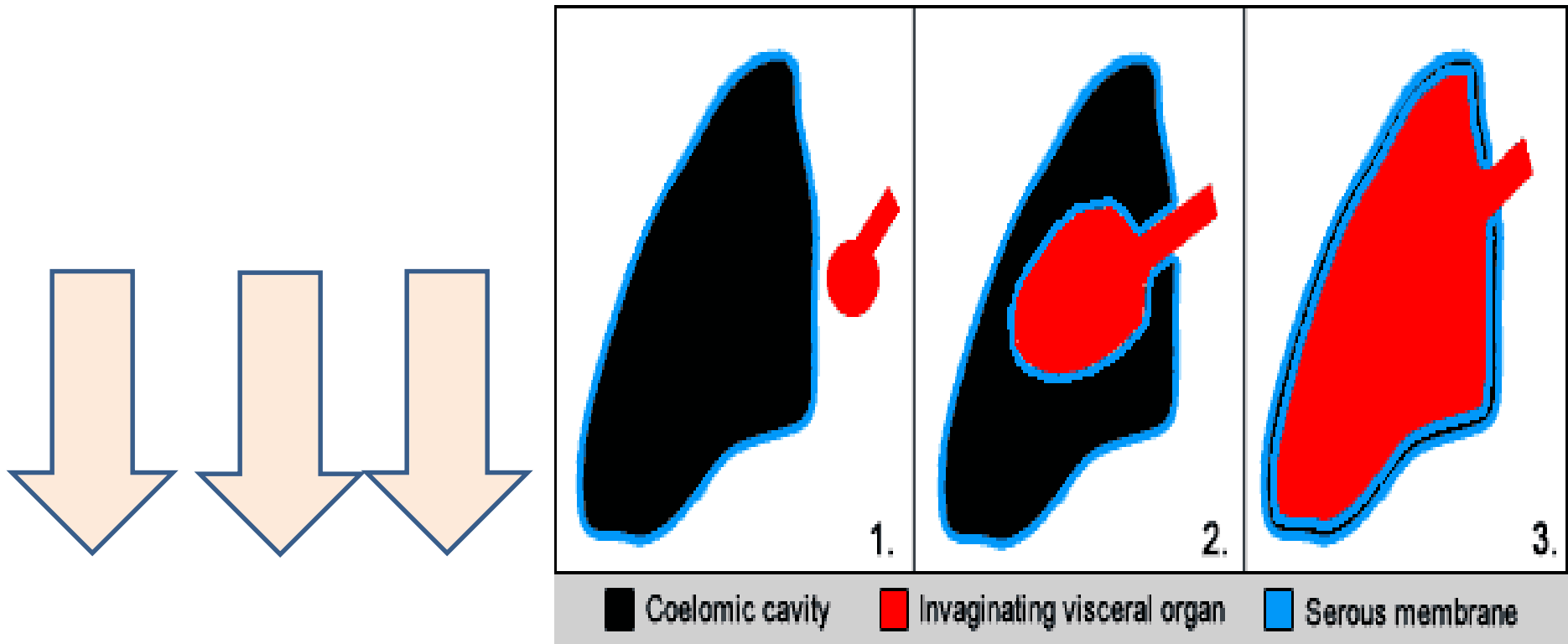


**Serous membrane = serosa**, it lines a body cavity that does NOT open to the exterior and it covers the organs that lie within the cavity.

- a. pleura = lungs
- b. pericardium = heart
- c. peritoneum = abdomen

The serous membrane has two portions:

1. parietal portion = lining outside the cavity
2. visceral portion = covers the organ



Remember: Serous membranes epithelial layer secretes a lubricating **SEROUS FLUID**, that reduces friction between organs and the walls of the cavities in which they are located.

The serous fluid is named by location:

- ✓ Pleural fluid is found between the parietal and visceral pleura of the lungs.
- ✓ Pericardial fluid is found between the parietal and visceral pericardium of the heart.
- ✓ Peritoneal fluid is found between the parietal and visceral peritoneum of the abdomen.