Liver

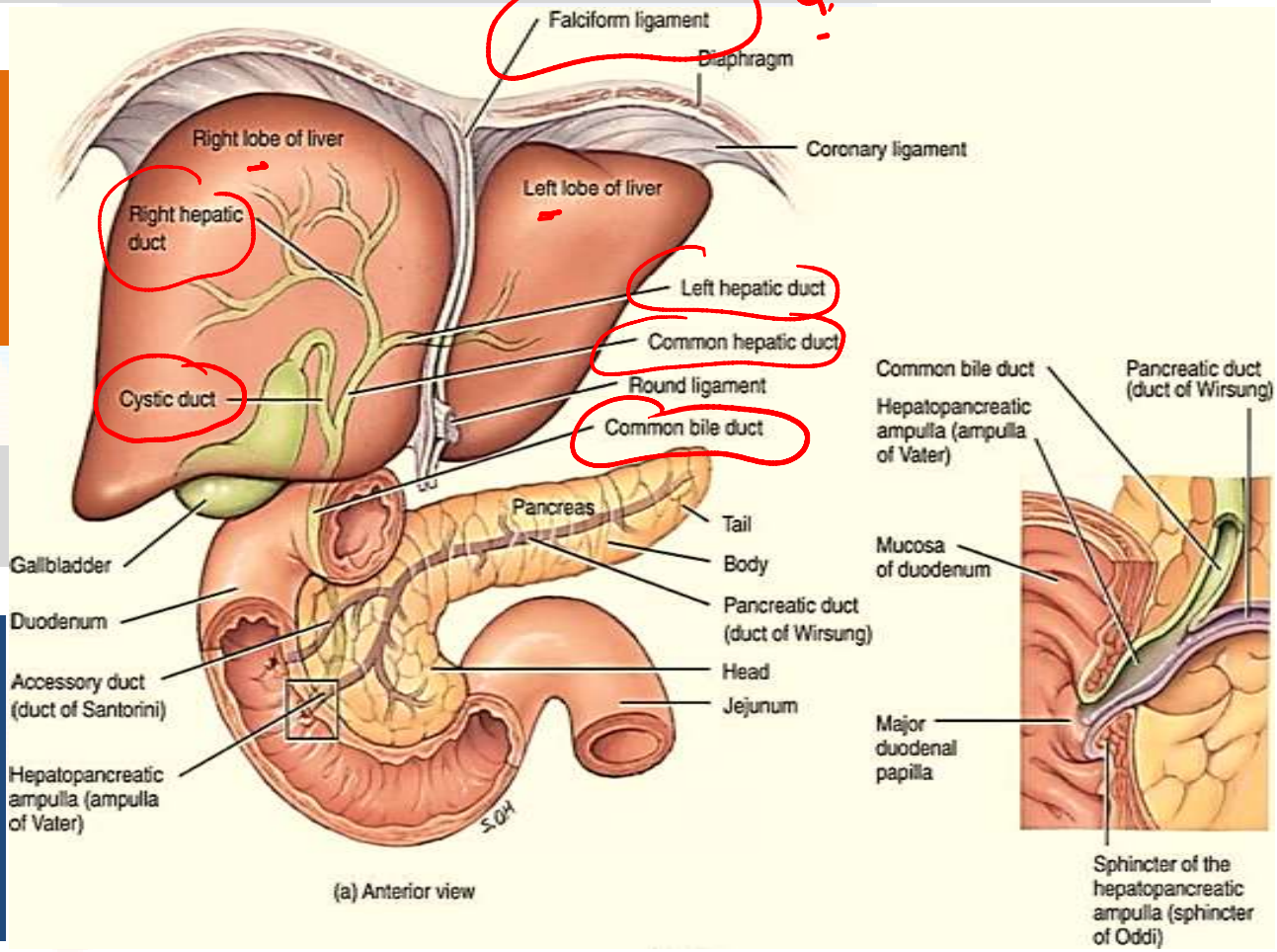
It develops from **endoderm**. (Weight 1.5 kg, both exocrine and endocrine). In human it is found in right side of abdominal cavity, below the diaphragm.

The liver is the largest gland of body. Right and left liver lobe are separate from each other by the **falciform ligament**.

Right and left hepatic duct develop from right and left liver lobe. Both these ducts combine to form a **Common Hepatic duct.**

Gall bladder is situated below right lobe of liver.

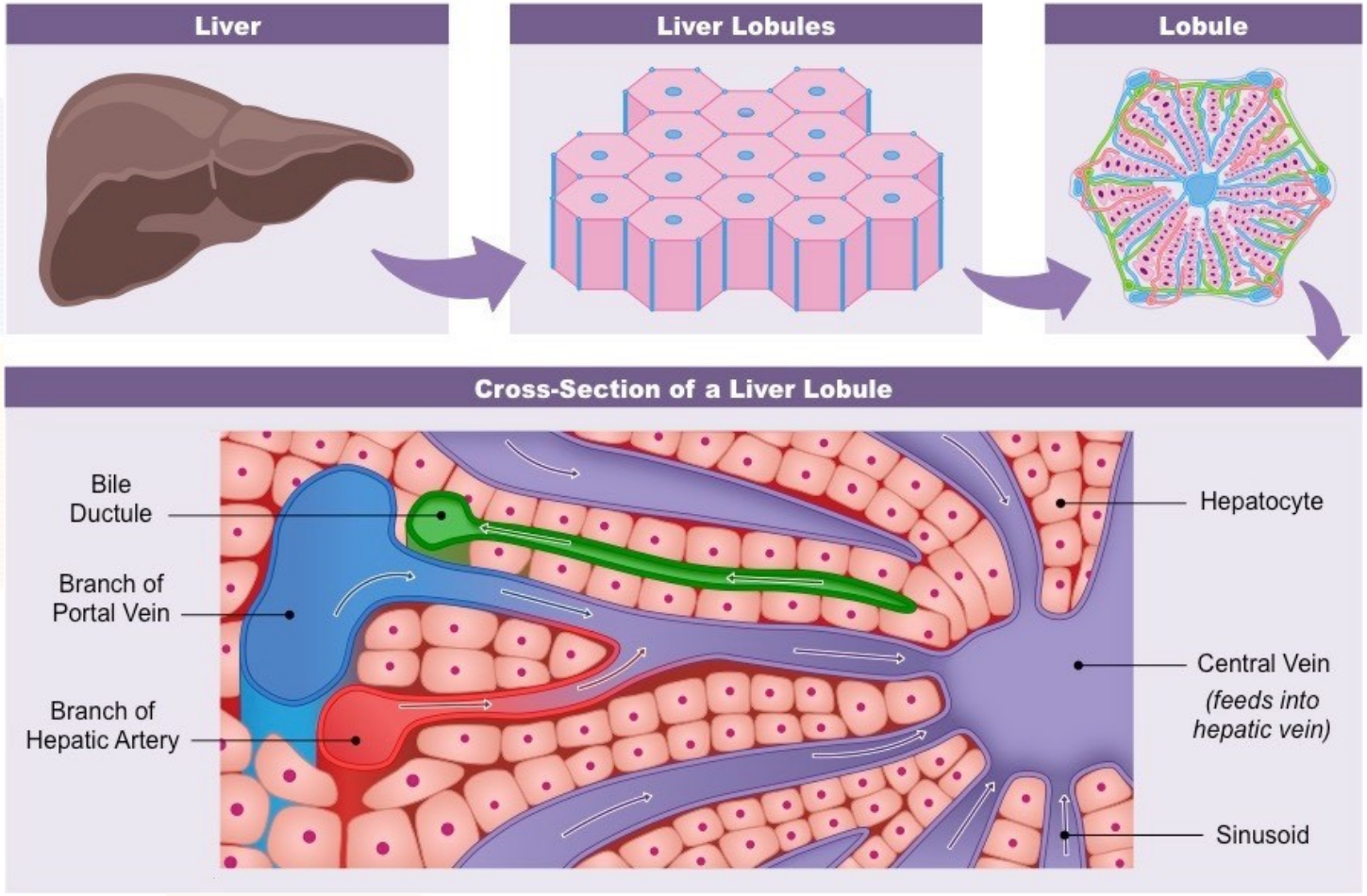
Cystic duct of gall bladder is connected to common hepatic duct to form a common bile duct also called **ductus choledocus.**



Each liver lobe is formed of hexagonal hepatic lobules, surrounded by a thin connective tissue sheath called the Glisson's capsule.

The hepatic lobules are the structural and the functional units of the liver, containing hepatic cells arranged in the form of Hepatic cords present around a central vein.

The bile secreted by hepatic cells passes through the hepatic ducts and is stored as well concentrated in a thin muscular sac called the Gall Bladder.



Functions of Liver - 1

Secretion & synthesis of bile

- This is the main function of liver. Bile is yellowish-green, alkaline fluid. In bile juice, bile salts, sodium bicarbonate, glycocholate, taurocholate, bile pigments, cholesterol, Lecithin etc. are present.
- Bile salts help in emulsification of fats. Bile prevents the food from decomposition. It kills the harmful bacteria.

Carbohydrate Metabolism

The main centre of carbohydrate metabolism is liver.

- **Glycogenesis-** The conversion and storage of extra amount of glucose into glycogen
- **Glycogenolysis-** The conversion of glycogen into glucose again when glucose level in blood falls down
- **Gluconeogenesis-** At the time of need, liver converts non-carbohydrate compounds (e.g Amino acids, fatty acids) into glucose.
- **Glyconeogenesis :** Synthesis of glycogen from lactic acid (which comes from muscles) is called glyconeogenesis.

Functions of Liver - 2

Storage of Fats

Liver stores fats in a small amount. Hepatic cells play an important role in fat metabolism.

The storage of fat increases in the liver of alcohol addict persons (Fatty liver).

Deamination and Urea Formation

Liver converts ammonia (more toxic) into urea (less toxic) through **ornithine cycle** .

Purification Of Blood

Synthesis Of Heparin

Synthesis of Plasma Proteins

Liver stores vitamin A, D, E, K, B_{12}

Storage of Minerals

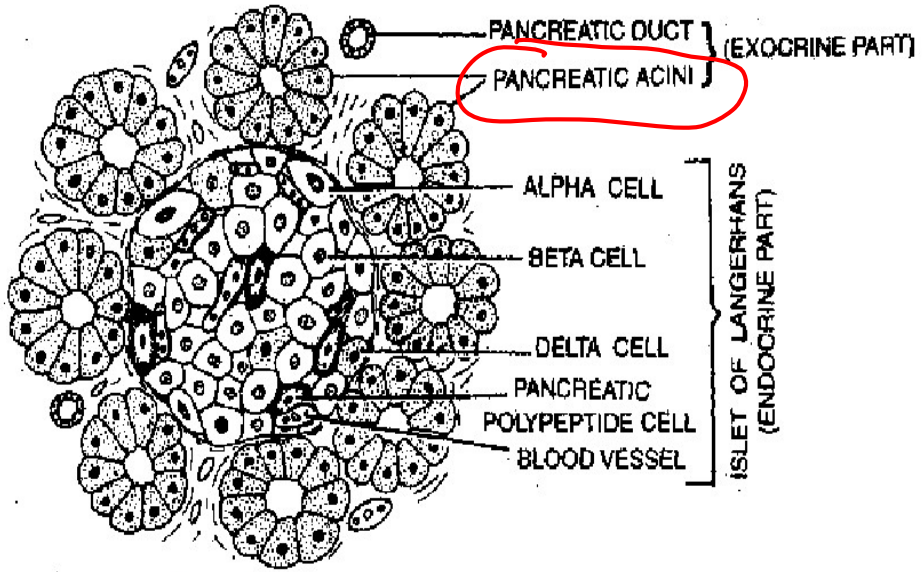
Detoxification

Hemopoiesis

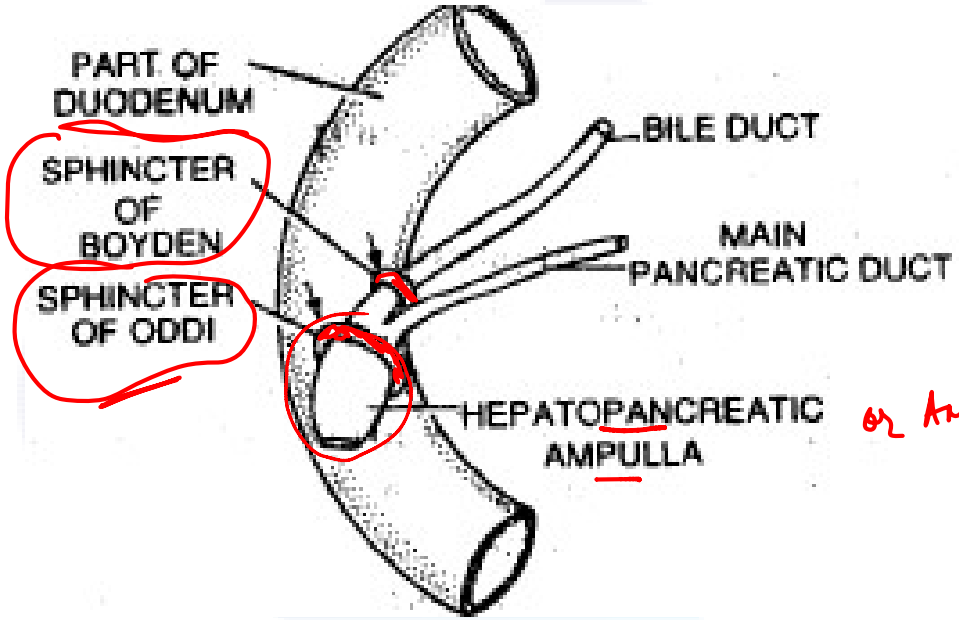
Synthesis of Vitamin A

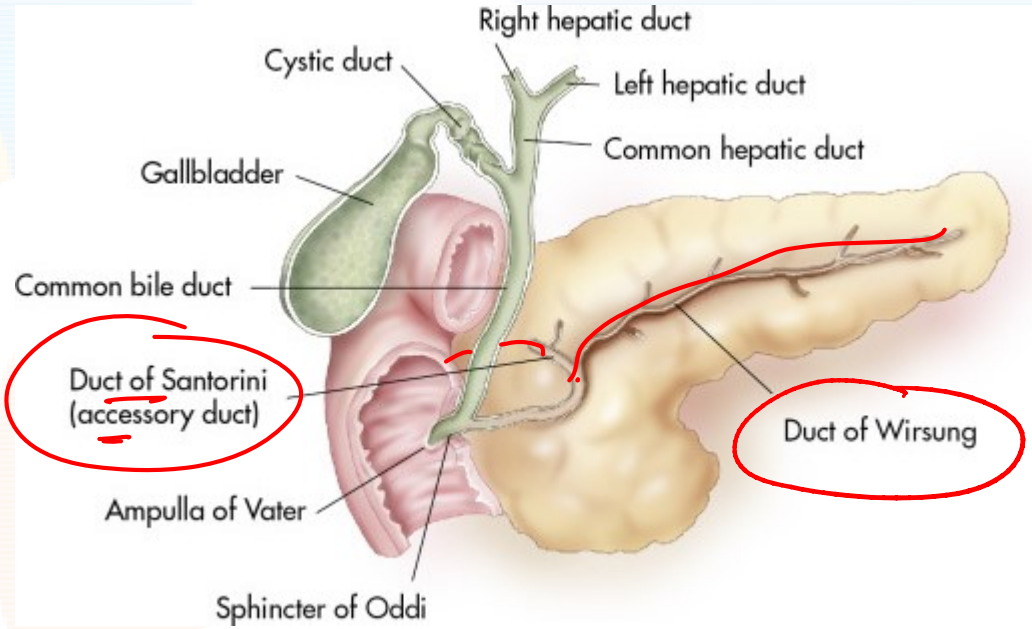
Pancreas

- It's develop from **endoderm**, which is soft, lobulated and elongated organ.
- It is made up of numerous acini. **Acini** is a group of secretory cells surrounding a cavity. Each acini is lined by pyramidal shaped cells. These acinar cells **secrete the enzyme of pancreatic juice.**
- Some group of endocrine cells are also found in between groups of acini called **islets of Langerhan's**. So this gland is exocrine as well as endocrine (Heterocrine). **Its 99% part is exocrine** while **1% part is endocrine** .
- In humans both bile duct and pancreatic duct combine to form common duct called as **Hepato-Pancreatic duct**.

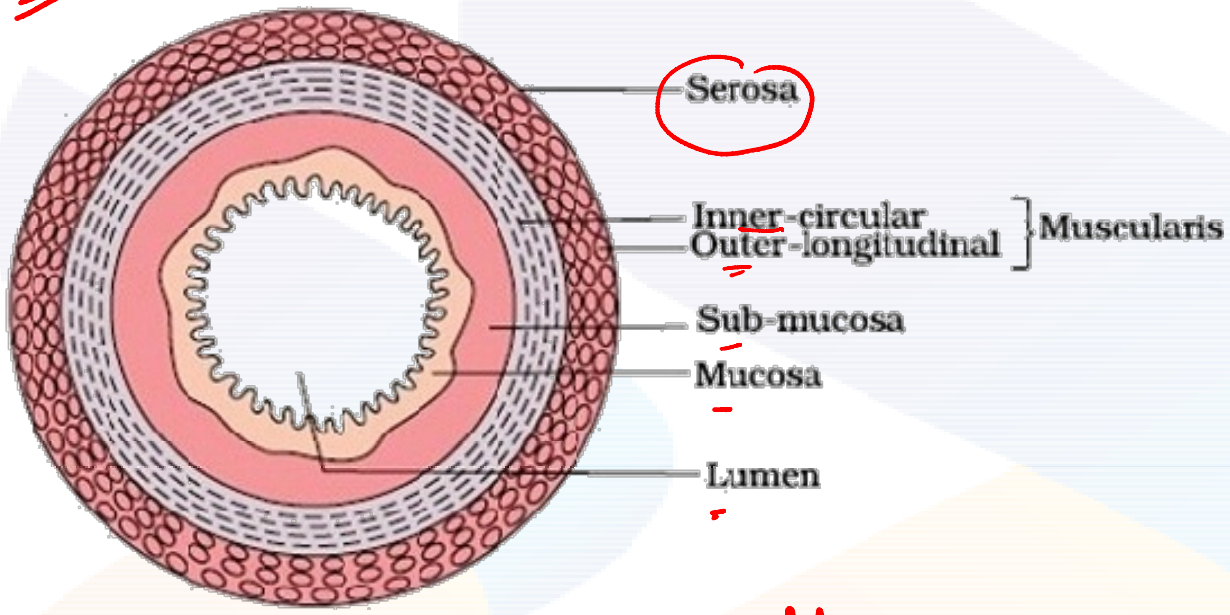


Section of pancreas


PART OF DUODENUM
SPHINCTER OF BOYDEN
SPHINCTER OF ODDI
BILE DUCT
MAIN PANCREATIC DUCT
HEPATOPANCREATIC AMPULLA
or Ampulla of Vater


Right hepatic duct
Cystic duct
Left hepatic duct
Common hepatic duct
Gallbladder
Common bile duct
Duct of Santorini (accessory duct)
Duct of Wirsung
Ampulla of Vater
Sphincter of Oddi

HISTOLOGY OF ALIMENTARY CANAL



Nerve plexus

Auerbach's - b/w longitudinal & circular muscle

Meissner's plexus - b/w circular muscle of sub-mucosa ~~but also muscle~~ oblique muscle of submucosa

Physiology of Digestion - 1

Digestion in oral cavity	Food enters through mouth food is tasted in oral cavity and mixed with saliva, tongue mixes the food with saliva. This food with saliva is called bolus.
	This saliva (pH 6.8 – 7.0) contains water (99.5%) and electrolytes (Na^+, K^+, Cl^-, HCO^{3-}, Thiocynate).
Mechanical Digestion	In mouth teeth, tongue and lips have Important role in mechanical digestion through the process of chewing or **mastication**.
Chemical Digestion	· In this type of digestion saliva act with food particles. · Saliva contain 99.5% water & 0.5% salts. · These salts are organic and inorganic type. · The main components are mucin, lysozyme, thiocynate and Ptyalin.
Mucin	It is a **glycoprotein**. It lubricates the food particles. It helps in the swallowing of food.
Lysozyme	Kills the harmful bacteria. Due to this reason saliva is a **antiseptic lotion**.
Thiocynate	Kills the harmful bacteria. So it is called **bacteriocidal salt.**
Ptyalin	Ptyalin is found in human saliva, because human food is mainly made up of starch. Ptyalin digest only ripe and cooked starch

Physiology of Digestion - 2

Peristalsis

Peristalsis is progression of coordinated contraction of involuntary circular muscles, which is preceded by a simultaneous contraction of the longitudinal muscle and relaxation of the circular muscle in the lining of gut.

Digestion of food in stomach

When the food enters into stomach **G-cells** secrete gastrin hormones which stimulate the secretion of gastric juice by gastric glands.

Composition of Gastric juice

- Water = 99.5%
- HCl = 0.2 - 0.3%
- pH = 1.5 to 2.5 (very acidic)
- mucus water, HCl and gastric enzymes (Pepsinogen, Prorennin, Gastric Lipase etc.).

Functions of HCl

1. The main function of HCl (activater) is to convert inactive enzymes (zymogens) into active enzymes.

$$\textbf{Pepsinogen} \xrightarrow{HCl} \textbf{Pepsin.}$$

$$\textbf{Prorennin} \xrightarrow{HCl} \textbf{Rennin.}$$

2. It destroys all the bacteria present in the food.
3. HCl stops the action of saliva on food. In stomach, the medium is highly acidic.

Digestion by Rennin (Chymosin)

Rennin, acts on milk protein **casein.** Casein is a soluble protein.

Physiology of Digestion - 3

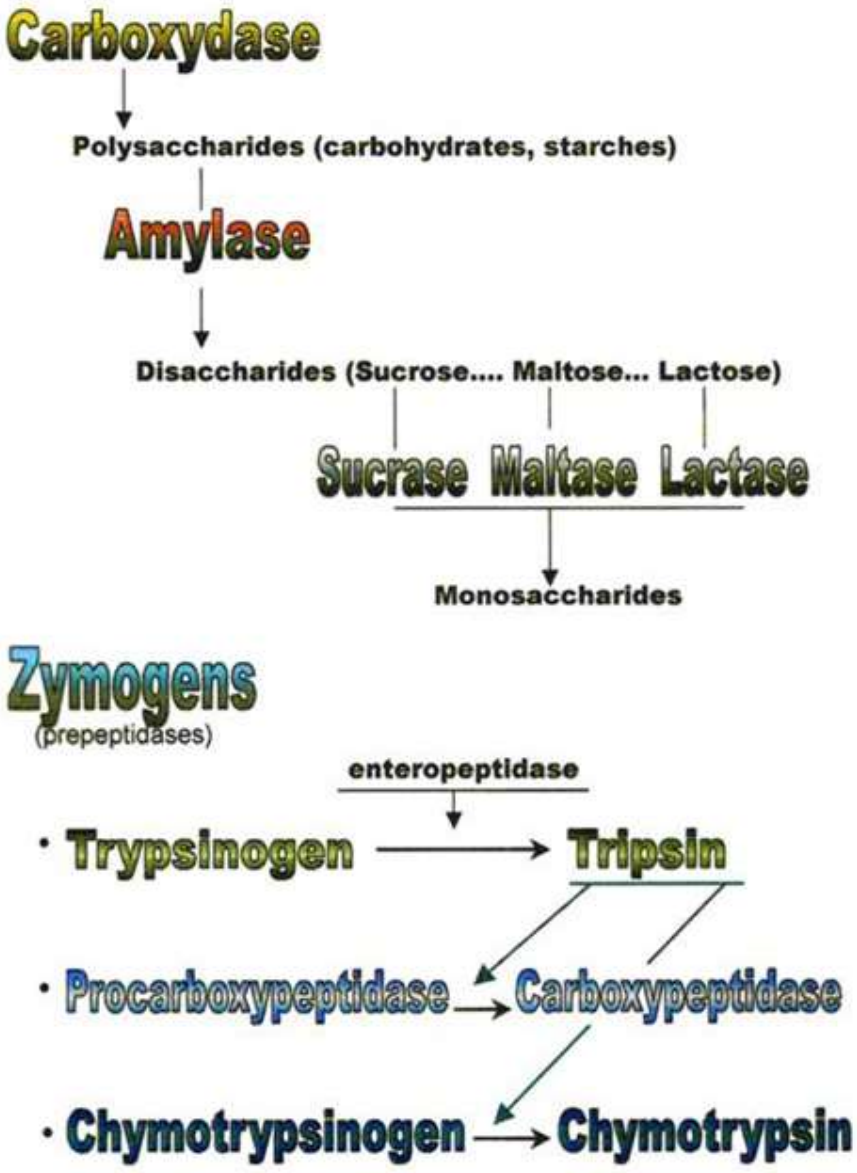
Digestion by Pepsin	Inactive pepsinogen on getting proper pH converts into active pepsin.
	Enzyme which breakes the peptide bond.
Digestion by Gastric Lipase	It converts fats into fatty-acids and glycerols. It is secreted in a less amount so less digestion of fats takes place here.
	This lipase acts on emulsified fat and convert it into fatty acid & glycerol. 1% emulsified fat is present in the food.
Digestion Of Food In Small Intestine	Mechanical and chemical digestion
Mechanical Digestion	This process of digestion mainly occurs by the help of segmentation. It is a mixing of kind with digestive juice and bring food particle in to contact of mucosa.

Chemical Digestion: occurs with help of various enzymes in Digestive system.

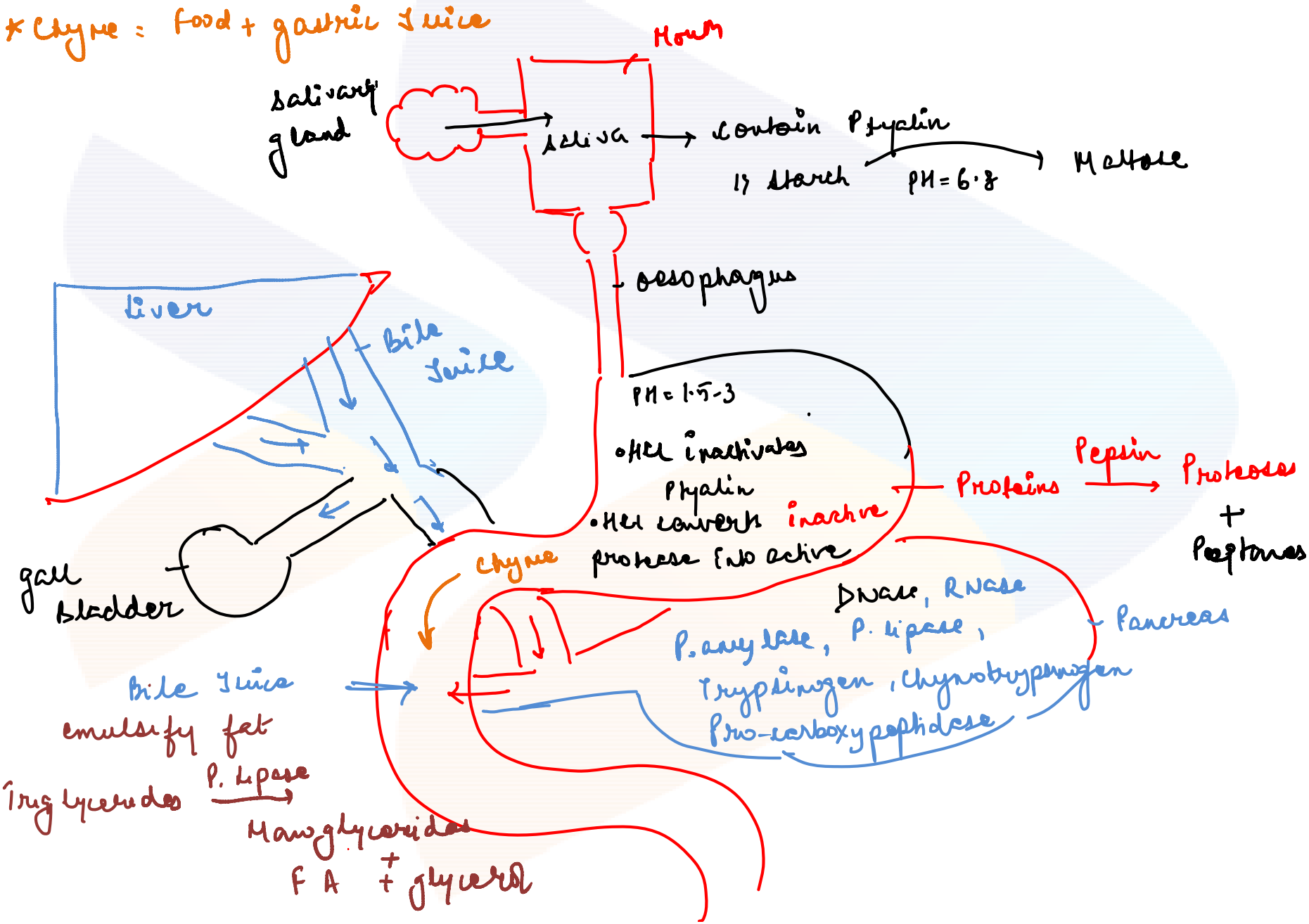
When food leaves the stomach through its pyloric end and enters the duodenum it is called chyme (acidic).

Pancreatic Juice

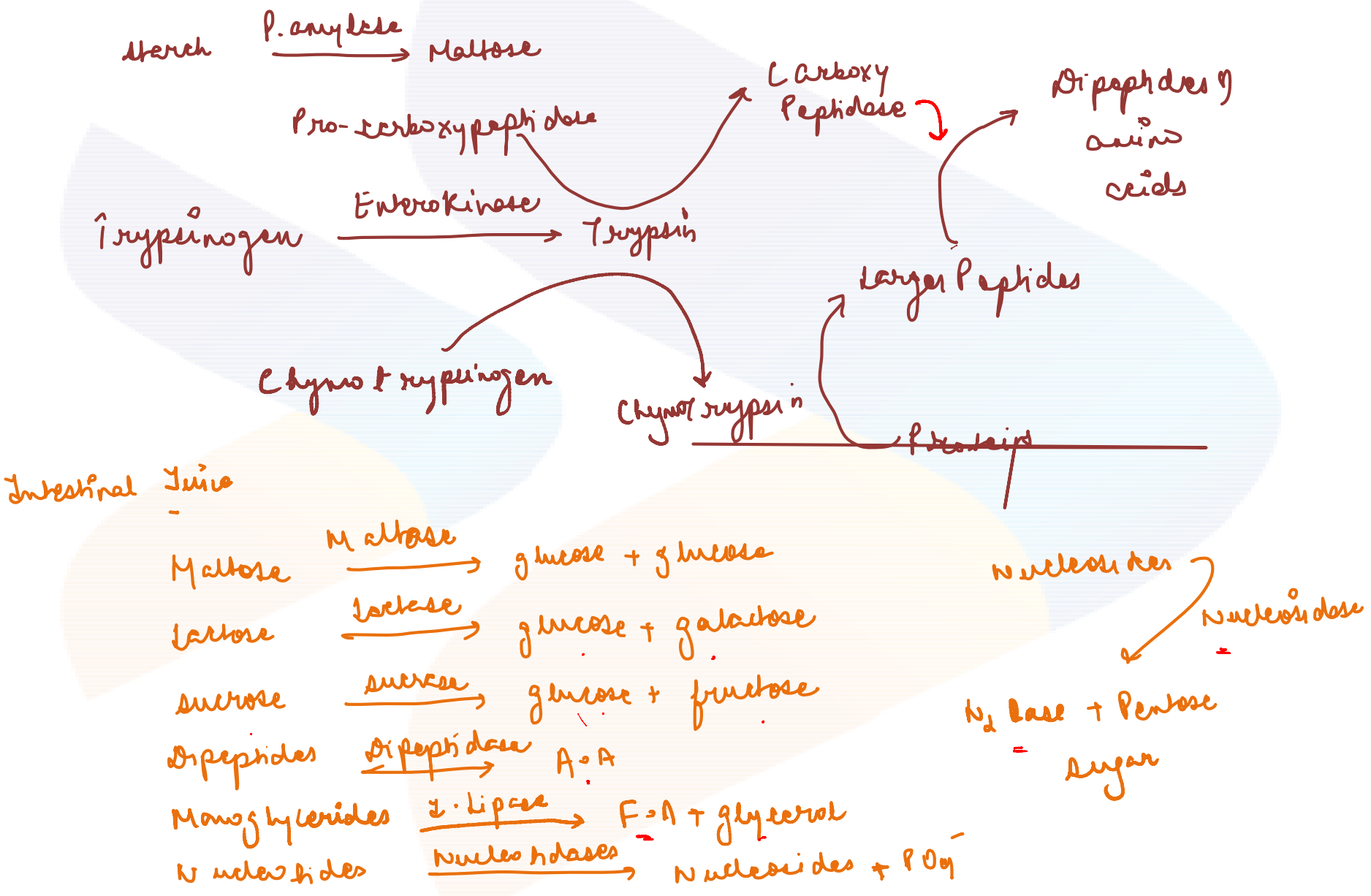
- pancreatic-juice is secreted by the exocrine cells of the pancreas
- Pancreatic juice is highly odouriferous, colourless basic fluid which contains enzymes and salts.
- Pancreatic, a - Amylase
- Trypsinogen and Chymotrypsinogen
- Trypsin and chymotrypsin are **Endopeptidase** type of enzymes
- **Fat digesting enzyme:** In pancreatic-juices various Fat-digesting enzymes are found which are collectively called **steapsin**.
- **Nucleases = DNase and RNase -** Digestion of DNA and RNA.



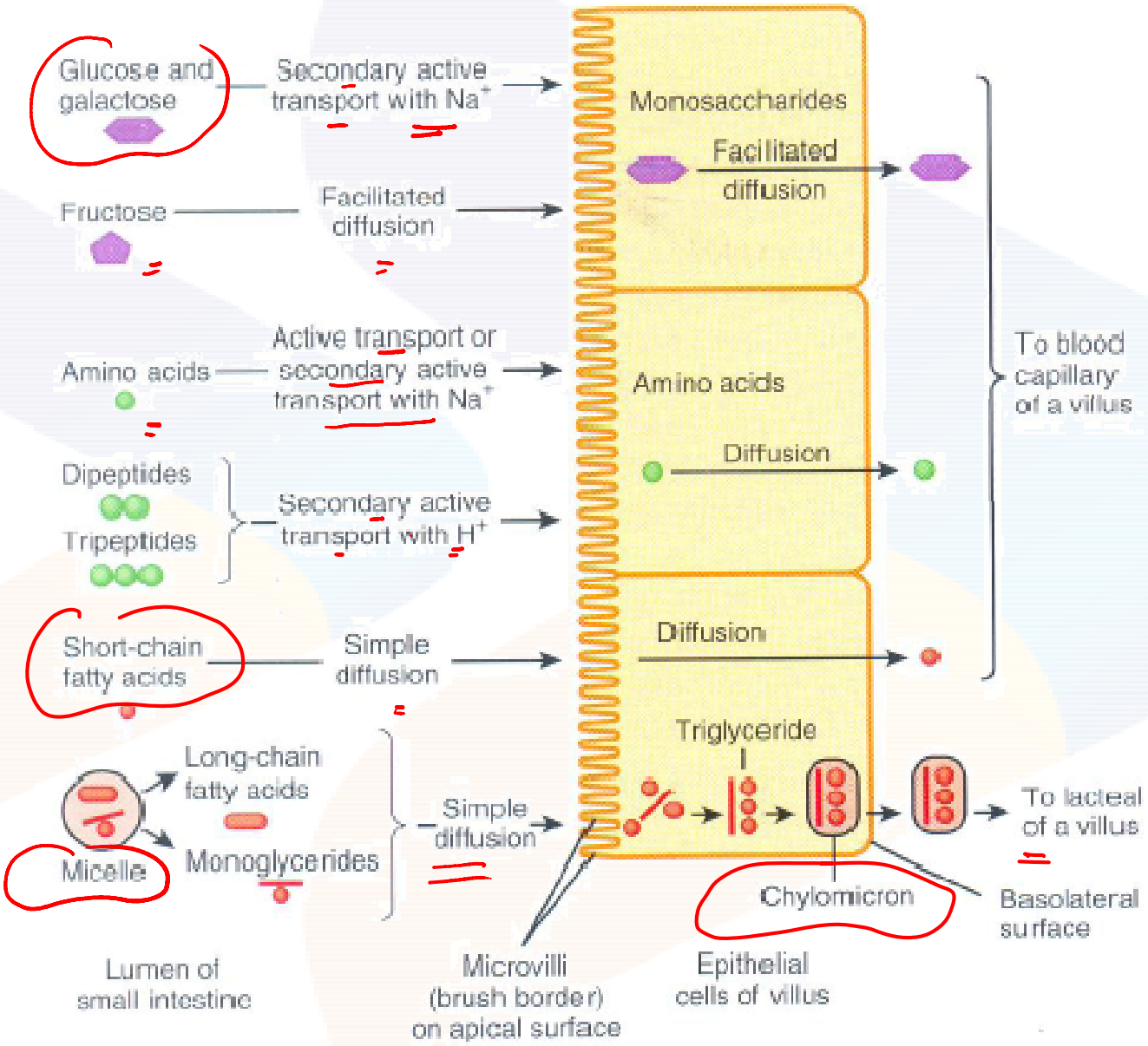
Enzymes involved in Digestion: Overview



Enzymes involved in Digestion: Overview



ABSOPRTION



(a) Mechanisms for movement of nutrients through absorptive epithelial cells of the villi

Absorption in Different Parts: Summary

Mouth	Stomach	Small Intestine	Large Intestine
Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed into the blood capillaries lining them.	Absorption of water, simple sugars and alcohol etc. takes place.	Principal organ for absorption of nutrients. The digestion is completed here and the final products of digestion such as glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph.	Absorption of water, some minerals and drugs takes place. Secretion of mucus which helps in adhering the waste (undigested) particles together and lubricating it for an easy passage.

Disorders of Digestive System - 1

- **Jaundice:** The liver is affected, skin and eyes turn yellow due to the deposit of bile pigments.
- **Vomiting:** It is the ejection of stomach contents through the mouth. This reflex action is controlled by the vomit centre in the medulla. A feeling of nausea precedes vomiting.
- **Diarrhoea:** The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea. It reduces the absorption of food.
- **Constipation:** In constipation, the faeces are retained within the rectum as the bowel movements occur irregularly.
- **Indigestion:** In this condition, the food is not properly digested leading to a feeling of fullness. The causes of indigestion are inadequate enzyme secretion, anxiety, food poisoning, over eating, and spicy food.
- **Kwashiorker –** It is a protein deficiency disease. It commonly affects infants and children between **1 to 3 year** of age.
  - **Symptoms –** Underweight, stunted growth, poor brain development loss of appetite anaemia, **oedema** on lower leg and face.
  - **Cure –** Proteins are necessary for growth, repair of tissue and for body defence therefore adequate amount of proteins must be present in the diet.
  - **Sources in food –** Cereals pulses, meat, fish, milk, groundnut, peas, leafy vegetables etc.

Disorders of Digestive System - 2

- **Marasmus –** It is caused by protein-energy-malnutrition(PEM) or deficiency of protein and total food caloric value. It mainly occure in the age group of **one year** in newly born baby.
  - **Symptoms** – Impairs physical growth, subcutaneous fat diseappears, ribs become very prominent, limbs become thin and skin becomes dry, thin & wrinkled. There is **no oedema** on leg and face but loss of weight occurs.
  - **Cure** – Diet with adequate proteins and proper caloric value should be given to the infants.
  - **Source in food** – Same as kwashiorkor.
- **Hypercholesterolemia (Overnutrition)** – It is caused due to intake of excess of saturated fat such as butter, ghee, red meat, egg. Cholesterol level in blood rises abnormally (hypercholesterolemia) this may cause thrombosis and heart attack.
- **Obesity (Overnutrition)** – It is caused by excessive intake of high caloric nutrients such as sugar, honey and saturated fat. Fat accumulates in the tissue. This may cause high blood pressure, diabetes and heart diseases.
- **Hypervitaminosis (Overnutrition)** – It is caused by excessive intake of vitamin. Such as excess of vitamin D causes deposition of calcium in soft tissue. Excess of vitamin A causes lack of appetite, itching rash etc.
- **Fluorosis** – It is caused by excessive intake of fluorine. It is characterised by mottled (brownish discolouration) teeth.

Gastrointestinal Hormones

Hormone	Source Secretion	Stimulus to	Target/Action
Gastrin	Pyloric stomach and duodenum/G-cells	Vagus nerve activity; peptides and proteins in stomach.	Secretory cells and muscles of stomach; secretion of HCl and stimulation of gastric mobility.
Cholecystokinin (CCK)	Upper small intestine (Duodenum)	Food (fatty chyme and amino acids) in duodenum.	Gall bladder; contraction of gall bladder (bile release)
Secretin	Intestinal wall (Duodenum)	Food and strong acid in stomach and intestine.	Pancreas, secretory cells and muscles of stomach; secretion of water and bicarbonate($NaHCO_3$); inhibition of gastric motility.
Gastric Inhibitory Peptide (GIP)	Upper small intestine (Duodenum)	Monosaccharides and fats (fatty chyme) in duodenum.	Gastric mucosa and muscles; inhibition of gastric secretion and mobility/motility (slowing food passage).

•**Duocrinin** is secreted by the duodenal epithelium and stimulates the Brunner's gland to release mucus and enzymes into intestinal juice.
•**Enterocrinin** is secreted by small intestine which stimulates the crypts of lieberkuhn to release enzymes into the intestinal juice.
•**Vasoactive Intestinal peptide (VIP)** is secreted by the epithelium of entire small intestine which dilates peripheral blood vessels of the gut and also inhibits gastric acid secretion.
•**Villikinin** is secreted by the epithelium of entire small intestine which accelerates movement of villi.
Pancreatic polypeptide (PP) is secreted by the pancreatic polypeptide cells of islets of Langerhans. It inhibits the release of pancreatic juice from the pancreas.
•**Somatostatin** secreted by the delta cells of islets of Langerhans of pancreas inhibits the secretion of glucagon by alpha cells and insulin by beta cells. Somatostatin produced by argentaffin cells of gastric and intestinal glands supresses the release of hormones from the digestive tract.