



Handwritten Notes
on
Digestion and Absorption

Digestion and Absorption

- Carbohydrates } Macronutrients /
 - Proteins } Proximate Principles of food.
 - Fats }

- Vitamins } Micronutrients /
 - Minerals } Protective principles of food.
 - Water }

• Human Alimentary Canal -

Gastrointestinal tract + Digestive glands.

• Mouth Cavity

- Vestibule → narrow slit between lips and teeth.

- Palate → Roof of mouth cavity.

Hard Palate - anterior part having 'Rugae'
 (Transverse folds) on its surface.

Soft Palate → posterior part

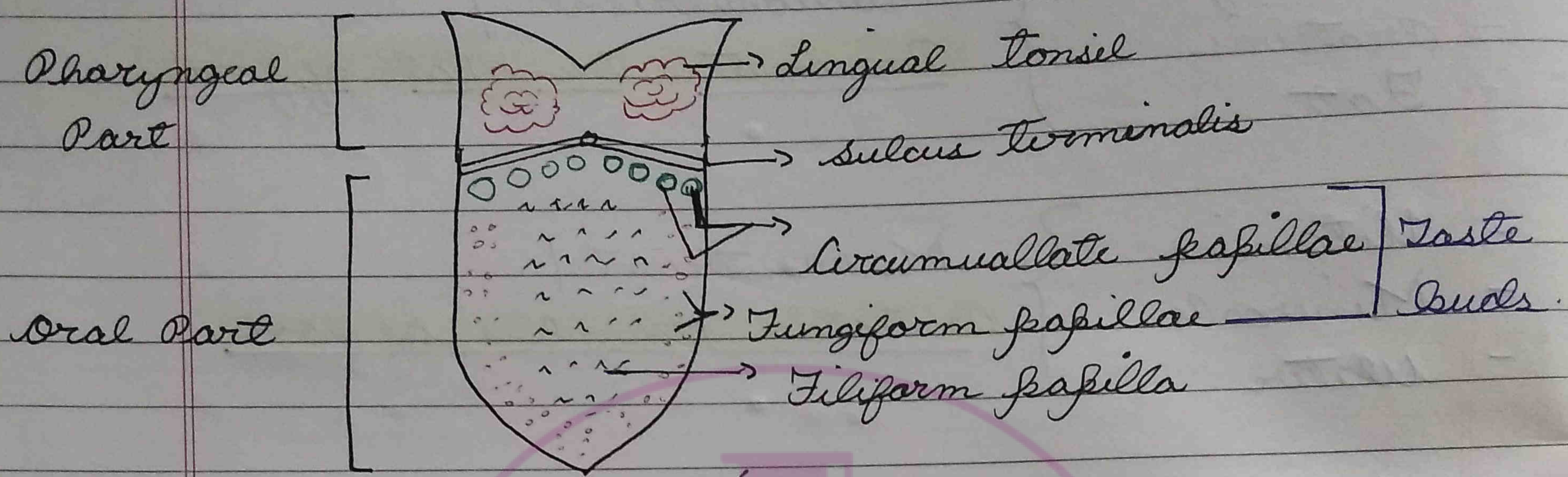
- Uvula: part of soft palate which closes
 the internal nostrils during
 swallowing.

• Tongue: Present on the floor of the mouth cavity,
 attached by frenulum.

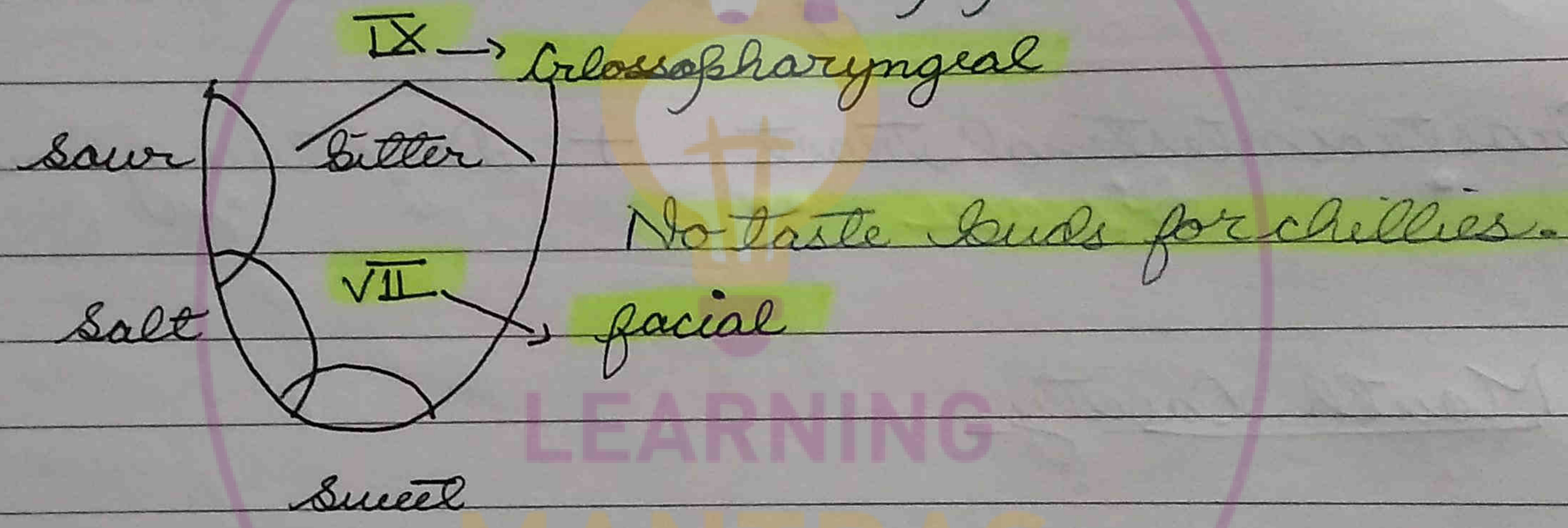
- Made up of voluntary muscles, having epidermis.

- Tonsil → lymphoid tissue, which helps remove infection from food and water.
- Tongue is also attached to hyoid bone.
- Taste buds are absent on filiform papilla.

- Taste papillae are present over tongue epidermis.



(Foliate papillae - absent in humans)



X - Vagus (Throat)

- Three cranial nerves VII, IX and X are taste sensing nerves present in mouth.

Teeth

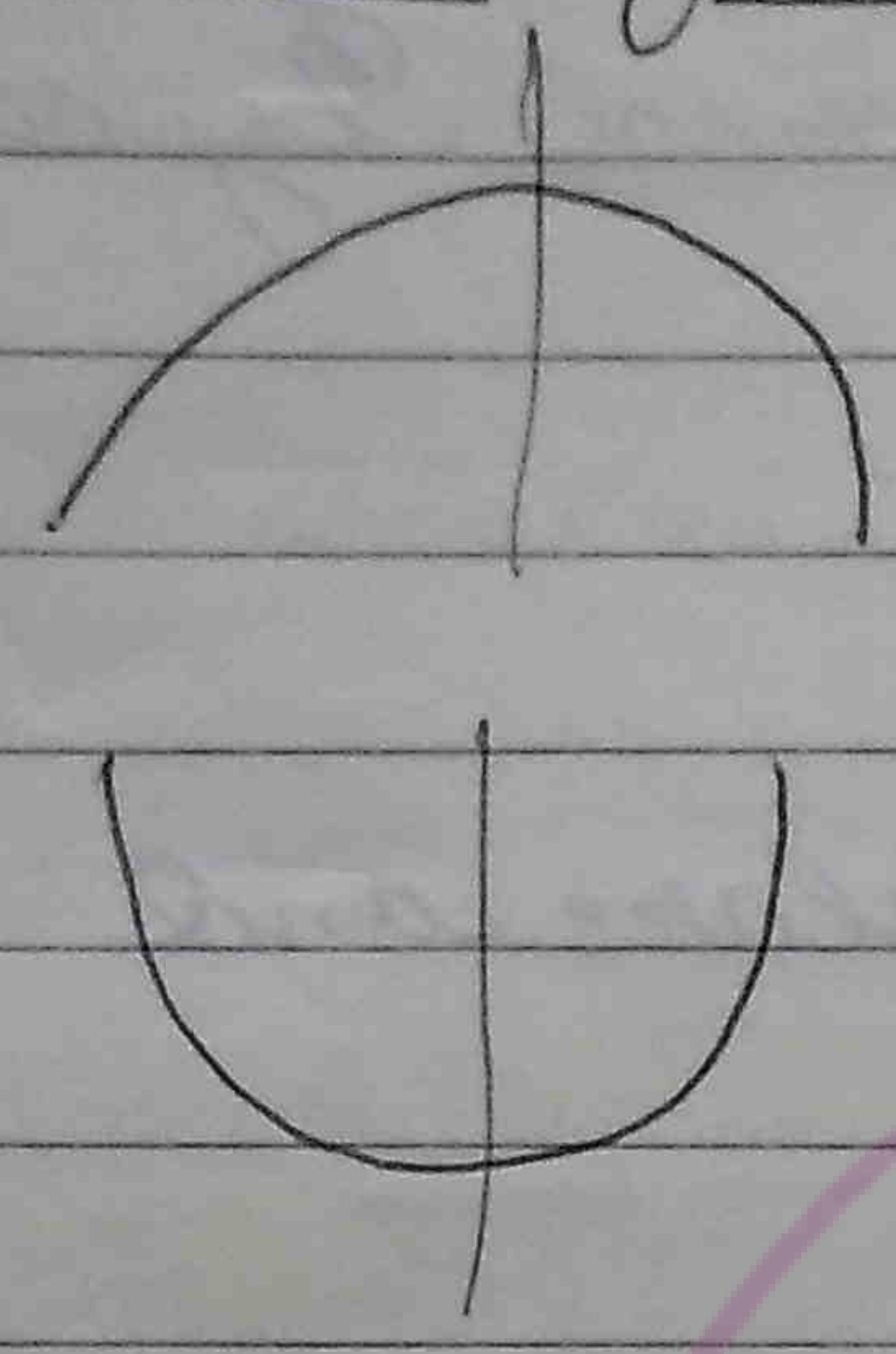
- Thecodont - embedded in sockets of jaw bone.
- Diphyodont - erupt twice in life (Milk and permanent)
- Heterodont - different types of teeth

- milk teeth don't have premolars.
- Ameloblast cells are present only in embryonic life hence enamel is secreted only once.
- Except Enamel all other parts of teeth is of mesodermal origin.

Milk teeth - 20

Permanent teeth - 32

Dental formula

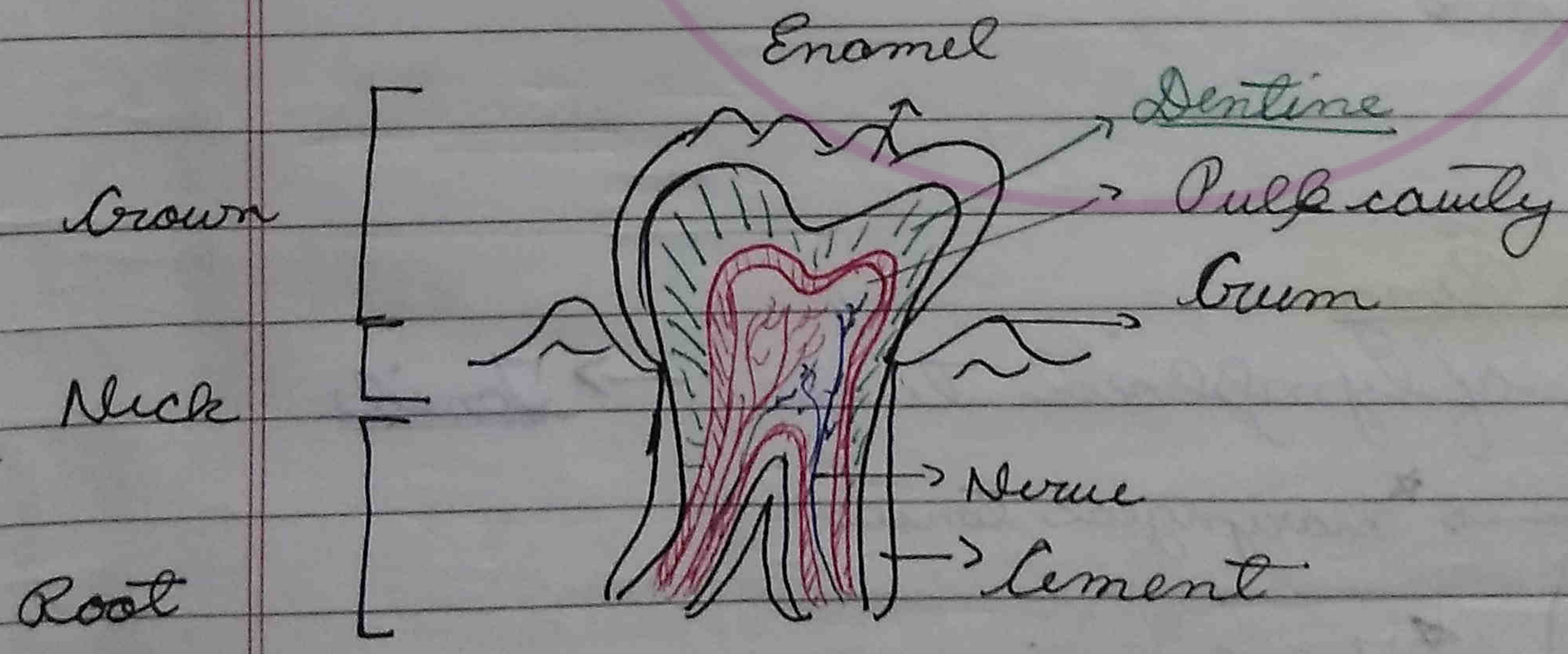


	i	c	pm	m	
milk	<u>2</u>	<u>1</u>	<u>2</u>		$= \frac{5}{5} = \frac{10}{10} = 20$

	i	c	pm	m	
permanent	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	$= \frac{8}{8} = \frac{16}{16} = 32$

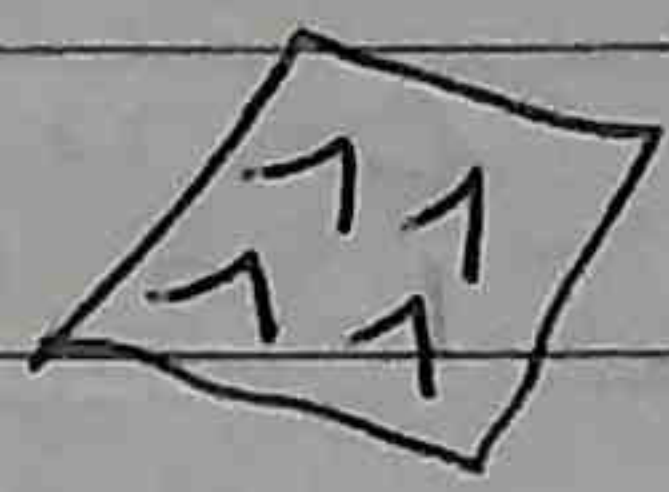
- 12 teeth come only once in a life time and are called monophyodont i.e. all premolars and third molar.

Section through tooth



→ Enamel → ectodermal in origin
 - secreted by Ameloblast cells
 - Hardest substance

→ Dentine → mesodermal in origin
 - secreted by odontoblast cells

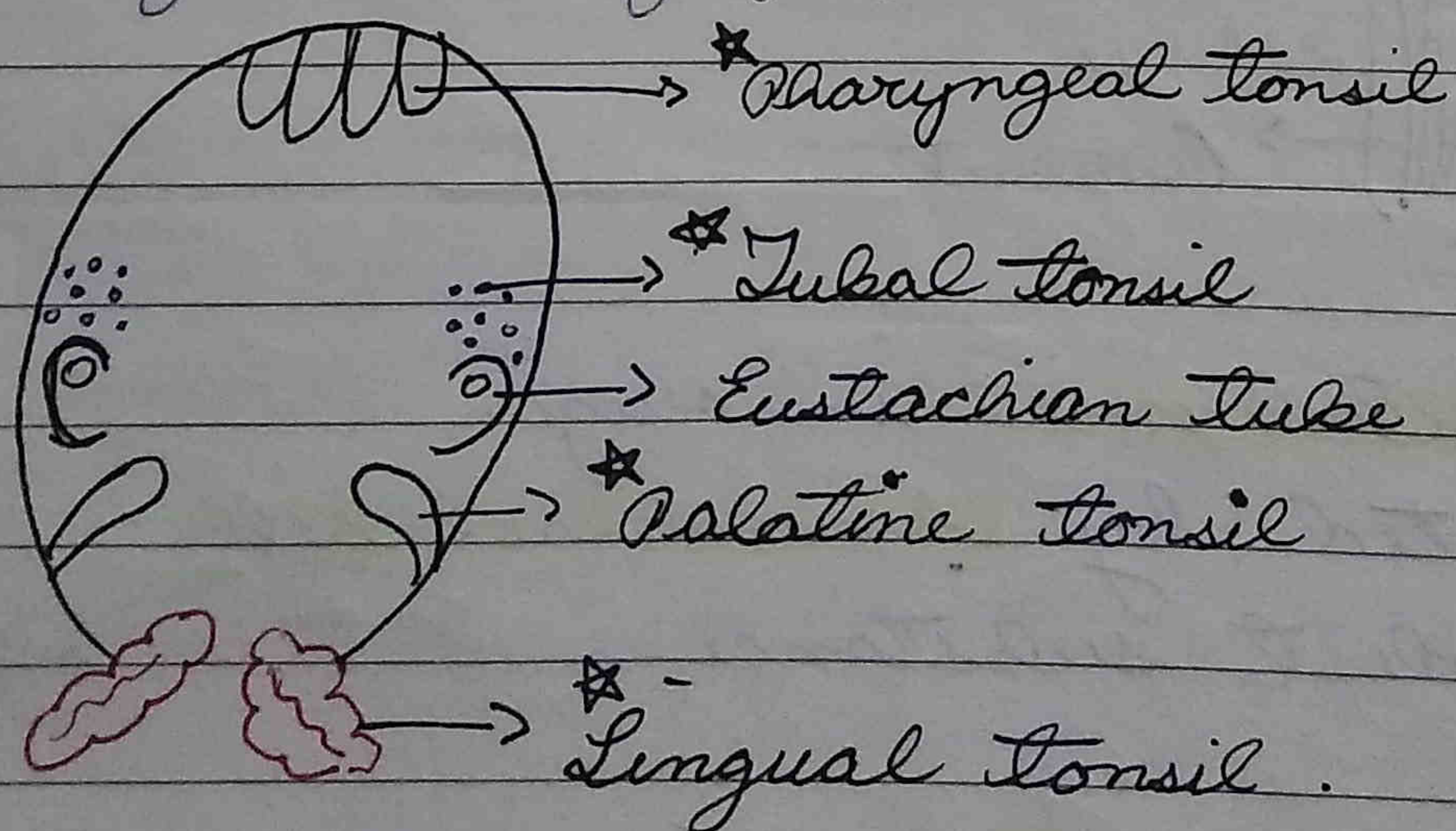
- Dentine contains less calcium phosphate hence is less harder than enamel.
- Dentine on crown area is covered by enamel and in root area is covered by cement.
- Bunodont:  Blunt cups on surface of molars and premolars.

• Pharynx (Throat)

- Common passage for food and air.
- Oropharynx
- Nasopharynx
- Laryngopharynx

• Waldeyers Ring

Arrangement of lymphoid tissue → Tonsils



- ★ Tonsillitis: inflammation of tonsils usually palatine tonsils.

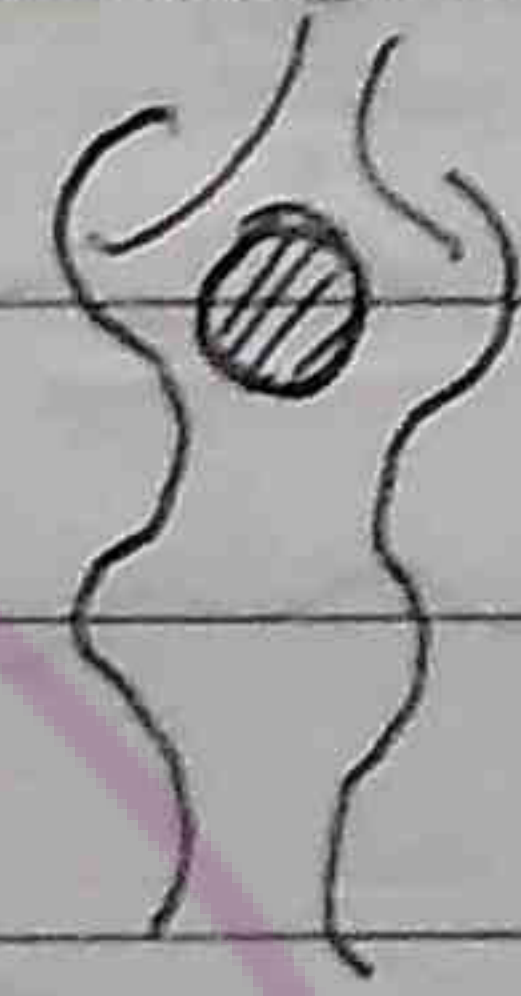
Alimentary Canal

Esophagus (food pipe)

connects mouth cavity to stomach

Peristalsis → alternate contraction and relaxation which propels the food bolus.

Esophagus has no digestive glands but mucus glands are present for lubrication.

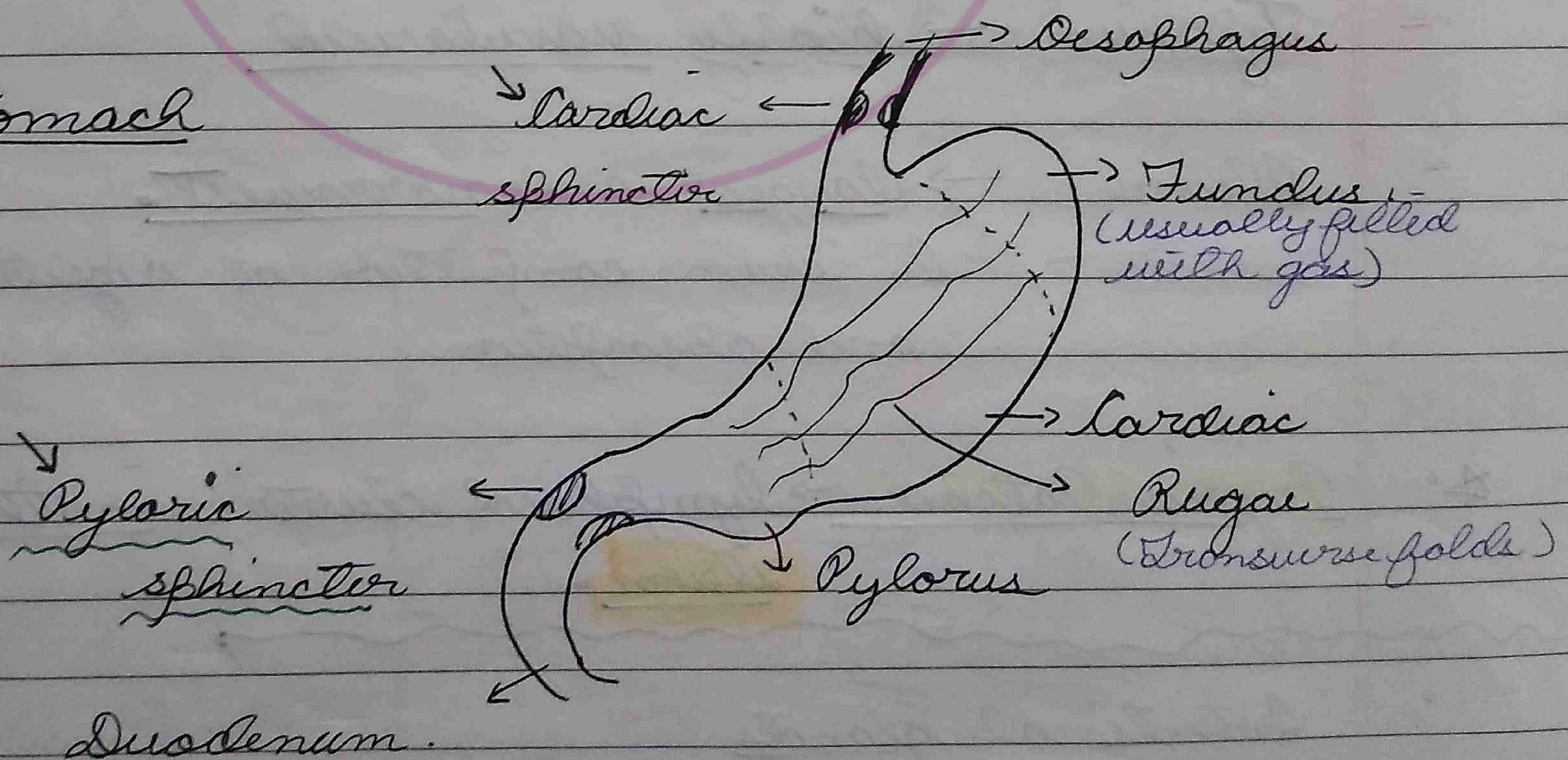


It has two sphincters

★ Upper esophageal sphincter

★ Lower esophageal sphincter / Cardiac sphincter.

Stomach



Intrinsic factor is required for absorption of vitamin B₁₂.

Gastric glands

- Mucus neck cells secrete mucus.
- ★ - Oxyntic cells / Parietal cells secrete HCl and Intrinsic factor.
- ★ - Peptic cells / Chief cells → secrete Pepsinogen and Prorennin.

Small Intestine

- 6.25 metres

- Duodenum → broadest and shortest region.
 - Bile duct and pancreatic duct open in it.
- Jejunum → highly vascularised
- Ileum → longest and narrowest.
 - In ileum completion of digestion and absorption.
- ★ Peyer's Patches → lymphoid clusters in the ileum.

Intestinal glands

- Crypts of Lieberkuhn = enzymes - lipase, lactase, sucrase, maltase, amino peptidase, etc.

Lamina Propria: Loose connective tissue below epidermis

Transverse Colon

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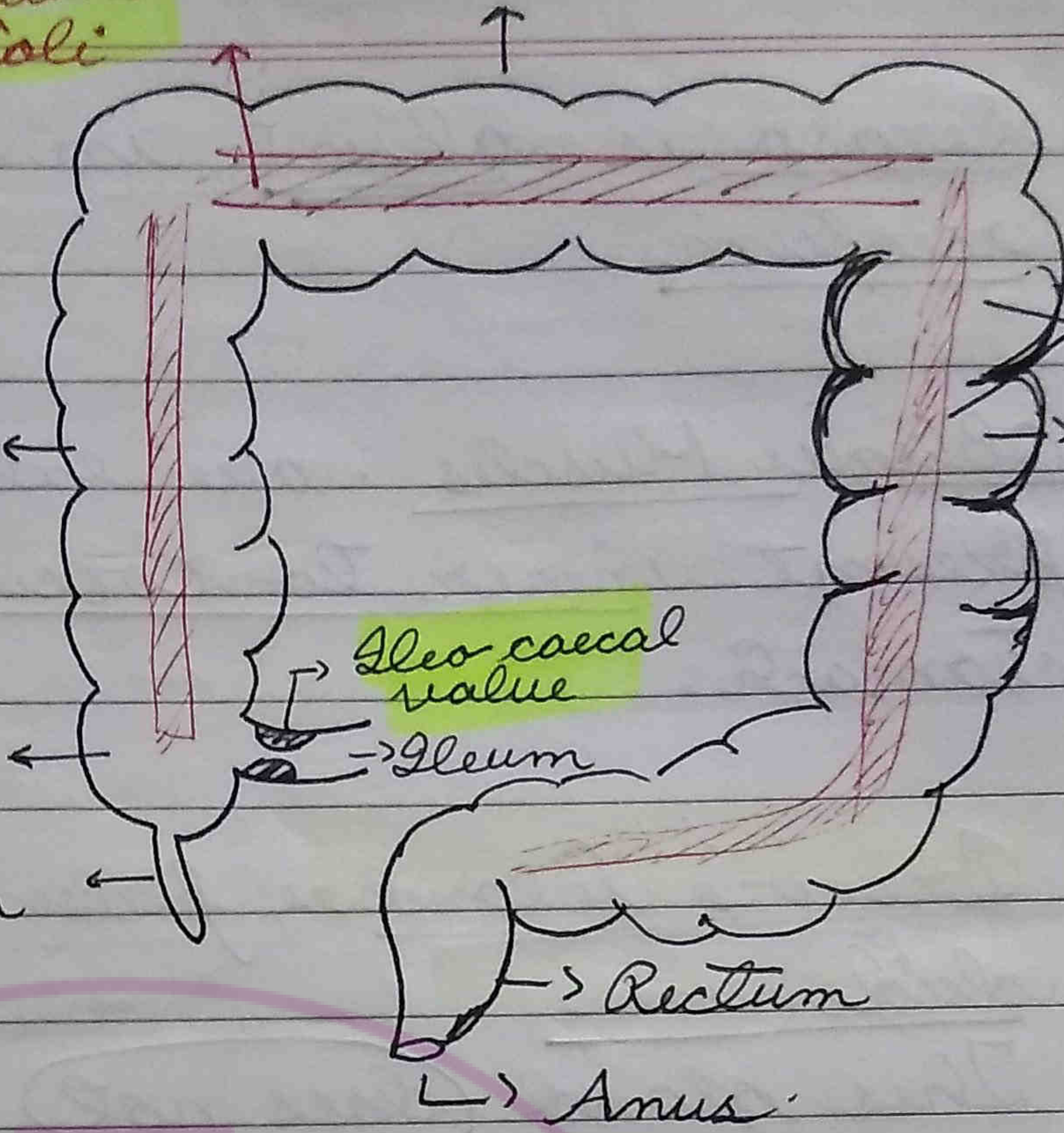
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- Large intestine
- Caecum
- Colon
- Rectum

Ascending colon

Caecum
 Vermiform appendix

Taenia coli



Haustra

Descending colon

Valve caecal
 Ileum

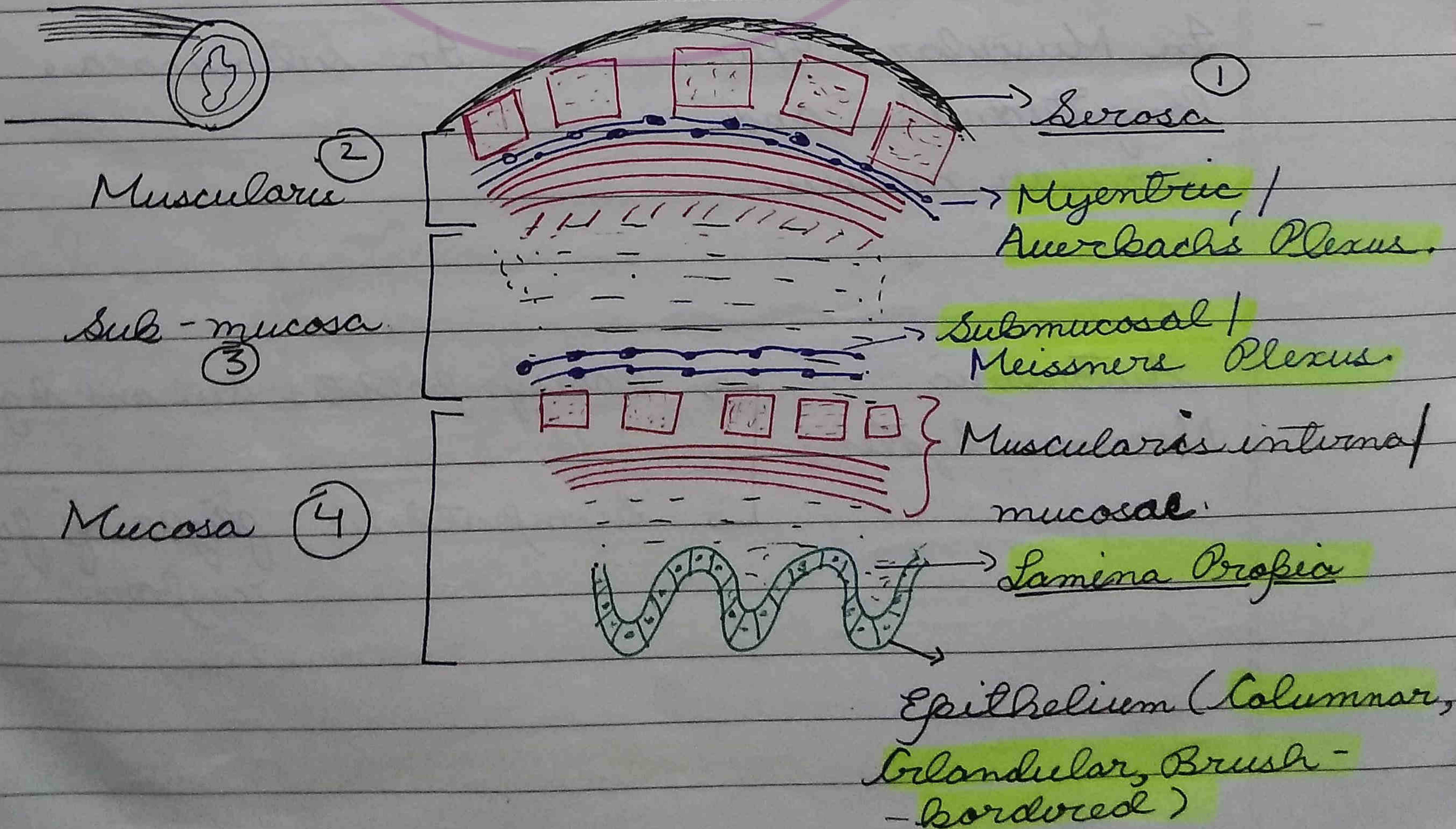
Rectum

Anus

Haustra are formed due to cluster of longitudinal muscles ^(Taenia coli) in the form of bands. There are 3 bands present.

★ Digestion (absent) in large intestine.

Histology of Gastro-Intestinal Tract



★ Brunner's gland is present in submucosa instead of mucosa. classmate
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★ Serosa is absent in esophagus and rectum.

★ Oblique Muscles are extra layer of muscles present inner to circular muscles in stomach.

★ Brunner's Gland is present in submucosa of duodenum.

This gland does not secrete enzymes, but secretes only mucus.

Enteric Nervous System

Nervous system associated with gastrointestinal tract.

Auerbach's Plexus

Meissner's Plexus

- In Muscularis Mucosae longitudinal and circular muscles.

- In submucosa.

Autonomic Nervous System

→ Parasympathetic: Rest and Digest
→ Sympathetic: flight of fight response.

- Brain is considered to be the second brain because of the no. of neurons present here.

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- Peristalsis and enzyme secretion is initiated by Parasympathetic system and decreased by sympathetic nervous system.
- Peri
- ☆ Auerbach's Plexus controls peristalsis.
- ☆ Meissner's Plexus controls the secretion from gastrointestinal glands.

- Digestion: Breakdown of complex insoluble substances into simpler soluble substances.

- Alimentary Canal

Mouth Cavity -

- Tongue → Perception of taste
- Tongue → Aids in mixing saliva
- Tongue → Aids in swallowing.

Teeth → chewing of food.

• Digestive Glands

- Salivary Glands

3 pairs, present outside the buccal cavity.

- Parotid Gland: largest

- opens through Stenson's duct.

- ☆ Mumps → viral infection of parotid.

- Both lysozyme and thiocyanate are bacteriocidal.
- Parotid → Stenson's duct
- Sublingual → Rivinus
- Sub-mucillary / mandibular → Wharton's duct.

• Sublingual Duct Island

- Located beneath the tongue.
- Open through Duct of Rivinus.

• Submucillary / Submandibular Island

- present on sides of lower jaw.
- opens through duct of Wharton's duct.

• Secretion of all three glands is called saliva

• Saliva

- pH 6.8 : slightly acidic
- contains water, mucins
- Salivary amylase (Ptyalin)
- Lysozyme
- Ions - Na^+ , Cl^- , HCO_3^- , Thiocyanate (SCN^-), K^+

• Salivary amylase breaks down starch.

• Salivary secretion is stimulated by Para-sympathetic nervous system and inhibited by Sympathetic nervous system.

- Aptyalism → Failure of secretion of saliva.

Those who have this are more prone to dental caries.

B_{12} is required for maturation of RBC

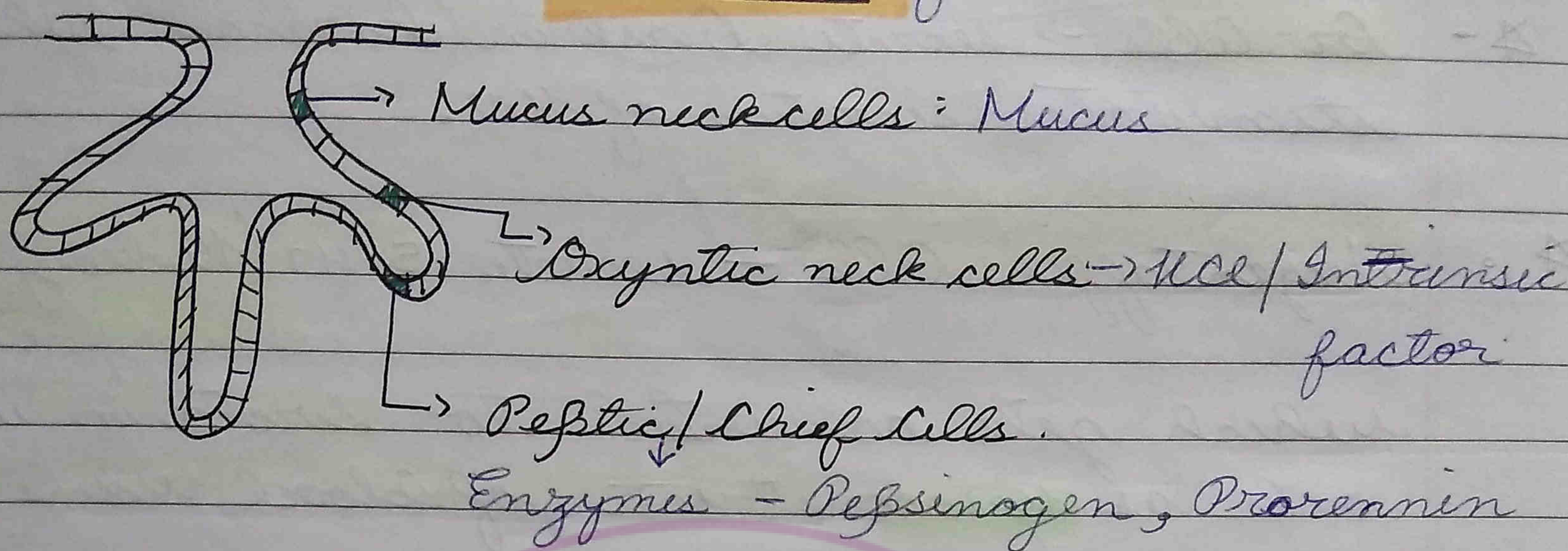
Iron in the food we eat is in the form of Fe^{+3} which cannot be absorbed and has to be converted to Fe^{+2} which can be absorbed.

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Gastric Glands

Located in the mucosa of stomach.



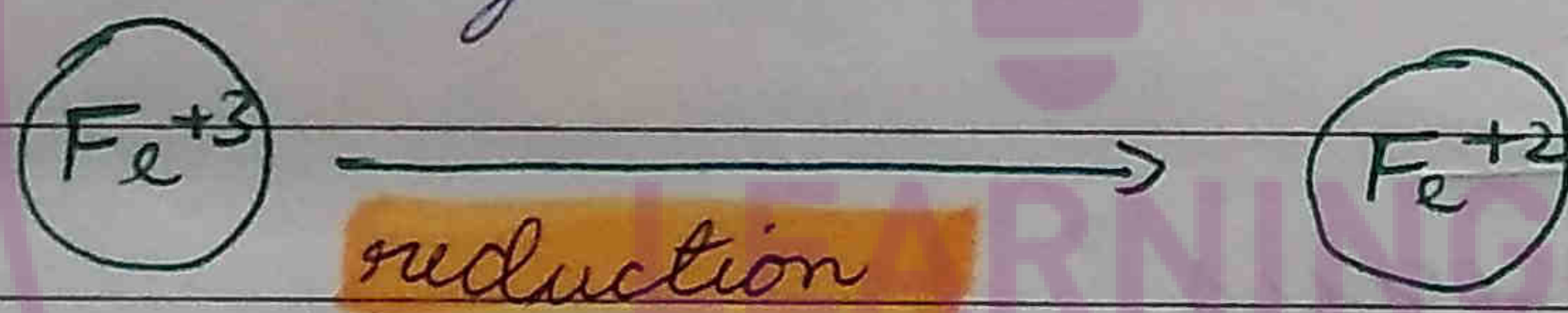
- Mucus → alkaline, glycoproteinaceous

- HCl :- makes medium acidic

- activation of inactive prozymes

- kills germs

★



cannot be absorbed

Absorbed

- Castle's Intrinsic Factor →

- Glycoprotein

- Binds with vitamin (B_{12}) and helps its absorption in ileum.

- Deficiency of B_{12} → Pernicious anaemia.

★★ If oxyntic cells are damaged then both iron deficiency anaemia and pernicious anaemia will occur.

Endocrine cells

☆ G cells → secrete Gastrin hormone which stimulates secretion of HCl.

☆ Argentaffin cells - secrete 5-HT (Hydroxytryptamine) which gets converted to Serotonin which acts as vasoconstrictor of blood vessels.

- Stem cells: Replace worn-out cells of stomach.

Gastric Juice

- Water, mucus

- Enzymes - Pepsinogen, Prorennin

* [Lipase - active in infants]

- HCl

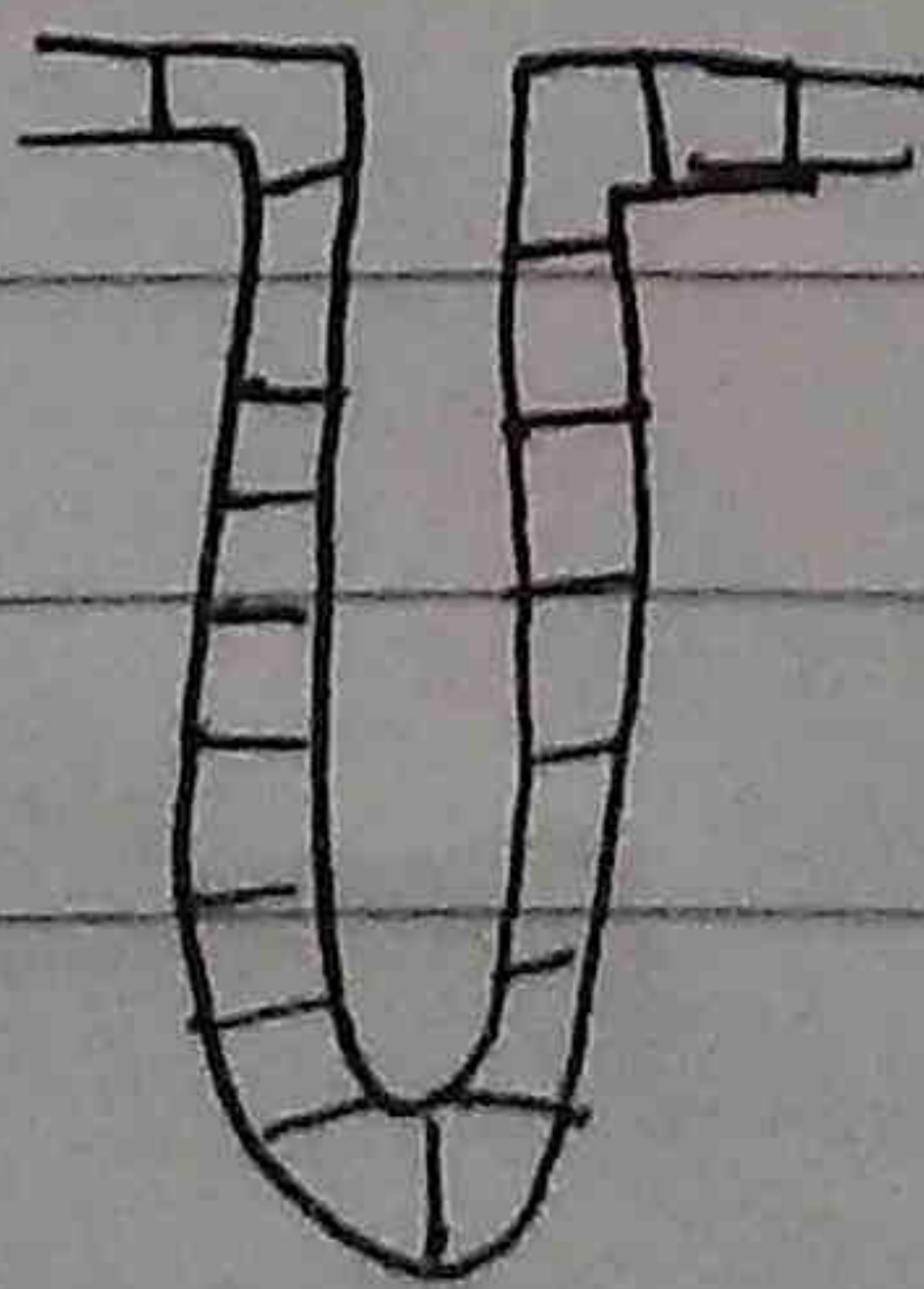
- Castle Intrinsic factor

Acidic

pH 1.5-3

Intestinal Glands

• Crypts of Lieberkuhn: Simple tubular glands in mucosa of small intestine.



☆ Brisson's capsule is characteristic of mammals.

☆ Enteroogastrone is hormone secreted by duodenal mucosa

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Brunner's gland → Located in submucosa of duodenum.

- secretes (only) mucus

Secretions from crypts of Lieberkuhn and Brunner's gland is called Intestinal Juice / Succus Entericus.

Alkaline - pH 7.4 - 7.8

Water, Mucus, HCO_3^-

Enzymes - Sucrase, Lactase, Maltase, Lipase, Enterokinase, Aminopeptidase, Nucleosidases.

Liver →

- Largest gland of the body.

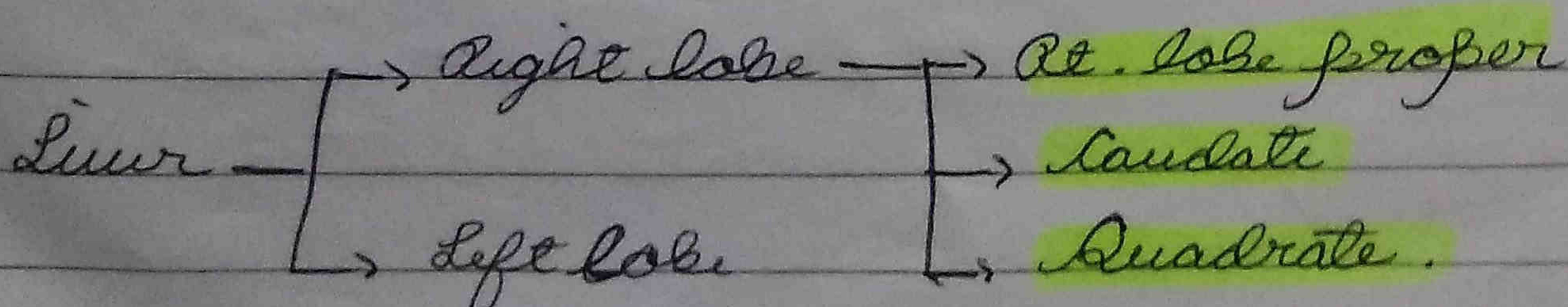
- Located beneath the diaphragm on the right side.

- Liver is comprised of two lobes - joined by falciform ligament.

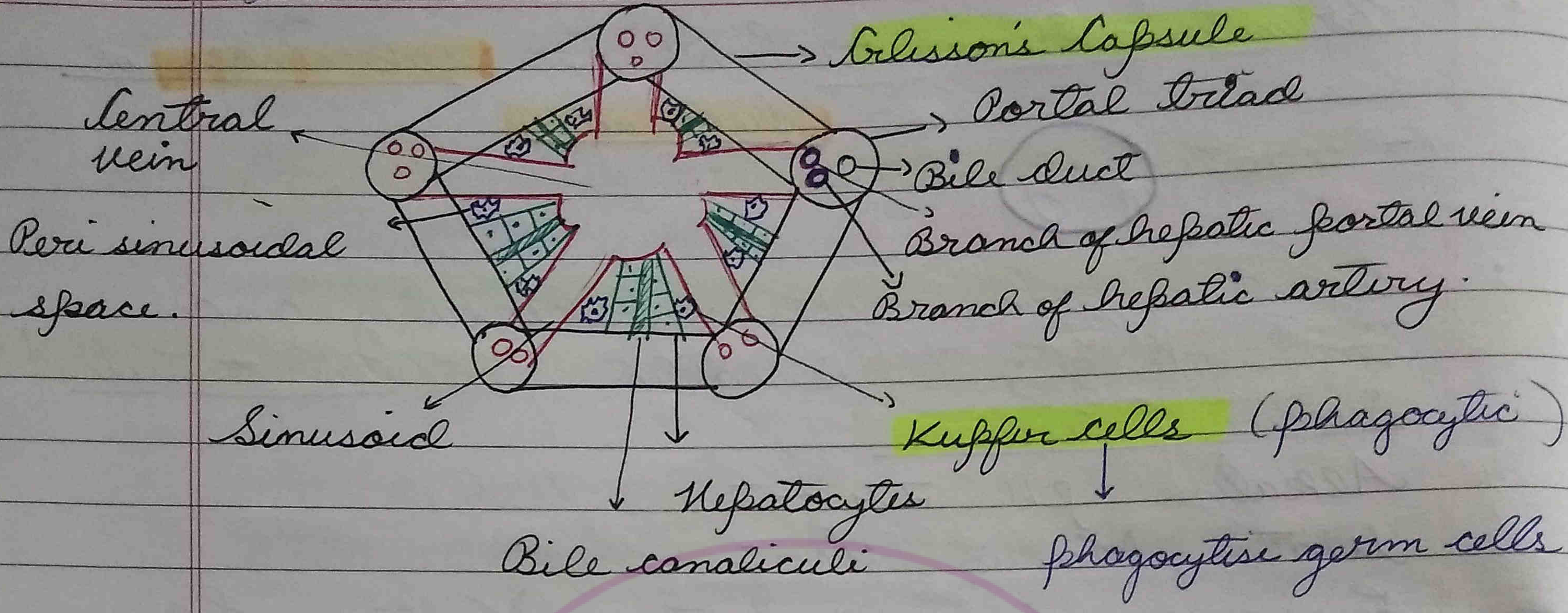
- Each lobe is divisible into lobules which are structural and functional units of liver.

☆ Brissone's capsule: Fibrous sheath beneath visceral peritoneum.

This surrounds the lobes and lobules.



- Q. Y. Q. Hepatic Portal vein bring nutrient rich, oxygen deficient blood.
- Hepatic artery brings oxygen rich, nutrient deficient blood.



Bile juice

- water, HCO_3^-

* Bile Salts: Sodium taurocholate } synthesized from cholesterol.
Sodium glycocholate

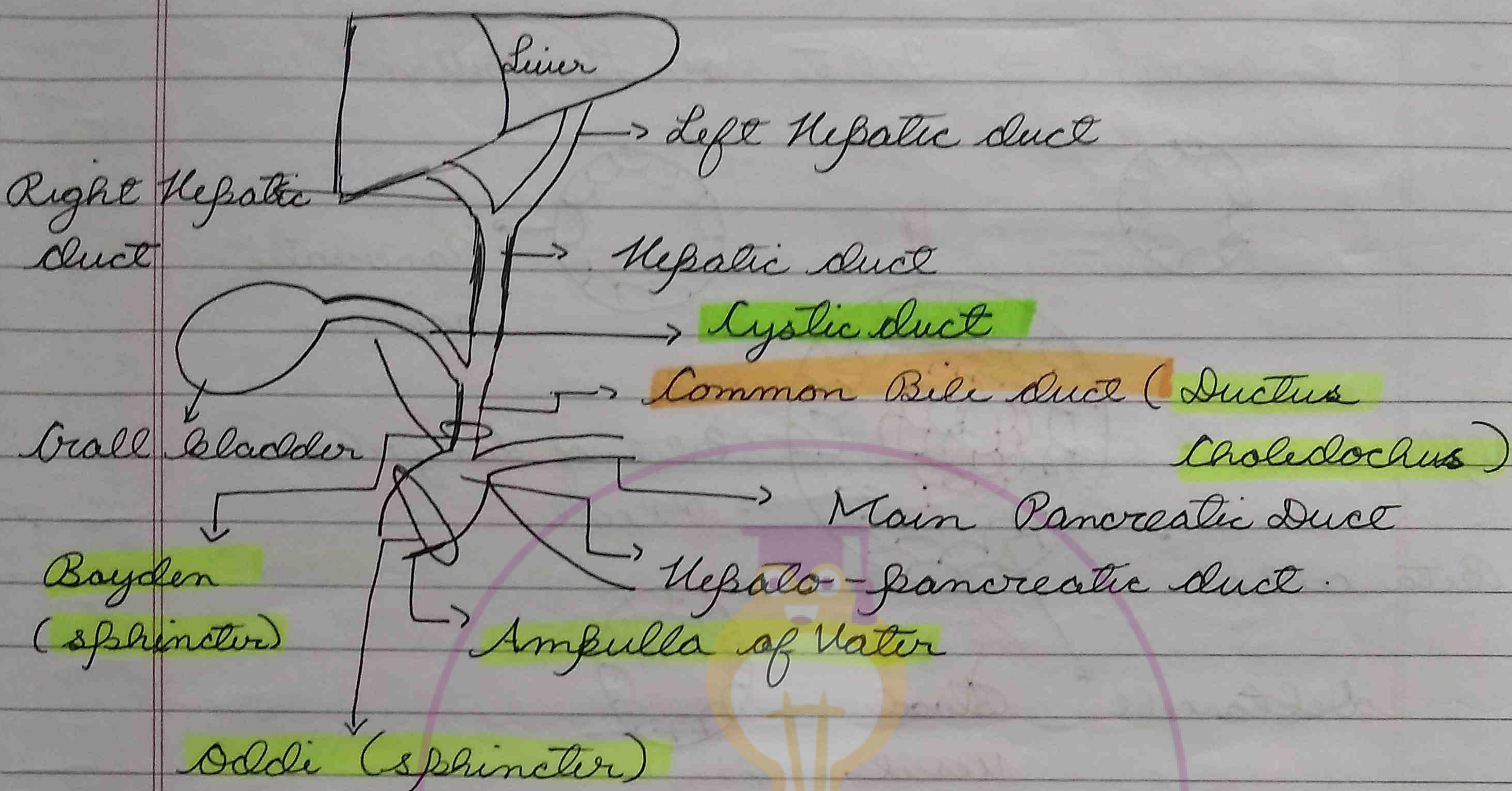
Bile pigments - Bilirubin, Biliverdin

Break down (waste formed Haem porphyrin)
product of RBC.

Hepatic Bile -> alkaline pH = 8.6

stored in gall bladder: water is absorbed and as a result acidification occurs hence gall bladder bile has a pH of 7.4

Liver and Gall Bladder



Gall stones: due to precipitation of cholesterol

★ Cholelithiasis → formation of gall stones

Cholecystectomy → surgical removal of gall bladder.

Pancreas

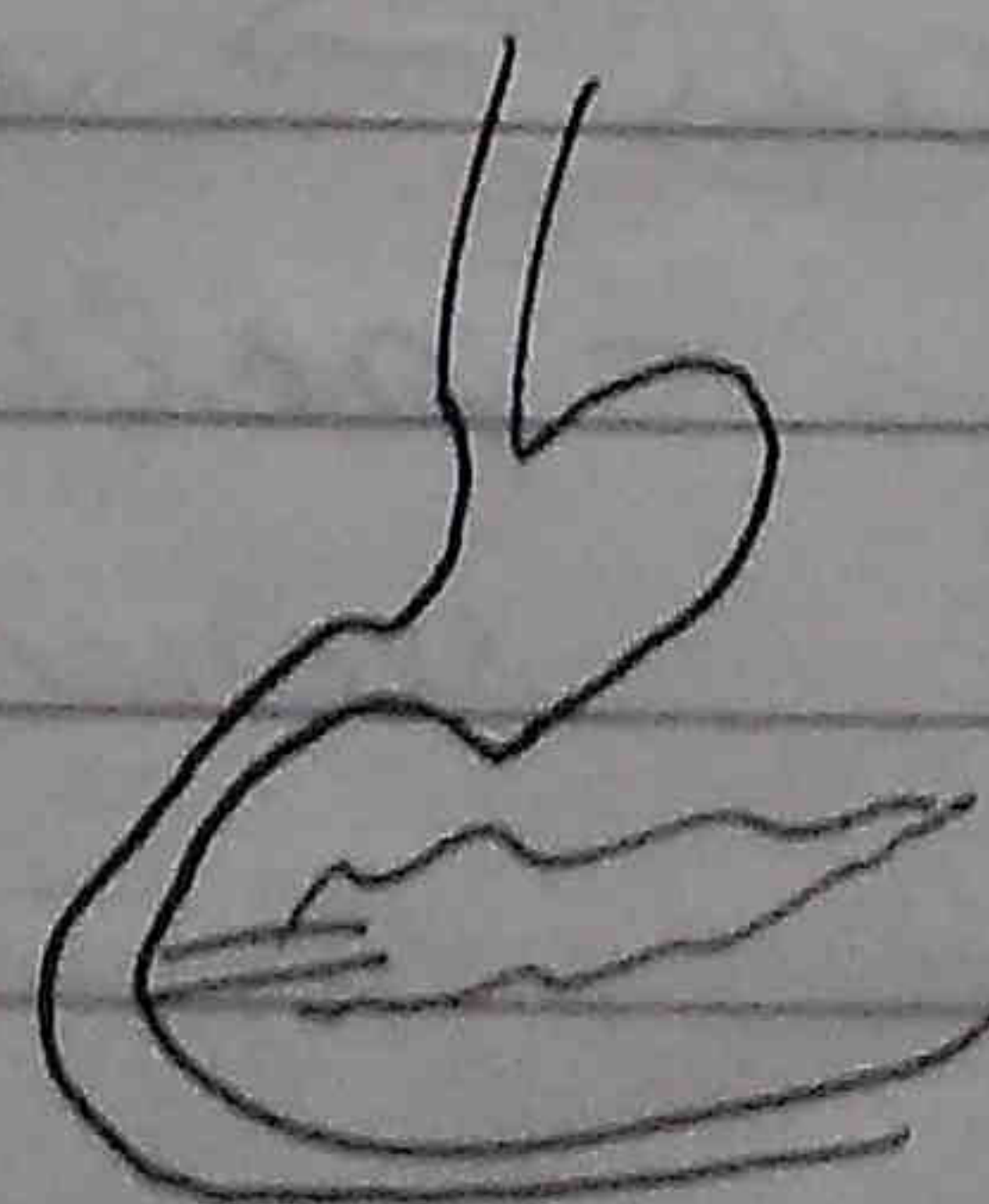
Mixed Gland

Both exocrine and endocrine
 with duct ductless

Head

Body

Tail



★ Bicarbonate in pancreas is secreted by acinar cell.

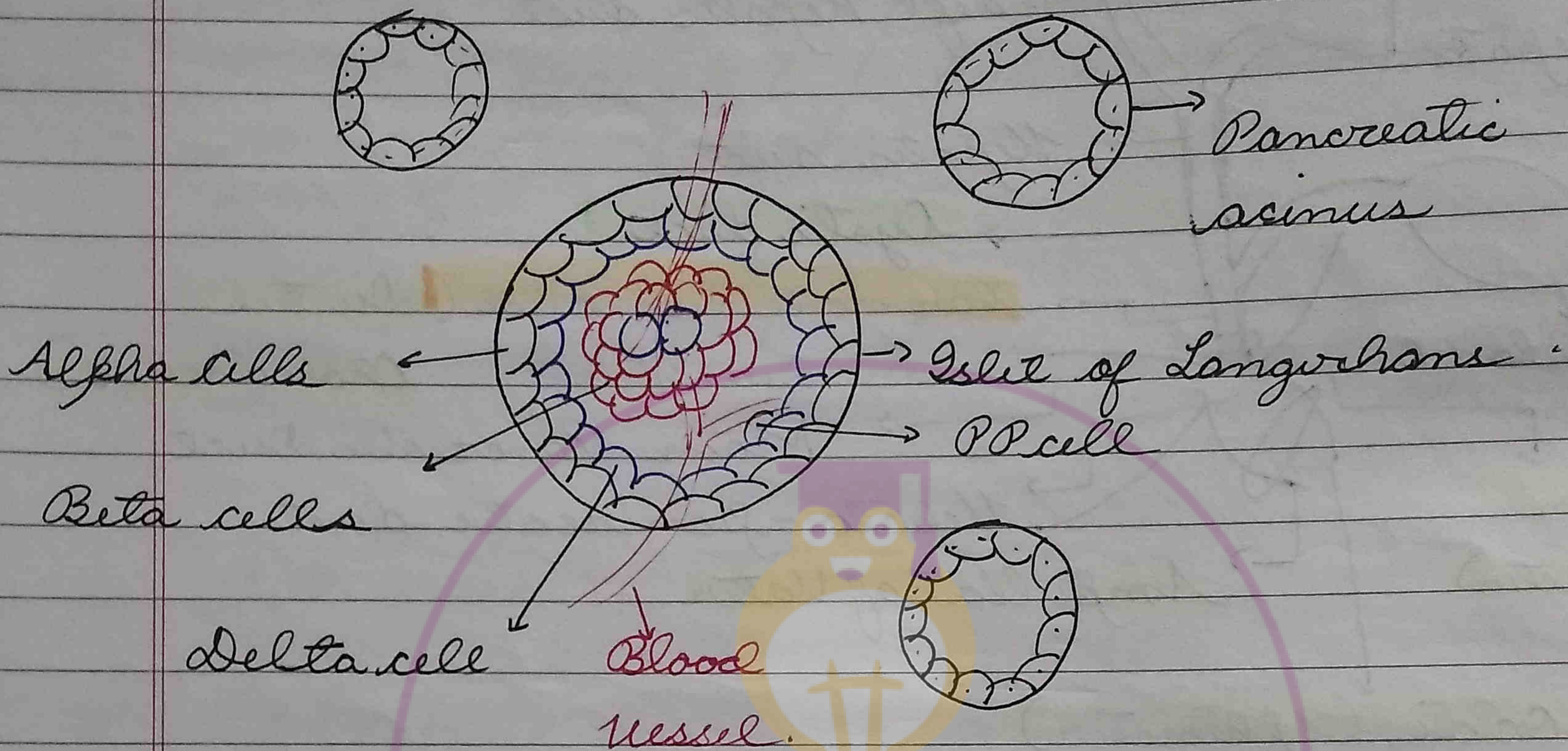
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★ Exocrine → β Pancreatic acini

Endocrine → Islets of Langerhans



Islets of Langerhans

- Alpha cells — secrete Glucagon hormone
- Raises blood glucose level.
- Beta cell — secrete insulin hormone
lowers the blood glucose level.
- Delta cell — secrete Somatostatin.
- Inhibits insulin and glucagon.
- P.P. cell → secrete Pancreatic Polypeptide.
- acts on pancreatic acini and inhibits secretion of pancreatic juice.

Pancreatic Juice

Exocrine part secretes pancreatic juice.
Alkaline pH = 7.6

Components

Water, HCO_3^-

Enzymes - Trypsinogen, Chymotrypsinogen,
Procarboxypeptidase, Proelastase, Lipase,
Pancreatic amylase, Nucleases.

★ Wirsung's Duct → Main pancreatic duct which joins the bile duct to form Hepato-pancreatic duct.

★ Duct of Santorini → Accessory pancreatic duct which opens directly into the duodenum.

Physiology of Digestion

• Ingestion → intake of food.

• Mastication → Teeth chew the food and there is physical breakdown.

• Deglutition → Swallowing.

• Deglutition centre is located in medulla.

• Food bolus is pushed by the tongue.

• Involuntary muscles in the pharynx are stimulated.

• Larynx moves up.

• Epiglottis swings and covers the glottis (wind pipe opening).

• soft palate and uvula close internal nostrils.

• upper oesophageal sphincter relaxes and bolus moves into it.

• Digestion of carbohydrates

Dietary carbohydrates

Starch

Sucrose

Lactose

Cellulose — undigestible

• In the mouth cavity

starch	Amylase	Maltose + Dextrins
↓		↓
Polysaccharide	6.8	(disaccharides) Oligosaccharide

• In the stomach

• Salivary amylase is denatured due to acidic pH

• No further carbohydrate digestion.

- 30% breakdown of starch occurs in mouth, the rest occurs in intestine.
- ★ Salivary amylase is called Ptyalin and pancreatic amylase is called Amylopsin.

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- In small intestine

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- Pancreatic Juice

Pancreatic Amylase (Amylopsin)

Starch $\xrightarrow[7-8 \text{ hr}]{\text{Amylase}}$ Maltose + Dextrin

- Succus entericus

Maltose $\xrightarrow{\text{Maltase}}$ Glucose + Glucose

Dextrin $\xrightarrow{\text{Dextrinase}}$ 5-8 Glucose units

Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose

Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose

- ★ Lactose intolerance: Milk sugar remains undigested due to insufficient lactase.

- Digestion of cellulose

- Remains undigested in humans

- acts as roughage / fibre

- Cellulase: absent in vertebrates

Ruminants have symbiotic micro-organisms in their gut which aid in cellulose digestion

In horse, donkey, the microbial fermentation occurs in caecum.

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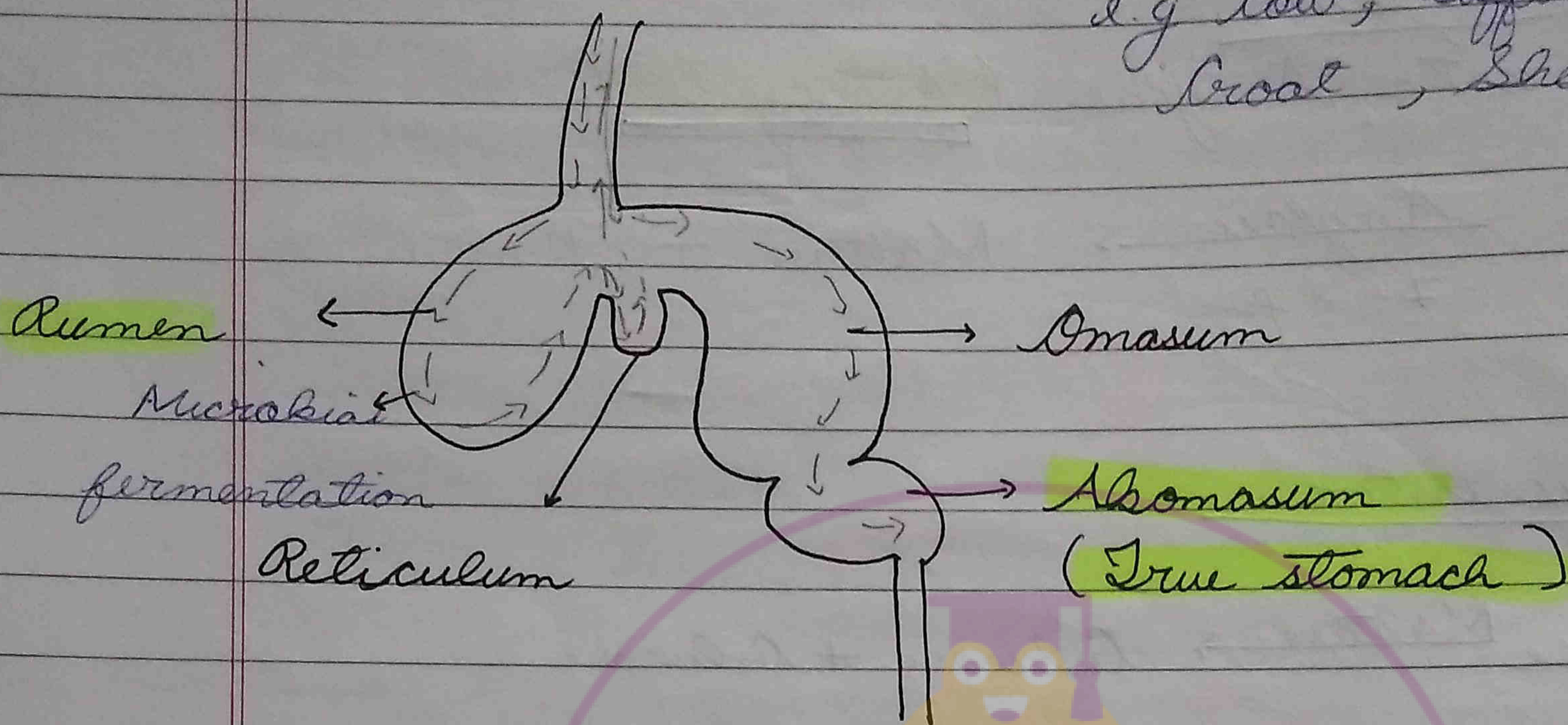
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Proteases released in inactive form so that auto-digestion of cell doesn't take place.

Ruminant Stomach

(4) chambered

e.g. cow, Buffalo, Goat, Sheep.



★ HCl secreting cells are present in true stomach: abomasum.

Digestion of Proteins

Proteins

- macromolecules

- Monomer unit of proteins are amino acids

- Proteases → protein digesting enzymes.

- Prozymes / Zymogens: Inactive precursors of proteases.

Protein digestion starts from stomach, it does not occur in mouth.

• Pepsin is most effective at a pH of 1.8.

• Pepsin shows autocatalytic property.

★ Pepsin acts on calcium paracaseinate hence digests Casein.

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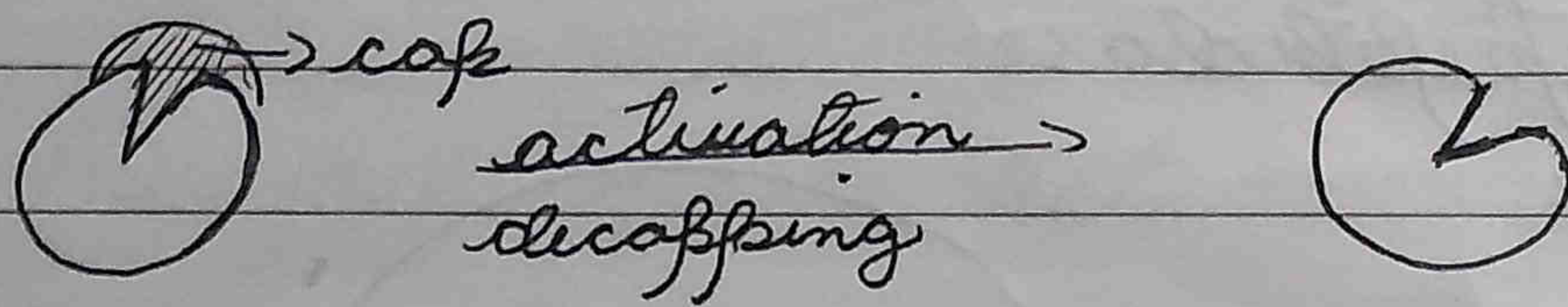
• In the stomach:

• Gastric Juice -

HCl

Pepsinogen $\xrightarrow{\text{HCl}}$ Pepsin (active)

Prorennin $\xrightarrow{\text{HCl}}$ Rennin



• Pepsinogen $\xrightarrow{\text{Pepsin}}$ Pepsin (Autocatalysis)

• Rennin - digest milk protein (Casein)

Casein $\xrightarrow{\text{Rennin}}$ Paracasein

Paracasein + Ca^{2+} \longrightarrow Calcium paracaseinate.
= 'curdling of milk'

Calcium paracaseinate $\xrightarrow{\text{Pepsin}}$ Peptones
(smaller polypeptide chains)

Proteins $\xrightarrow{\text{Pepsin}}$ Peptones and Protoses.

★ Chyme - Ingested food + gastric juice

• Acid chyme moves into small intestine.

• Neutralisation of acidic chyme occurs by bile juice.

- Trypsin also has autocatalytic property.
- Carboxypeptidase cleaves where COOH group is present.
- Aminopeptidase cleaves where amino group is present.

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Enzyme action in small intestine —

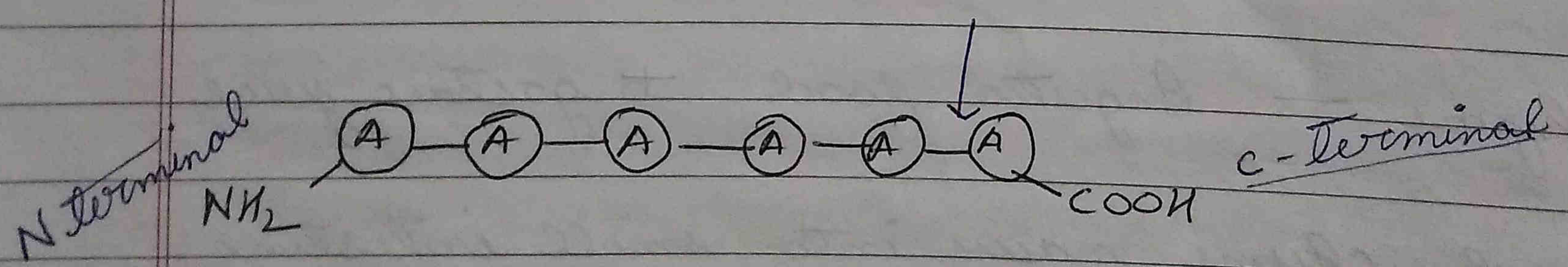
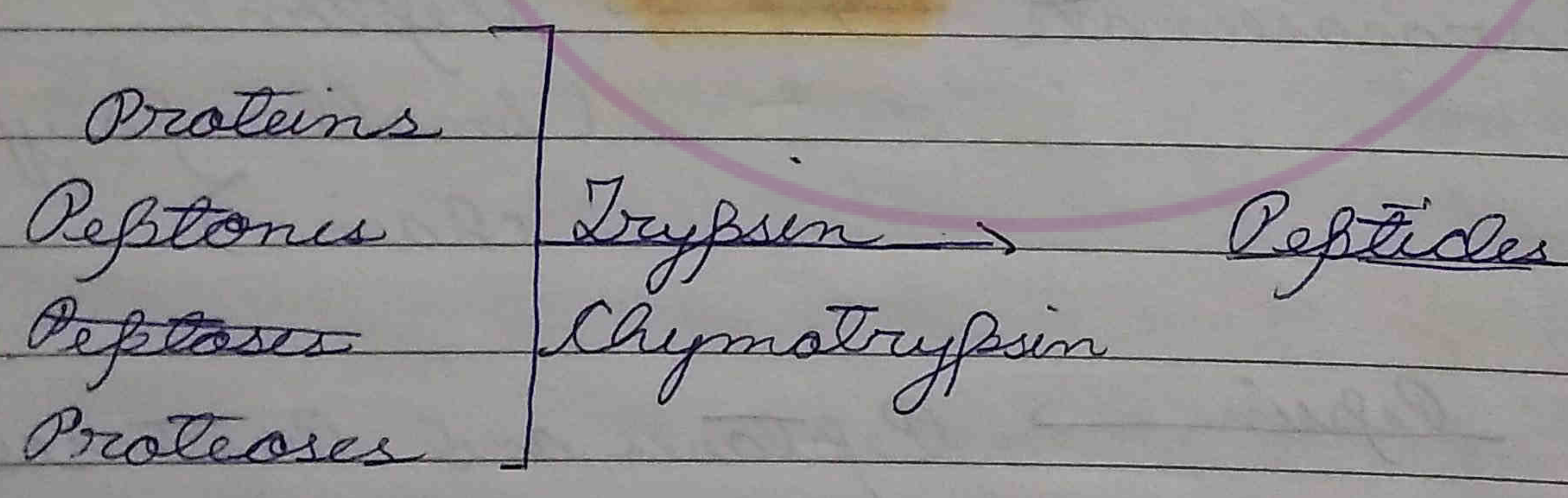
- Pancreatic Juice:
- Inactive proteases
 - Trypsinogen
 - Chymotrypsinogen
 - Procarboxypeptidase
 - Proelastase

Trypsinogen $\xrightarrow{\text{Enterokinase (succus entericus)}}$ Trypsin (Endo-)

Chymotrypsinogen $\xrightarrow{\text{Trypsin}}$ Chymotrypsin (Endo)

Procarboxypeptidase $\xrightarrow{\text{Trypsin}}$ Carboxypeptidase (Endo)

Proelastase $\xrightarrow{\text{Trypsin}}$ Elastase (Endopeptidase)



Carboxypeptidase → cleaves peptide bond from c-terminal end.

Elastin protein $\xrightarrow{\text{Elastase}}$ Peptides

- Enterokinase acts on trypsinogen and not on proteins

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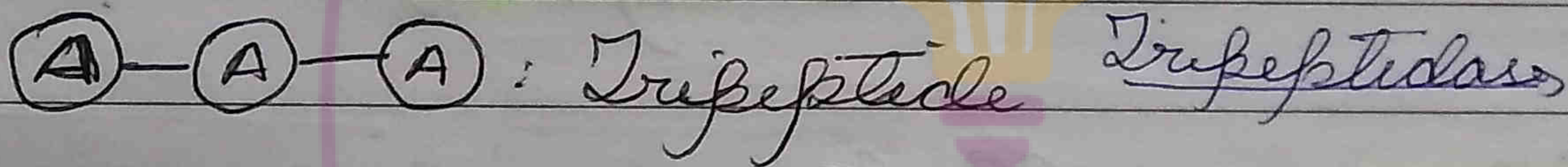
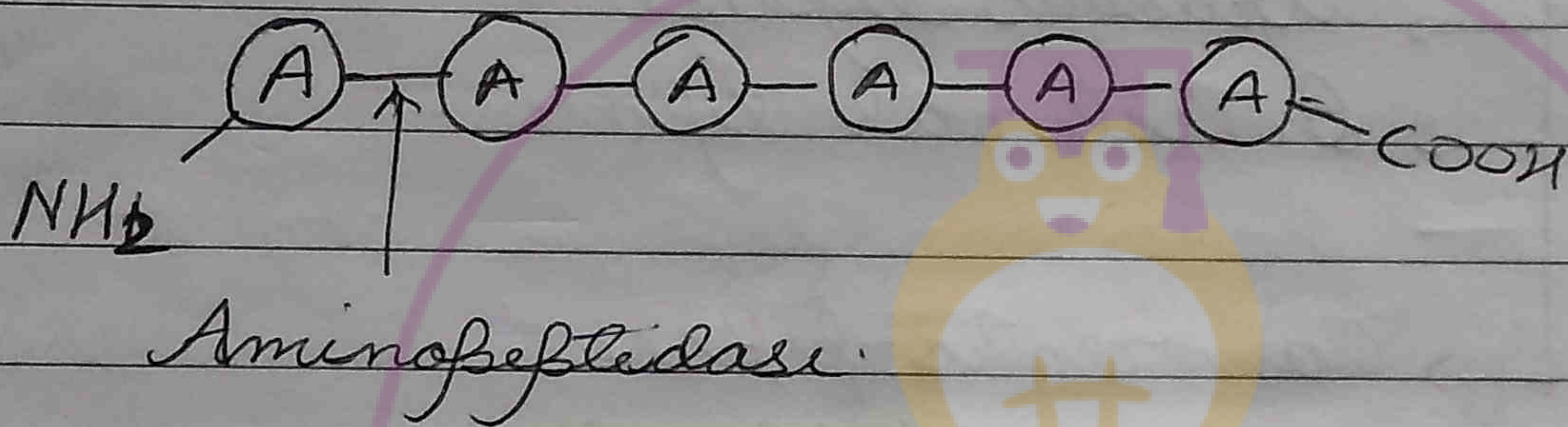
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Proteases in Succus Entericus

- Enterokinase

- Aminopeptidase: cleaves terminal bond from (Exopeptidase) N-terminal.

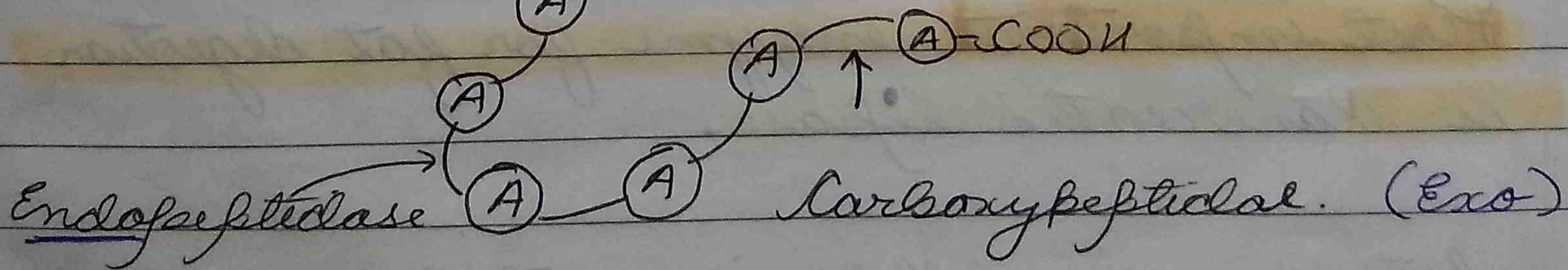
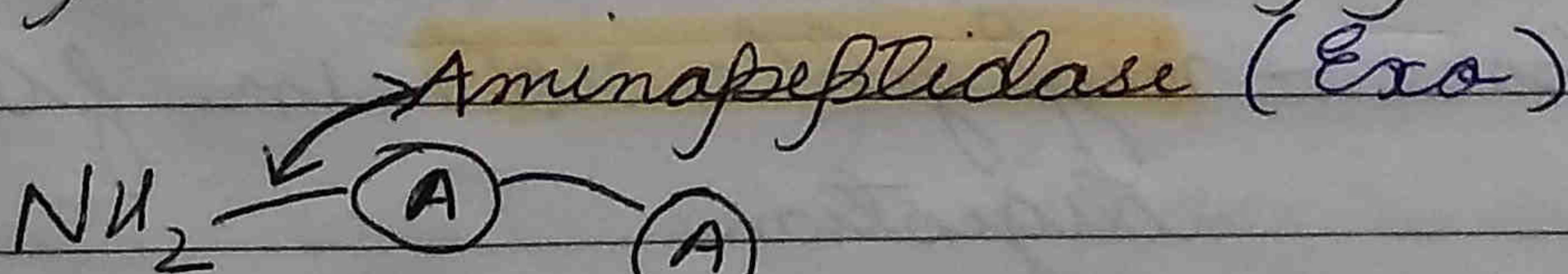
- Tri-/Di-peptidases act on tri/dipeptides



Proteases

↓
Endopeptidases

↓
Exopeptidases



End product of protein digestion is Amino-acids.

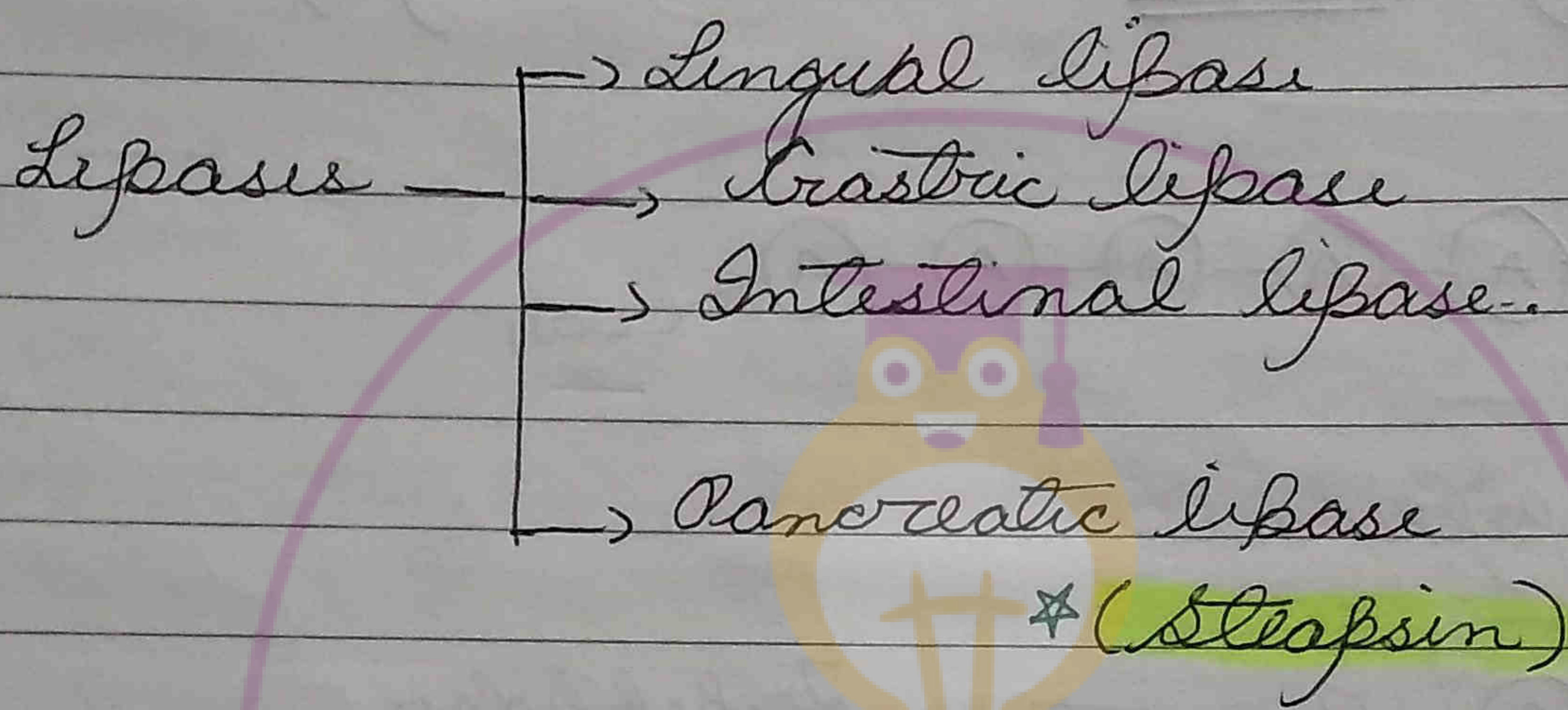
★ Fat digestion cannot take place even if lipases are present if emulsification does not take place.

Digestion of Fats

Dietary fat / Lipid.

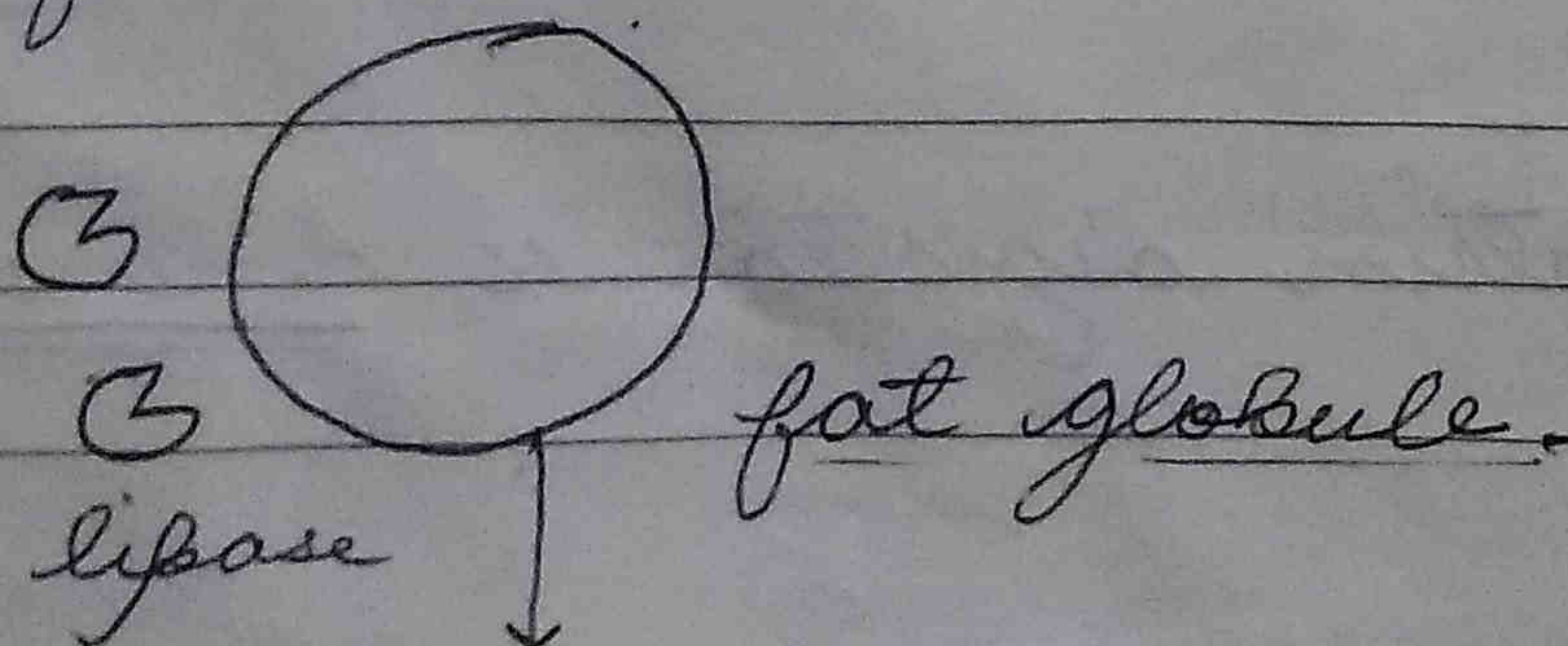
- ★ - Triglycerides
- ★ - Cholesterol (digestion not required, directly absorbed)

Lipases → fat digesting enzymes.

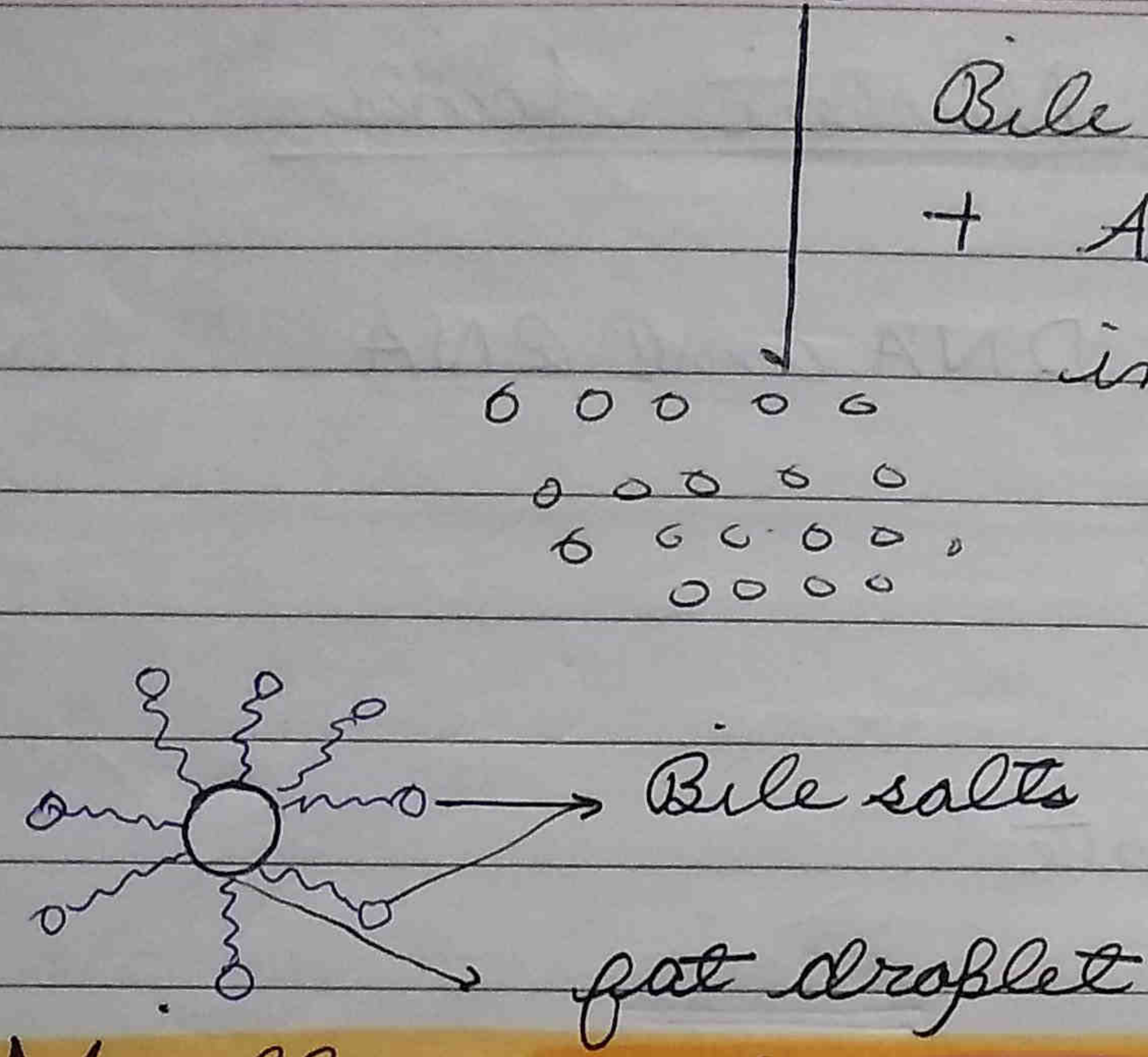


- Ebner's Gland on the tongue which secretes lingual lipase.
- ★ Gastric lipase - active in children as pancreas are insufficient.
- Intestinal lipase - negligible role in fat digestion.
- ★ Most important enzyme for fat digestion is Pancreatic lipase.

fats are insoluble in water.



- Only water soluble substances can be acted upon by enzymes.
- fat globule is too large for active site of lipase hence has to be broken down.

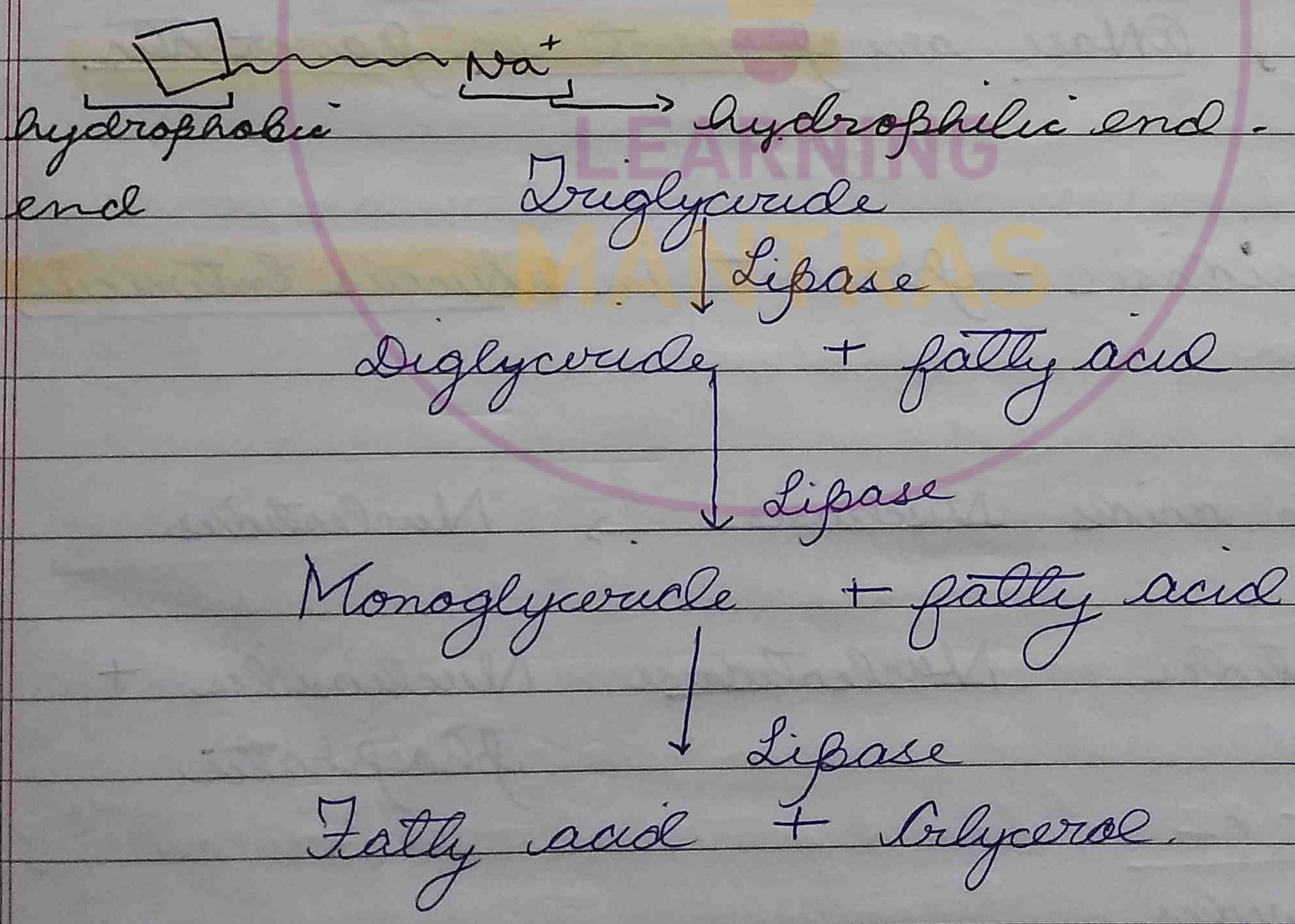


Bile salts + Agitation in intestine → **Emulsification**: conversion of large fat droplets into small droplets surrounded by bile salts to form water soluble micelles.

Micelle - water soluble.

Bile salts: Sodium taurocholate and Sodium glycocholate

They have been synthesised from cholesterol.



End product of fat digestion is **fatty acids** and **glycerol**.

- **Lipase / Esterase** → cleaves ester bond between fatty acids and glycerol.
- From 1 triglyceride, 3 fatty acid and glycerol formed.

- Nucleases are present in pancreatic juice
- Nucleotidase, Nucleosidase present in succus entericus

Digestion of Nucleic Acids

Nucleic acids — DNA and RNA

|
Nucleotides

/ \
Nucleosides Phosphate

/ \
Nitrogenous Pentose sugars
Bases

- Nucleases — enzymes which digest nucleic acids.

• DNase, RNase are present in pancreatic juice.

- Nucleosidases - present in Succus Entericus

Nucleic acids $\xrightarrow{\text{Nucleases}}$ Nucleotides

Nucleotides $\xrightarrow{\text{Nucleotidase}}$ Nucleosides + phosphate

Nucleosides + phosphate $\xrightarrow{\text{Nucleoside phosphorylase}}$ Nitrogenous base + sugar phosphate

★ Vitamin B₁₂ consists of element Cobalt

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End products of Digestion

Carbohydrates - Monosaccharides like Glucose, Fructose, Galactose.

cellulose - remains undigested

Proteins - Amino acids + smaller peptides

Lipids - Fatty acids and Glycerol

Nucleic acids - Nitrogenous bases and sugar-phosphates

Regulation of Digestion

Neural control : Salivation is initiated on the sight of food, smell of food or on tasting the food.

- Gastro-intestinal secretions are stimulated by Parasympathetic Nervous ^{system} and inhibited by Sympathetic Nervous System.

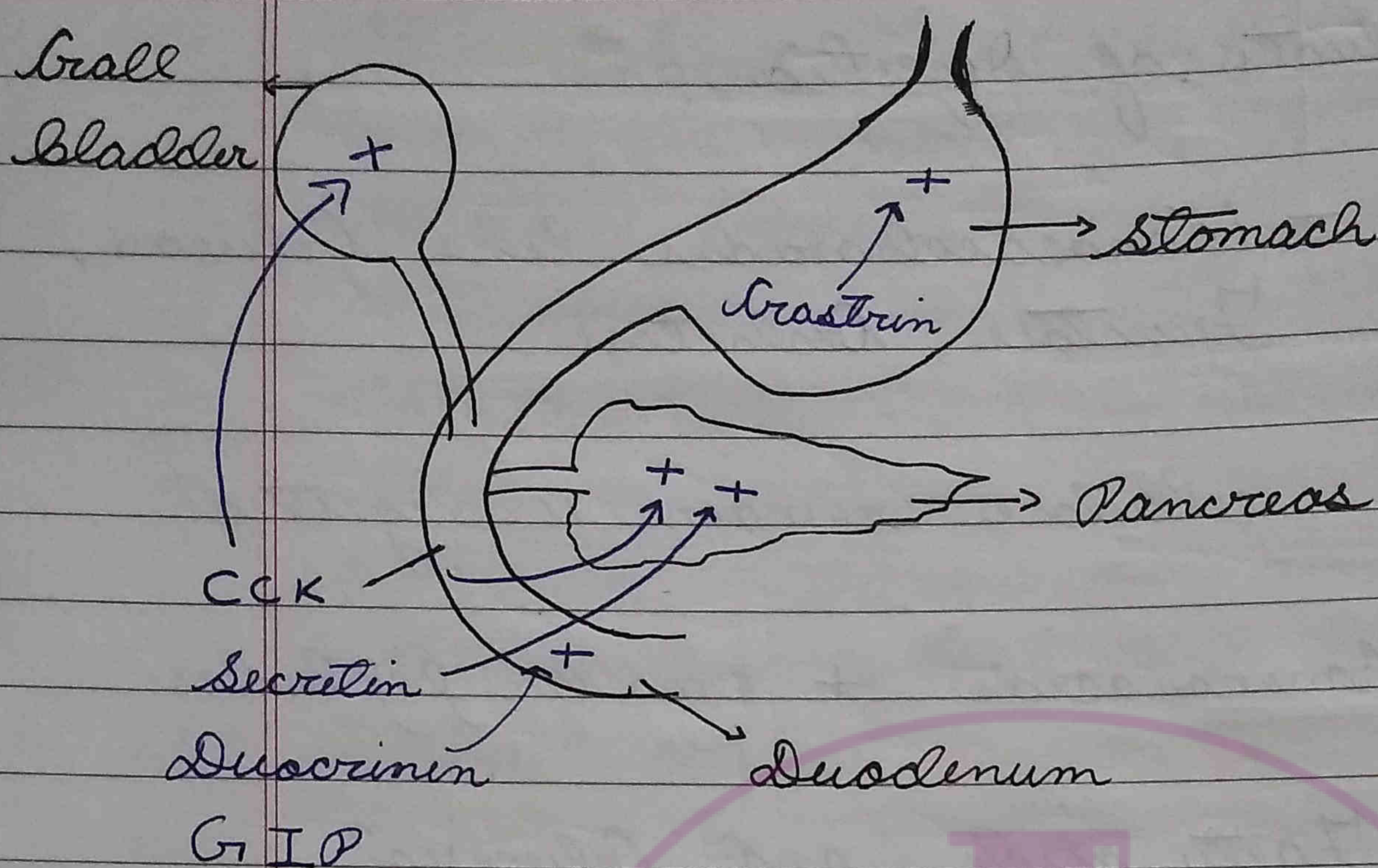
Hormonal Control

- Gastrin : secreted from mucosal cells in stomach.

- Stimulates secretion of HCl and Pepsinogen.

- Gastric juices are secreted under the stimulus of Gastrin, which is sti released under

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- GIP and Gastrin are antagonistic.
 - ★ Gastric glands are stimulated by acetylcholine secreted by parasympathetic nervous system.



stimulus of parasympathetic nervous system i.e. Vagus (X), Acetylcholine, Histamine.

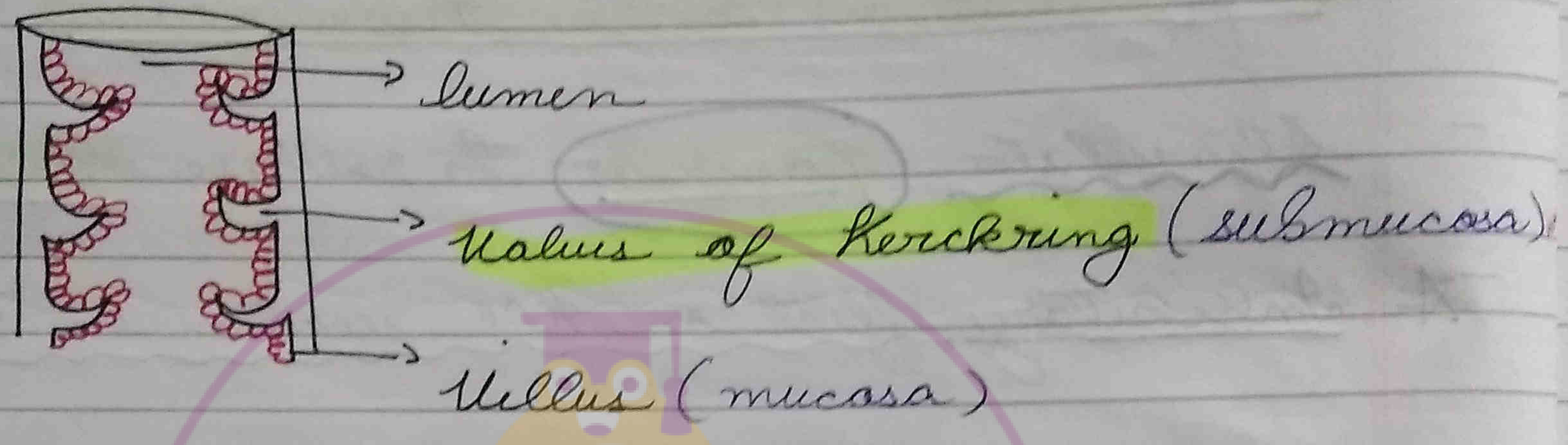
- GIP (Gastric Inhibitory Peptide) collectively called Enterogastrone.
 - Inhibit the secretion of gastric juices.
 - This hormone is released from duodenal epithelium.
 - CCK-PZ (Cholecystokinin - Pancreozymin)
 - Released by duodenal epithelium in response to fats in the chyme.
 - Causes contraction of gall bladder to release bile.

- Stimulates release of pancreatic enzymes.
- Secretin :
 - Released from duodenal epithelium.
 - First hormone to be discovered.
 - Stimulates pancreas to release HCO_3^- ions.
 - ★ Inhibitory effect on HCl secretion in stomach.
- Duocrinin -
 - Released from duodenal epithelium.
 - Target of duocrinin is Brunner's Islands.
 - Stimulate the release of alkaline mucus to neutralize acidic chyme.
- Enteroocrinin -
 - Released from the epithelium of small intestine.
- Stimulates crypts of Lieberkuhn to release Succus Entericus.
- Motilin - from small intestinal epithelium.
 - Effect movement of villi.

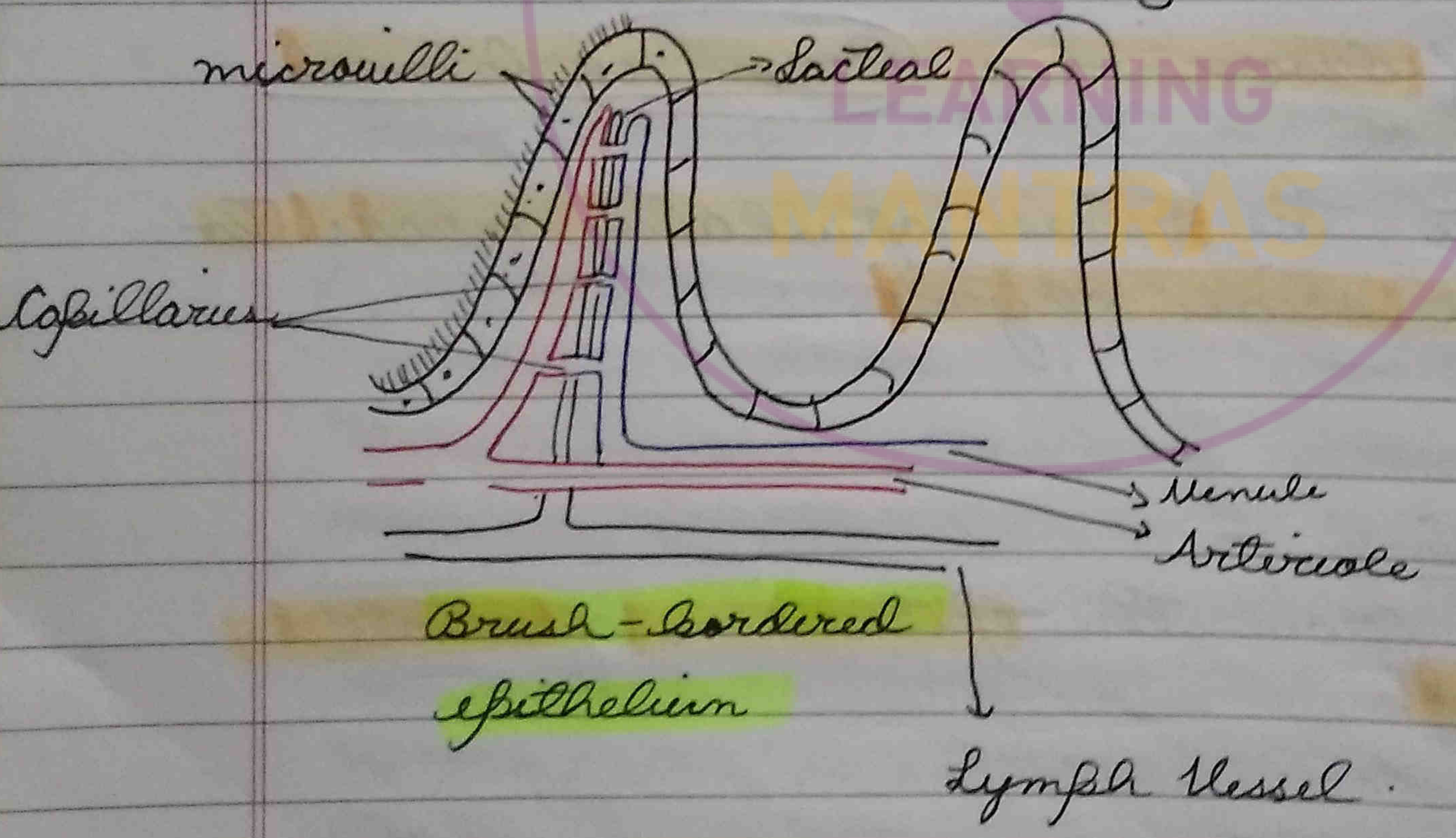
- 250 m² is the overall absorptive area of small intestine.
- Lacteal: blind ended.

• Absorption - End products of digestion are absorbed into the circulatory system.

• Anatomical consideration of small intestine.



• Structure of Villi



• Absorption

I Passive absorption

Substances move along concentration gradient without expenditure of energy.

- Bile salts work as transporters of fat droplets.
- Bile salts are absorbed at terminal part of Ileum.

• Glucose and Galactose are absorbed passively to a small extent.

↓ Major amount of Glucose and Galactose is absorbed by Secondary Active Transport / Na⁺ dependent co transport.

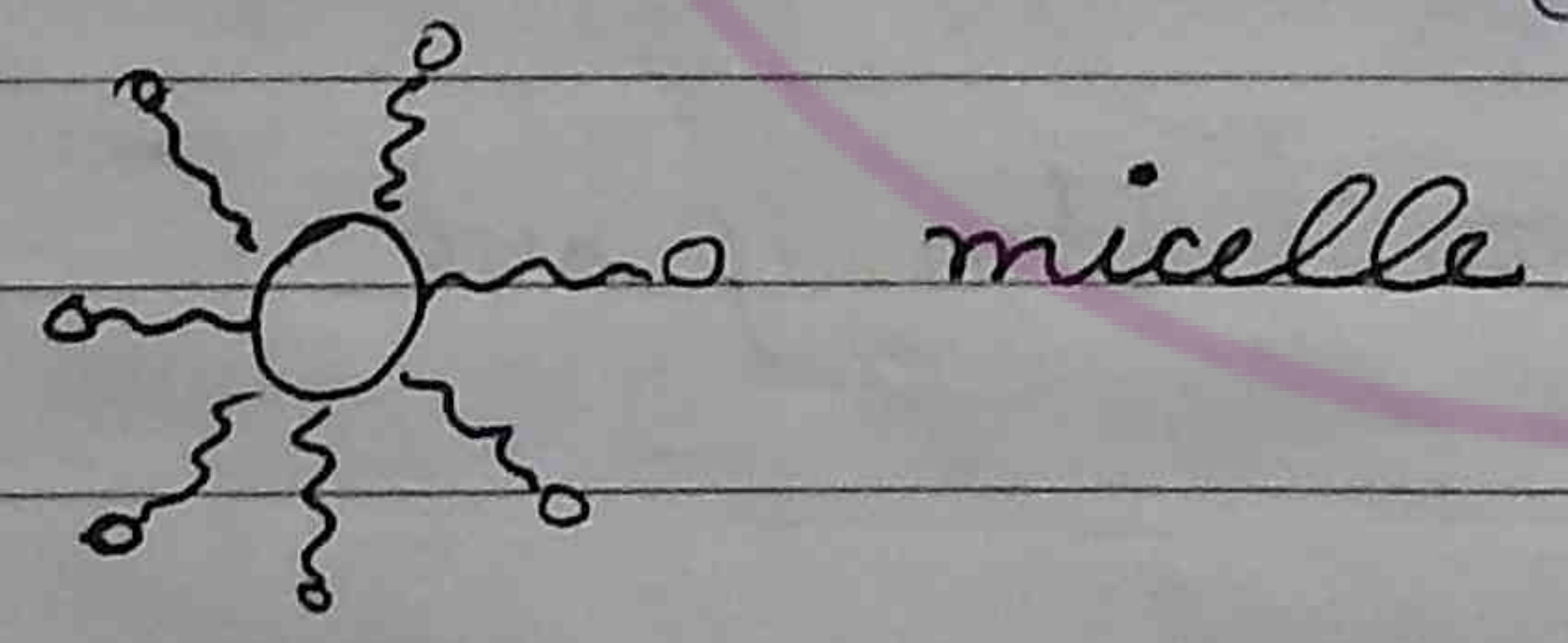
* Fructose - facilitated transport

• Absorption of Amino-acids

• Absorbed by Na⁺ dependent co-transport / Secondary Active Transport.

• Absorption of fatty acids and glycerol

• absorbed passively by simple diffusion.



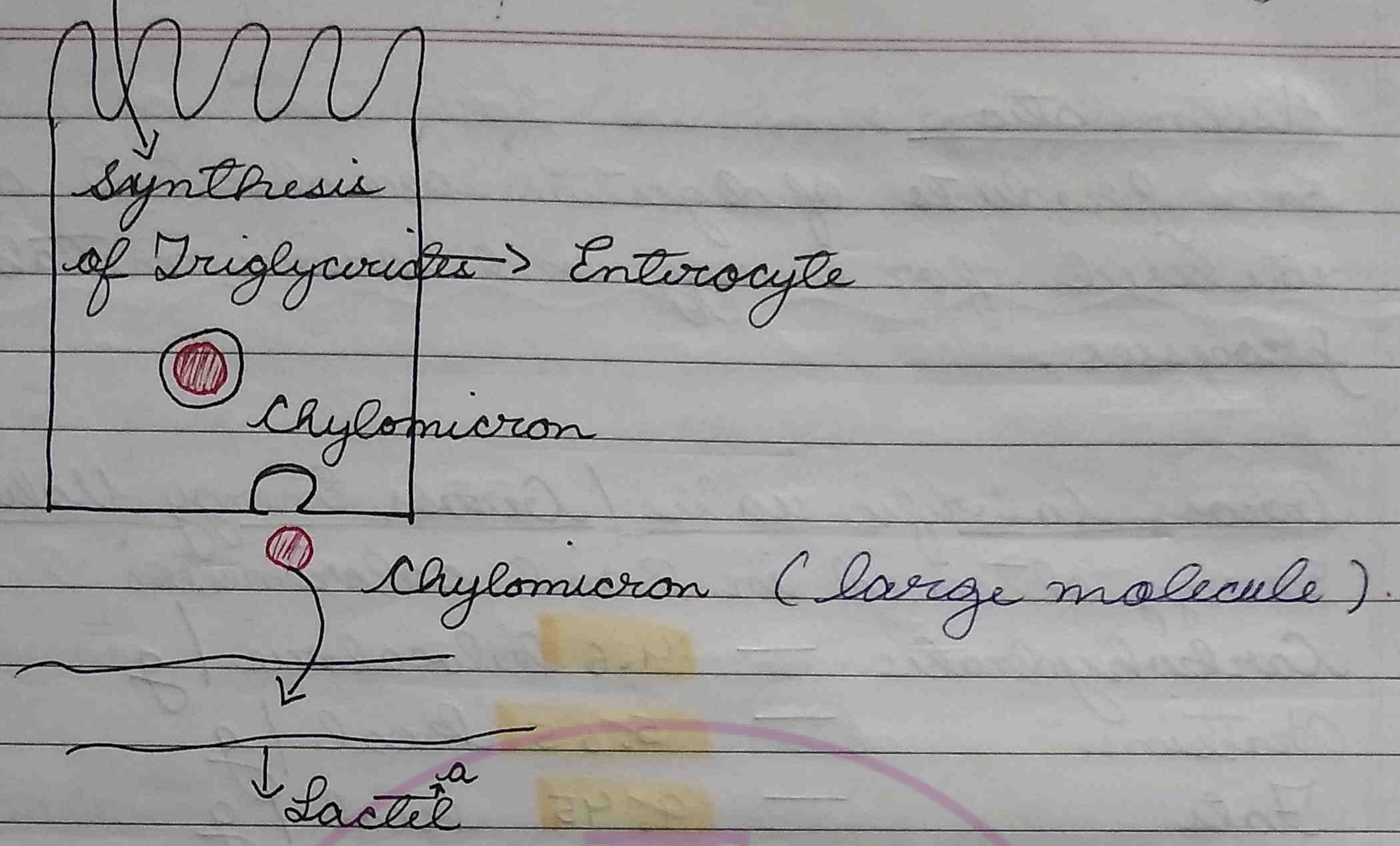
• Fatty acids and glycerol are transported to the surface of brush-border and the bile salts surround another fat droplet.

• Fat absorption

• Chyle
 milky appearance
 in lumen
 after fat digestion

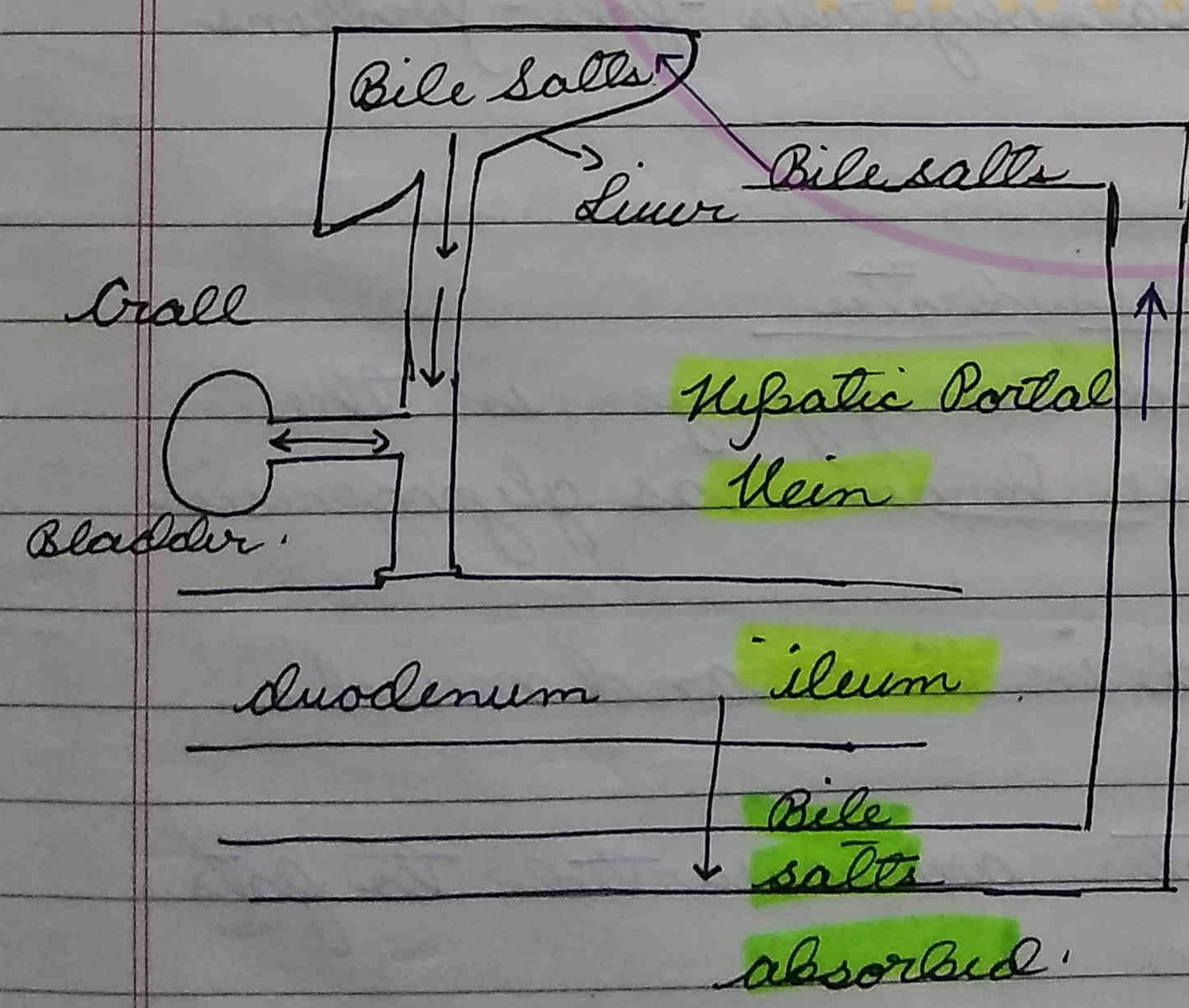
Fatty acids, Glycerol

Triglycerides associate with proteins to form trigly lipoproteins called triglycerides. ^{classmate} chylomicron. ^{Date}



Chylomicron - lipoproteins formed in enterocytes and transported into lacteal (lymph capillary).

Fate of Bile salts



• 95% of Bile salts are absorbed and only 5% are lost through faeces.

• Entero-hepatic circulation
 - Blood circulation b/w intestine and liver through which bile salts are recirculated.

Assimilation

End products of digestion are absorbed and utilised for energy and various metabolic processes.

Gross calorific value / Gross Energy Value

Energy obtained in Bomb calorimeter

Carbohydrates	—	4.6 kilocalorie / g
Proteins	—	5.65 kcal / g
Fats	—	9.45 kcal / g

Physiological Calorific Value

In Human Body: Actual energy produced by oxidation

Carbohydrates	—	4.0 Kcal / g of food
Proteins	—	4.0 kcal / g
fats	—	9.1 kcal / g

Order of utilisation - ⁽¹⁾ carbohydrates - ⁽²⁾ fats - ⁽³⁾ proteins

Assimilation of Carbohydrates

Glucose is converted to glycogen in the liver by the process known as glycogenesis.

Glycogen is stored in liver and muscles.

Excess carbohydrates are converted to fats.

★ Galactose is converted to glucose in the liver by an enzyme Mudyl transferase.

Other cells except RBC take part in protein synthesis.

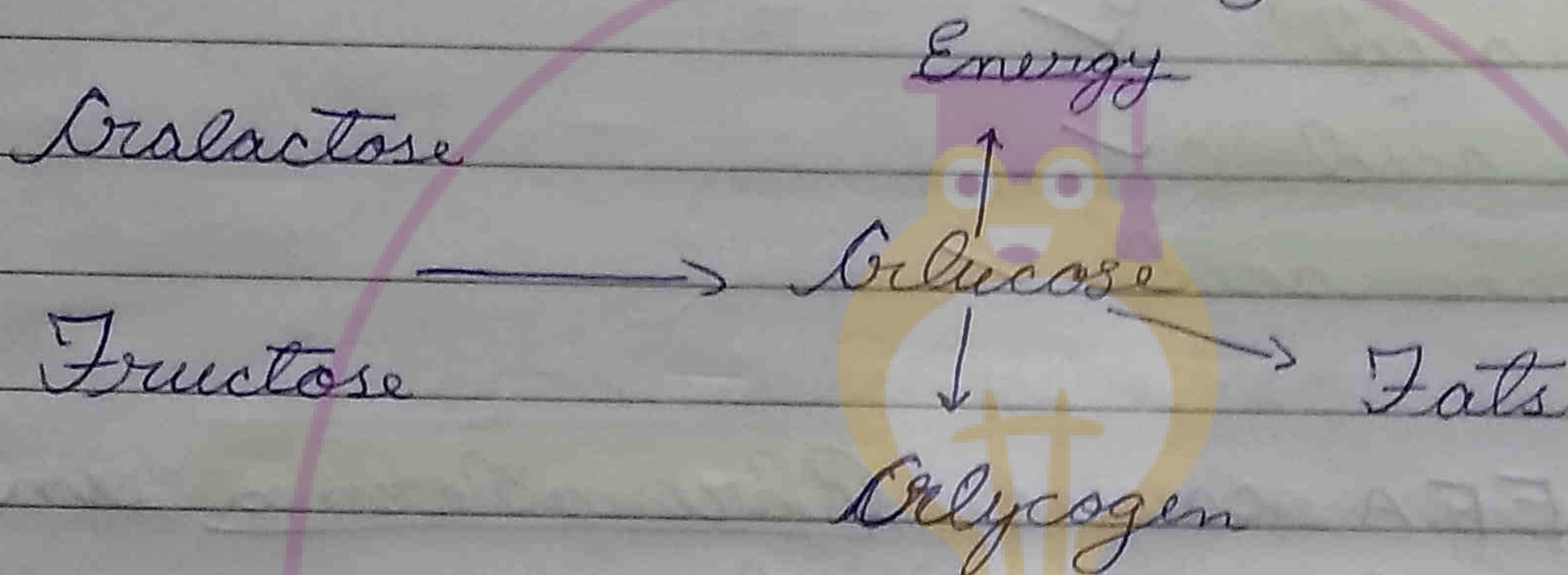
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In the absence of lactase, galactose accumulates in blood and causes galactosemia which results in damage to neurons in brain.

Milk free diet can help from adverse effect of high galactose.

Fructose is converted to glucose.



Assimilation of Amino acids

Utilised in protein synthesis.

20 standard amino acids

Essential Amino acids (EAA) - 10 in no.

i.e. Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Arginine, Lysine, Leucine.

Non-Essential Amino acids (NEAA) -

Not nutritionally essential as they can be synthesised in the body:

Glycine, Tyrosine, Aspartic acid, Glutamic acid, Cysteine.

• Proteins are required for formation of muscle and cell growth.

Fats

Essential fatty acids (EFA)

Nutritionally essential as cannot be synthesised in body.

ie Linoleic acid ✓

Linolenic acid ✓

Arachidonic acid ✓

Absence of EFA causes Pemphigus in which skin becomes scaly.

Vitamins and Minerals

• Do not require digestion.

• These are released from the food by the process of digestion.

• Absorbed by diffusion.

Vitamins: Organic molecules of small molecular weight.

Vitamins

Fat Soluble

A, D, E, K

Water soluble

B-complex, C

★ Vitamin B₁₂ cannot be absorbed directly due to its large size.

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Absorbed by simple diffusion.

• Also absorbed by simple diffusion except vitamin B₁₂ (cyanocobalamin) which combines with Intrinsic factor and is absorbed in ileum.

• Vitamin A (Retinol) → Yellow, fruits and vegetables.

β-carotene $\xrightarrow{\text{Liver}}$ Retinol

Used to synthesise photosensitive pigments — Rhodopsin and Iodopsin.

Deficiency — Night blindness.

• Excess keratin deposits on skin and cornea.

→ Hyperavitaminosis — Excess of fat soluble vitamins.

• D - (Calciferol) / Sunshine vitamin.

• Cholesteral when exposed to UV rays of sunlight is converted to Vitamin-D.

★ • Required for Ca²⁺ absorption.

• Maintain healthy bones and teeth.

• Deficiency —

• Rickets in children: bow legs, pigeon chest.

- Vitamin K is required for making clotting factors
- B₁ is required for maintaining nerve cells

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- Osteomalacia in adults.

- E (Tocopherol) / Anti-ageing vitamin.

- Very good antioxidant.

- Deficiency - causes sterility.

- K (Phylloquinone)

Obtained from green leafy vegetables and synthesised by gut bacteria.

Deficiency → Delayed blood clotting.

- Water soluble vitamins

- B₁ (Thiamine)

Obtained from:

- unpolished rice, milk

- synthesised by gut bacteria.

- Deficiency - Beri-Beri (Paralysis)

- ★ • Raw fish has an enzyme which destroys B₁.

Dermatitis: Inflammation of skin

- Milk rich in tryptophan, whereas cereals deficient.

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- B_2 (Riboflavin)

- Milk

- Deficiency \rightarrow Chilosis: cracking at the corners of mouth.

- Niacin / Nicotinamide

- Milk

- Cereals ^{are} deficient in niacin tryptophan

- Deficiency - Pellagra

niacin is

3 D disease \rightarrow Dermatitis, Diarrhoea, Dementia

- Precursor of tryptophan.

- Folic acid / Folacin:

- Deficiency - Megaloblastic anemia in which cells are larger than normal and have shorter life span.

- Cobalamin (B_{12})

Obtained from animal sources, Spirulina and synthesised by gut bacteria.

- Deficiency - Pernicious anaemia: shorter life span and less oxygen carrying capacity.

- C (Ascorbic acid)

Primates cannot synthesise ascorbic acid

- Deficiency \rightarrow Scurvy: Bleeding gums.

Minerals

Inorganic ions

Na^+ - major cation in extra cellular fluid.

K^+ - major cation in intra cellular fluid.

Ca^{2+} , phosphorus - healthy bones and teeth.

Fe^{2+} - for haemoglobin synthesis

Deficiency: Microcytic anaemia: RBCs of smaller size.

Egestion: Removal of undigested wastes through anus.

Large intestine: Absorption of water and few ions.

Rectum - wastes are collected, stretching of anus rectum initiates defecation.

★ Anus $\left\{ \begin{array}{l} \rightarrow \text{External sphincter} \\ \quad \quad \quad (\text{Voluntary muscles}) \\ \rightarrow \text{Internal sphincter} \\ \quad \quad \quad (\text{Involuntary muscles}) \end{array} \right.$

Faeces: undigested wastes, bacteria, water ions (K^+).

★ Stercobilin \rightarrow gives colour to faeces and is

a derivative of Bilirubin.

* Skatole → gives odour to faeces. Formed from tryptophan.

Disorders of Digestive System

• Constipation - Retention of wastes in large intestine.

Treatment by laxatives.

• Diarrhoea - Passing of watery stools frequently.

• Indigestion - Bloatingness due to gas, abdominal cramps as food is not digested properly.

caused due to stress, spicy food, overeating.

• Vomiting - It is reverse peristalsis in which stomach and small intestine efflux ^{food} through mouth.

Vomiting centre - located in Medulla oblongata

Vomiting is preceded by nausea.