

CHAPTER 01 : DIGESTIVE SYSTEMS OF HUMANS :-

Date: 8-7-25

- Nutrition :- Processes involved in collection and the processing of nutrients is called Nutrition. It's a part of catabolism.

Catabolism: Larger molecules break to smaller ones (breakdown)

Anabolism: Smaller ones form large molecules (synthesis)

Anatomically, human digestive system is tubular gastrointestinal tract comprising of vital digestive organs and accessory digestive organs.

• Vital Organs :-

- Mouth / Oral cavity
- Oesophagus
- Stomach
- Small and Large Intestine

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• Accessory Organs :- They're usually glands as :

- Teeth
- Tongue
- Liver
- Salivary glands
- Gall bladder
- Pancreas

Saliva production

Chewing

Bile secretion

Simplify and pushing the food

Insulin for sugar breakdown

RBC production and bile production

Layers of Digestive Tract :-

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- Serosa = Outermost layer, connective tissues
- Muscularis = Muscular layer, contraction and relax
- Sub-mucosa = Usually glandular, supports n transports.
- Mucosa = Innermost layers, absorbs nutrients and secretes digestive enzymes.

- **ORAL CAVITY** :-
 - Also called Buccal cavity.
 - Consists of Tongue, Glands, Oesophagus.
 - Has 2 palates, soft palate; it's the base of oral cavity.
 - Hard palate is the roof of oral cavity.
 - Tongue is a boneless part which has small projections called papillae on the surface. They assist in tasting the food by help of tastebuds and handle the food.
 - There are 3 glands which release a mixed fluid called Saliva. They're (1) Sublingual gland (2) Parotid Gland (3) Submandibular gland.
 - Oral cavity opens in the pharynx along with food pipe, there is nasal cavity also, so uvula is the covering of wind pipe.

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- The digestion takes place by two methods :-
(1) Mechanical Digestion (2) Chemical Digestion

- Mechanical Digestion :- Mechanical digestion is the physical breakdown of larger food molecules and mass into smaller pieces. This is carried out in the oral cavity by help of tongue & teeth. The process is called mastication as food is masticated by teeth.

- Chemical Digestion :- • Chemical digestion in oral.

cavity is minor. Two enzymes are released / secreted called salivary amylase and Lingual Lipase. Also a watery enzyme is released called Ptaulin as it's specific for the salivary amylase released in mouth while another type is released also within the body. It's similar to the pancreatic amylase and digests starch. Digests polysaccharides to maltose, maltotriose (tri-saccharide) and isosaccharide. The Lingual Lipase digests & simplifies lipids or acylglycerols. By the work of enzymes the digested mass of food called Bolus is formed.

- Key Point : Isomaltose is the iso-saccharide produced and it's same in structure of maltose with only difference in α -1-4 Linkage.

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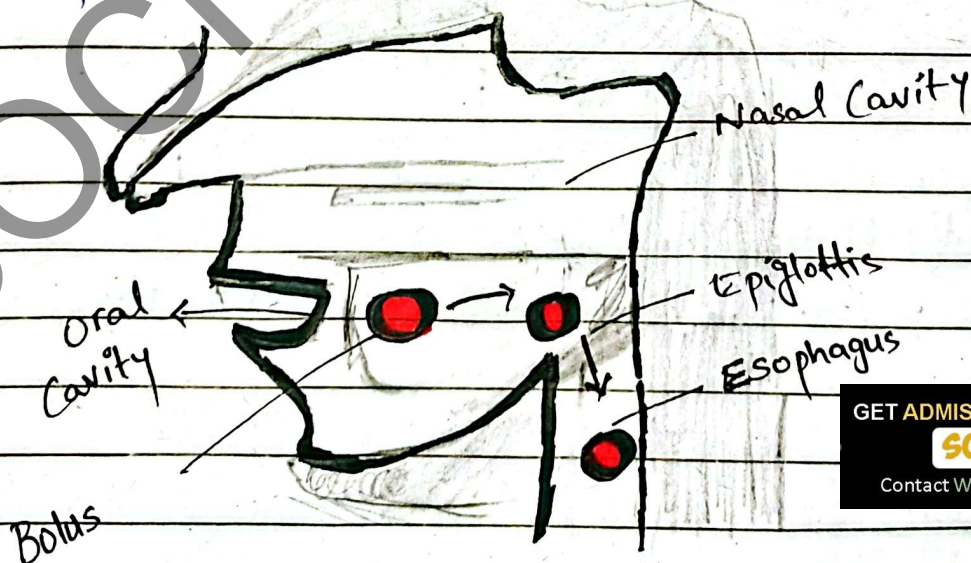
S**WALLOWING** :- Swallowing is Date: _____

the downward movement of the slightly digested food "bolus" from the oral cavity into oesophagus. Swallowing involves the movement of food downwards. It consists of 3 (three) phases:

(1) **Oral Phase** :- In this phase, food is mixed with saliva & tongue pushes the food back of the throat.

(2) **Pharyngeal Phase** :- Reflexes for swallowing are started, Soft palate lifts to close nasal passage. Bolus moves on back of the tongue which blocks food to move to oral cavity. Epiglottis closes the Larynx and any possible way to trachea; esophageal sphincter acts quick to open way to oesophagus.

(3) **Oesophageal Phase** :- Bolus is propelled down the way by peristalsis and Larynx returns to original position.



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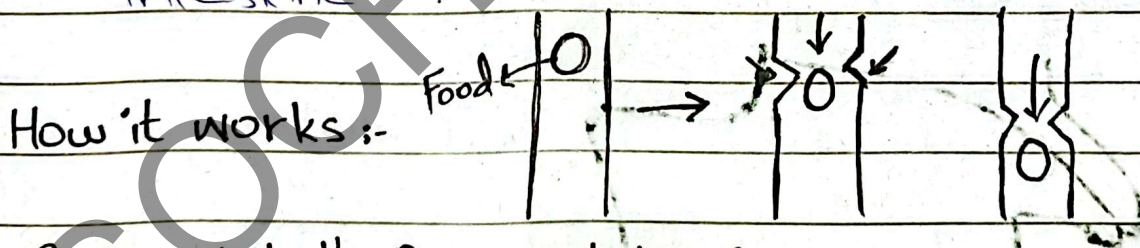
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Peristalsis :-

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- Peristalsis is the inward movement of food propelling it down the digestive tract by the contraction of muscles (antagonistic, they oppose)
- Wave like movement of food down the tract
- Food moves from mouth $\rightarrow$ anus by peristalsis.
- Functions :- Peristalsis performs 3 basic functions :-
(1) Propulsion (2) Mixing (3) Waste removal
It is involved in other functions of urinary tract and bile ducts. Moves gallbladder's released bile to duodenum. Takes urine from kidneys to bladder.
- Propulsion :- pushes food & fluids through digestive system for digestion and absorption.
- Mixing :- In stomach, peristalsis helps mixing food w digestive juices.
- Waste removal :- Drives waste to rectum from large intestine.



QLO : What's Antiperistalsis ?

It's like a vomiting reflex resulting in reverse flow of food.

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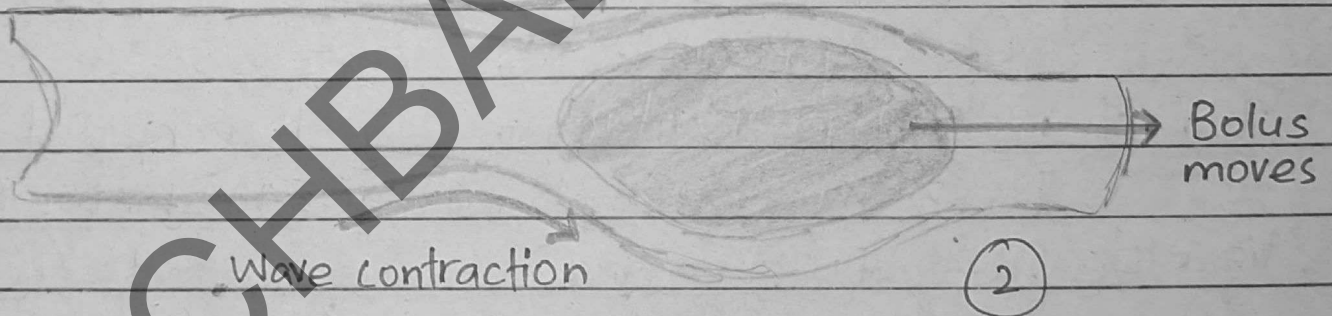
Peristalsis diagram :- The tract clinches from back of bolus and opens up from front; this caused food move ahead.



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OESOPHAGUS :- • It's also called the food pipe. It's located in the center of chest in mediastenum. Lies behind trachea but in front of vertebral column. It's about 25cm long. As it's a passage way, thus no digestion takes place here. Date: _____

- Working or Mechanism :- At the opening of upper part of oesophagus ring-shaped part called UES is present. (Upper Esophageal Sphincter). When it senses food or liquid coming through, it relaxes and opens wide so the food can pass through. When there's no signal of food, it stays closed. Food moves within esophagus by peristalsis. Similarly a LES (Lower esophageal sphincter) is also present which allows food to move in stomach. Without signal, it also stays closed.

- Stomach :- Stomach is the main - digestive organ of body. It's a muscular bag with glands which release digestive juices and enzymes. It is divided into 4 anatomical parts :

- (1) Cardia :- Located at junction of oesophagus and stomach. Prevents backflow of food into oesophagus.
- (2) Fundus :- Dome shaped region above cardia ; stores undigested food and gases.

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Date: _____

- (3) Body : Largest and central part of stomach; mixing & digestion main site.
- (4) Pylorus : Terminal part of stomach; regulates chyme going into duodenum.
- (5) Pyloic Sphincter :- Lower portion of pylorus, grinds food & secretes gastrin to stimulate digestion.

- Stomach Wall :- Stomach wall has four layers;
 - Serosa, • Mucosa • Sub-mucosa • Muscularis
 - Serosa is the outermost layer of stomach wall.
 - Muscularis being 2nd outermost has 3 layers; outer longitudinal, • Middle circular and inner oblique •
 - Sub-mucosa and mucosa are inner layers.

Stomach is lined with simple columnar epithelium.

- On surface of stomach is mucus which prevents digestion of stomach walls. Epithelial cells on stomach surface are of 4 types; (1) Surface mucous : Secrete mucus.
- (2) Parietal (oxyntic) : Secrete HCl
- (3) Chief (zymogenic) : Secrete pepsinogen
- (4) Endocrine cells : Secrete gastrin in blood (hormone)

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FUNCTIONS OF STOMACH :-

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Digestion in stomach occurs by 2 means; chemical or mechanical.

Mechanic Digestion :- The mixing action of stomach walls allows mechanical digestion to occur in stomach.

Contractions are produced by smooth muscles called mixing waves. These waves mix the bolus gently with acids for digestion ultimately leading to production of Chyme.

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Chemical Digestions :- Stomach secretes mucus, HCl and gastrin, intrinsic factor and pepsinogen. The mucus is alkaline and it prevents the digestion of stomach walls from acids. Parietal cells in pyloric region secrete intrinsic factor and concentrated HCl. Intrinsic factor is a glycoprotein which binds with Vitamin B12 and makes it ready to be absorbed in ileum.

The pH in the stomach is low, nearly 1-3 due to HCl. HCl has a huge role in killing bacteria which are ingested by humans along with food and it has a minor role in digestion. This low pH of stomach also prevents complete digestion of carbohydrates and proteins as it denatures the enzymes involved although pepsin works effectively due to its quality of low optimum pH.

Date: _____

- Pepsinogen is secreted by chief cells in the form of inactive pepsinogen. It's packed in zymogen granules. Once it enters the stomach, it's changed to pepsin due to low pH. It digests some proteins to smaller peptide chains.
- ROLE OF NERVOUS SYSTEM ON GASTRIN AND GASTRIC JUICE :-

Almost 2-3 litres of gastric juice is produced each day. Both nervous and hormonal mechanism regulate secretions. Hormones regulating stomach secretions include gastrin, secretin, gastric inhibitory polypeptide and cholecystokinin. Basically the nervous system and hormone gastrin plays the key role in secretions of stomach. Whenever food is seen, smelled or tasted, signals are sent to brain, results are the stimulation of stomach's glands to release the gastric juice. This is the nervous control.

Once food enters the stomach, the hormone gastrin is released which promotes secretion of HCl and pepsinogen. This is hormonal control. Putting them together they make the timely release of gastric juice.

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SMALL INTESTINE :-

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The small intestine is a part of digestive system. When food leaves stomach, it moves to the small intestine. It's connected to large intestine.

Intestines are responsible for breaking food down, absorbing nutrients and removing waste. Small intestine although it's named small but it is the longest part of GI tract and most of digestion takes place here. About 6m long and has 3 parts; duodenum, jejunum and ileum.

- Duodenum :- • 1st part of small intestine • 20-25cm long
- "C" shaped structure • Surrounds the top of pancreas.
- Starts from pyloric sphincter of stomach.

When food (chyme) enters the SI (small intestine) or in duodenum, it mixes with several digestive juices that break it down.

- (1) Pancreatic Juice :- comes from pancreas and enters the duodenum through a duct. It contains Pancreatic amylase, pancreatic lipase, trypsinogen, chymotrypsinogen.

- Pancreatic Amylase :- digests starch, hydrolyzes polysaccharides to maltose or glucose.
- Pancreatic Lipase : digests fats by hydrolysis into diglycerides, glycerol and fatty acids.

- **Trypsinogen**: Activated to trypsin by enzyme called enterokinase which is released by intestinal glands. Acts on proteins.
 - **Chymotrypsinogen**: Converted to chymotrypsin by trypsin itself.
 - **Bile**: Bile is manufactured in liver, stored in gall-bladder but released in duodenum. It emulsifies fat to break them down into small droplets called emulsion. Emulsification provides relative large surface area of lipid for lipase to act.
 - **Jejunum and Ileum**: Jejunum is about 2.5m long & ileum about 3.5m. Complete digestion takes place here, the lining of jejunum and ileum release these enzymes:-
 - **Amino peptidase**: Splits polypeptides into dipeptides.
 - **Erepsin**: Splits peptides to amino acids.
 - **Lactase**: Converts lactose to glucose and galactose.
 - **Maltase**: Converts maltose to glucose (two glucose)
 - **Sucrase**: Converts sucrose to glucose and fructose.
- The pancreatic lipase digests fats to glycerol and fatty acids. Chyme is turned to chyle, a watery emulsion.

ABSORPTION OF DIGESTED PRODUCTS:-

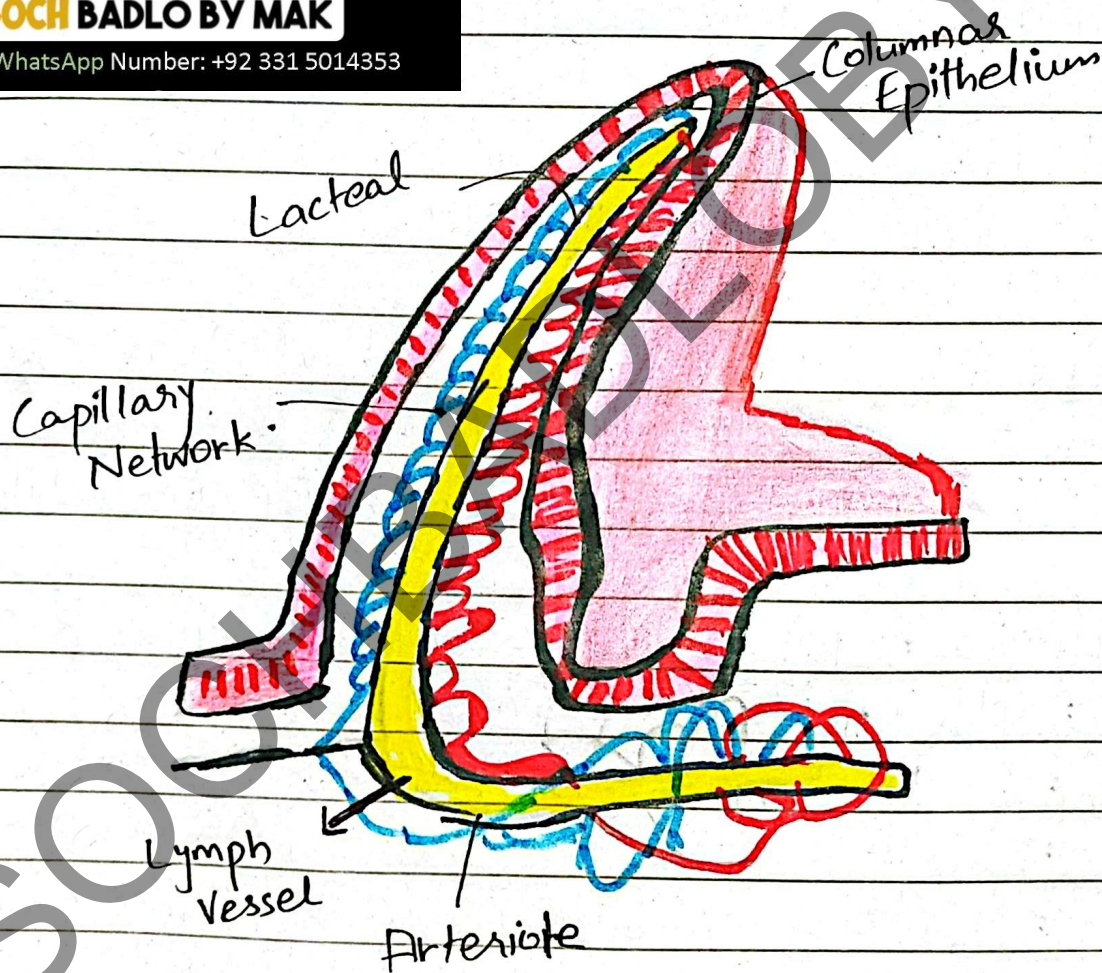
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Although the ileum is the major site for nutrient absorption, tiny finger like projections of mucosa form numerous villi which are 0.5mm or 1mm in length. Each villi is covered by columnar epithelium. It has a blood capillary network and a lymph capillary called a lacteal. Villi and micro-villi increase the surface of absorption.

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Villi STRUCTURE

Absorption of Carbohydrates and Proteins :-

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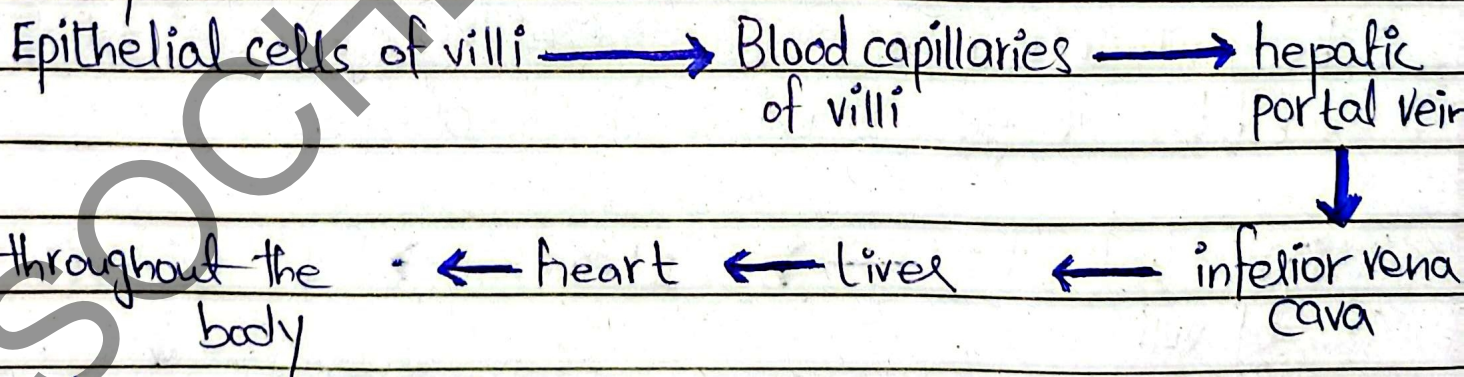
- Simplification occurs as:

Carbohydrates (complex) $\longrightarrow$ Mono-saccharides

Proteins (complex) $\longrightarrow$ Amino acids:

Mechanism :-

These simplified nutrients are absorbed to the epithelial cells of villi at first. From these cells, they are absorbed into blood capillaries of villi. Their mechanism may vary upon the condition but majorly it takes place through diffusion. This blood moves to hepatic portal vein and eventually to the inferior vena cava. This blood then moves to liver and then directly to the heart. From heart $\longrightarrow$ throughout the body. The heart pumps that nutritioned blood throughout the body.



- In liver, carbohydrates (non-glucose) are changed to glucose.
- Modification and some small extent absorption of amino acids is done in liver.

Absorption of Lipids :-

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Lipids are simplified to glycerols,

fatty acids and even cholesterol.

Lipids $\longrightarrow$ Glycerols, Fatty Acids, Cholesterol.

Mechanism:-

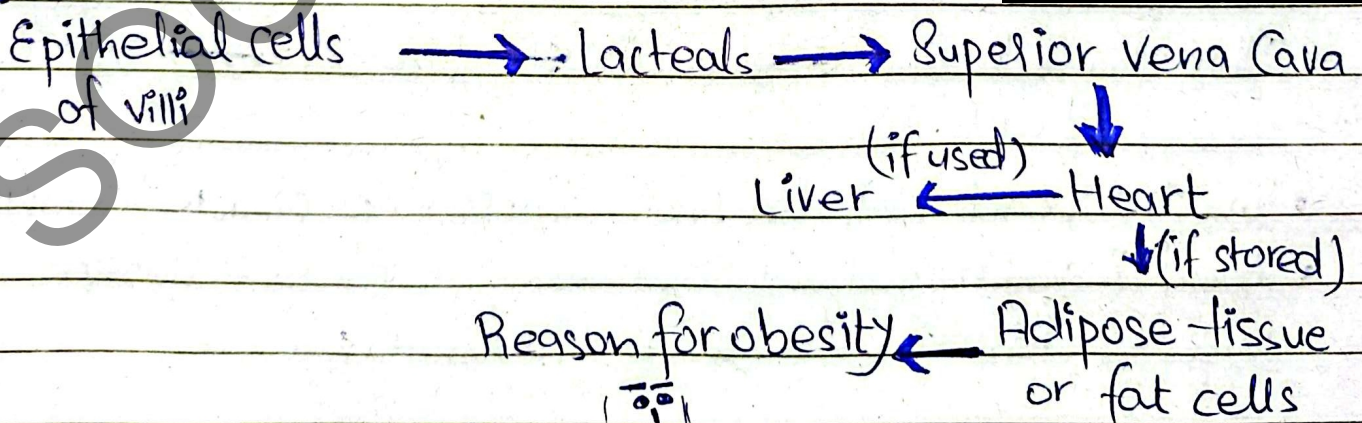
The simplified form of lipids is mixed with bile salts at first and then absorbed by epithelial cells of villi. When proteins are added into this mixture in epithelial cells, this mixture is converted into a VLDL (Very Low Density Lipoprotein) called Chylomicrons. It has 99% Lipid composition while 1% protein. VLDLs have high density of lipids but very less density of proteins. $\rightarrow$ very low

Now the LDL or VLDL are absorbed to the Lacteal, the part of villi; combined with lymph protein and then moves to the superior vena cava and then to the heart. Now its fate of storage is the fat cells of body where it moves while going through liver. But if it's used then it goes to liver and used.

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Large Intestine :-

Date: _____

Large intestine is the final part of absorption. It's a wide, tube-like organ that absorbs water & nutrients from undigested chyle. It forms & stores faeces. It includes colon, rectum and anus. Attached to ileum by ileocol junction guarded by sphincter. Unlike small intestine, it doesn't perform digestion, it removes waste from body. Cecum is the proximal part.

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- Functions of Large Intestine :- Large intestine has several important functions; major functions are
 - (1) Absorption of water & electrolytes
 - (2) Absorption of vitamins
 - (3) Reducing acidity of the material passing through because it came from stomach eventually.
- Absorbing water and electrolytes :- • LI works to reabsorb the watery content & electrolytes which makes stool solid. Remaining substances (unabsorbed) become faeces which is stored in rectum.
- Absorption of Vitamins :- The large intestine also works in absorption of vitamins which are produced by bacteria living in SI / LI. Important vitamins are Vit K and Biotin.

Date: _____

- Reducing acidity & protection from infections :-

- Secretes bi-carbonates to neutralize the acidity due to fatty acids etc.

- Acts as a mucosal-barrier and protects from infection

- **DEFAECATION** :- It's a process of expelling faeces from the body.

- In infants :- It's an involuntary reflex in infants as anal Sphincter relaxes on its own usually after feeding.

- In adults :- When it's appropriate, a person can initiate reflex on its own by contracting (contracting) abdominal muscles, the increased internal pressure forces down the faeces. Anal sphincter is relaxed and faeces is expelled.

STORAGE AND METABOLIC ROLE OF LIVER :-

The liver is one of the vital organs in human body. It's one of the most required and useful organs in body. It excretes a product called bile and regulates chemical levels in blood.

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STRUCTURE :- The liver is situated Date: _____

in the chest. It has two main parts; the larger right lobe, and smaller left lobe. Lobes contain blood vessels. Blood also travels through liver. These lobules are connected to bile ducts; tubes that transport bile from liver to small intestine. There are 2 sources of blood to liver; hepatic artery and hepatic portal vein.

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- FUNCTIONS :-
 - Produces bile which helps carry away waste and breakdown fats in small intestine.
 - Produces certain proteins for blood plasma eg:-fibrinogen, serum albumin and globulins.
 - Produces cholesterol and carrier proteins which rotate fats throughout body.
 - Conversion of poisonous ammonia to urea (detoxified)
 - Clears blood of drugs & poisonous substances. Helps Clots
 - Production of haemoglobin. Stores glycogen.
 - Removes bacteria. Clears bilirubin, if not cleared it leads to jaundice.

When it's done with work, the substances are excreted with bile and eventually in faeces.

COMPOSITION OF BILE :-

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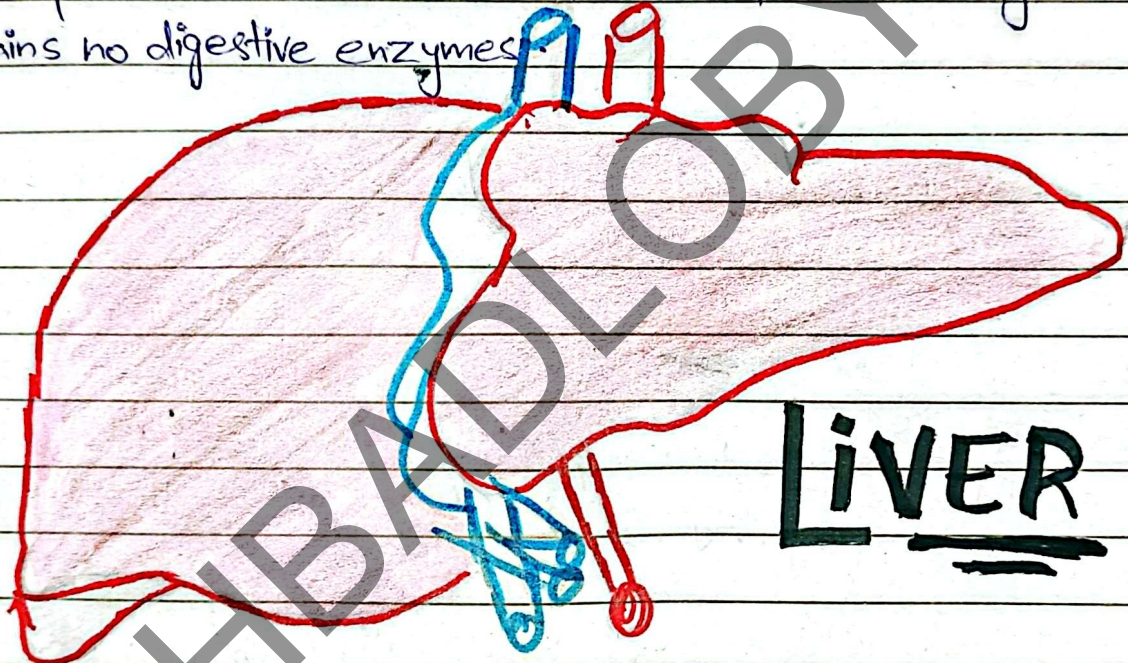
- Gall bladder is a sac-like structure on the inferior surface of liver about 8cm long and 4cm wide. It's connected to the bile duct by cystic duct. Bile is secreted by liver, stored in gall bladder.

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- Liver produces and secretes bile, stored in gall-bladder.
- Contains no digestive enzymes.



Bile consists of bile salts, sodium glycocholate, taurocholate, bili-rubin, lecithin, cell debris; It's produced by liver.

PANCREAS :-

Date: _____

Pancreas is a complex organ consisting of both endocrine and exocrine tissues. The endocrine part is comprised of Islets of Langerhans.

- STRUCTURE :- It consists of head, neck, body and tail.

Head : Widest part, located in duodenum

Neck : Connects head to body :

Body : Main part, behind the stomach

Tail : Tapered end of pancreas.

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- FUNCTIONS :- Most important function of pancreas is it produces some special enzymes which aid in digestion. It helps digest food in small intestine. It produces insulin which helps regulate blood sugar, lack of insulin leads to diabetes. Also aids reducing acidity in stomach. Its most important function is to produce 'Pancreatic Juice' which helps trigger enzymes for digestion such as Chymotrypsin, Trypsin, Amylase, Lipase.
- Amylase : Breaks starch to sugars
- Lipase : Breaks fats to fatty acids & glycerol
- Trypsin & Chymotrypsin : Break proteins to amino acids.
- Bicarbonates : Neutralizes acidic chyme.