# HUMAN PHYSIOLOGY

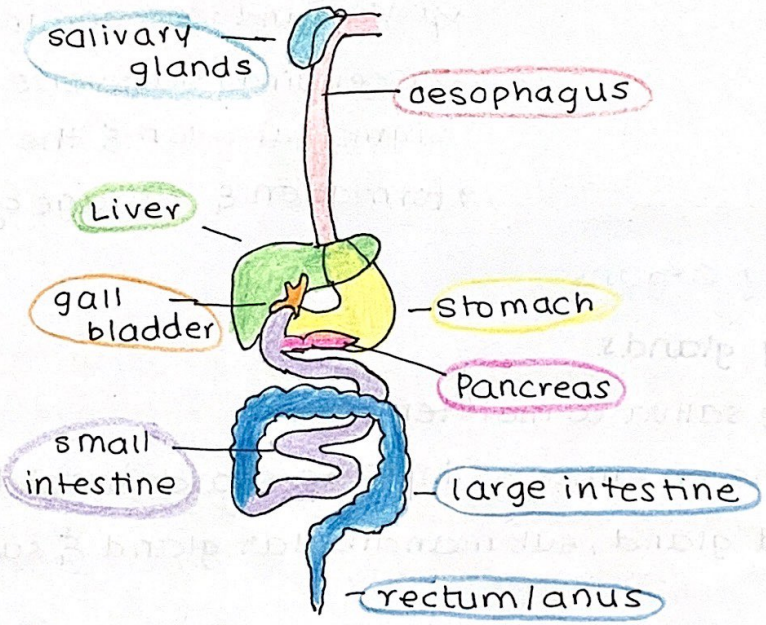
## 6.1 DIGESTION AND ABSORPTION

2 major groups of organs which compromise the human digestive system:

**Alimentary canal**: consists of organs through which the food actually passes.

Accessory organs: aid in digestion but do not transfer food.

- The role of digestive system is to break down the diverse mixture of large carbon compounds in food to yield ions and smaller compounds that can be absorbed.




### Alimentary canal

#### oesophagus

→ movement of food by peristalsis from the mouth to the stomach

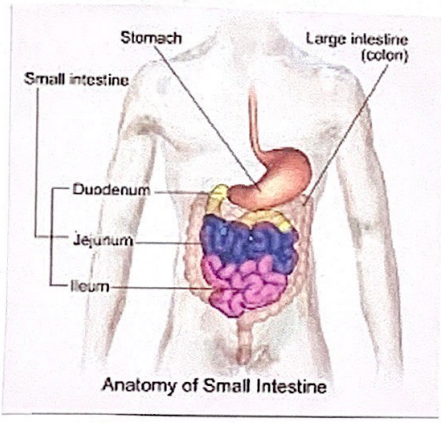
→ separated from the trachea by the epiglottis

## Stomach

→ food is mixed by churning
→ digestion of proteins
→ acid kills foreign bacteria and other pathogens
→ lined by gastric juices which create an acidic environment.

## Small Intestine

→ a long, highly folded tube where usable food substances are absorbed.
→ neutralizing stomach acids
→ consists of 3 sections - duodenum, jejunum and ileum.



Anatomy of Small Intestine

## Large Intestine

→ final section of the alimentary canal
→ water and ions are absorbed
→ ascending / transverse / descending / sigmoidal colon & the rectum
→ formation & storage of feces.

## Accessory Organs

### Salivary glands.

→ release saliva to moisten food
→ contains enzymes to initiate starch breakdown
→ parotid gland, submandibular gland & sublingual gland.

## Pancreas

→ produces enzymes that are released into the small intestine
→ secretes hormones that regulate the blood sugar levels.

## Liver

→ takes the materials absorbed by small intestine

→ makes key chemicals out of those

→ role - detoxification, storage, metabolism, bile production and haemoglobin breakdown.

→ secretion of surfactants in bile to break up lipid droplets.

## Gall bladder

→ stores the bile produced by liver

→ releases this bile into the small intestine via the common bile duct.

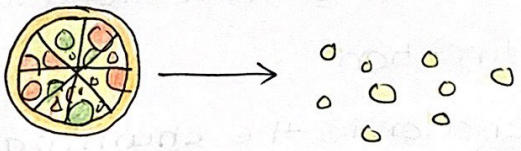
# MECHANICAL DIGESTION

In mechanical digestion, food is broken down into smaller fragments physically by the act of

→ chewing

→ churning

→ segmentation.



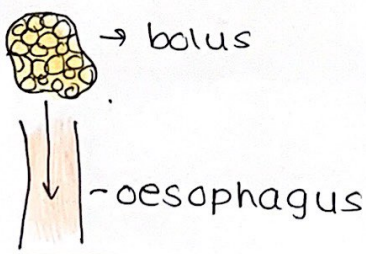
## Chewing

→ food is broken down in the mouth by grinding action of teeth - chewing

→ tongue pushes the bolus towards the back of the throat - travels down the oesophagus.

→ epiglottis prevents the bolus entering the trachea.

→ uvula prevents it from entering the nasal cavity.



## Churning

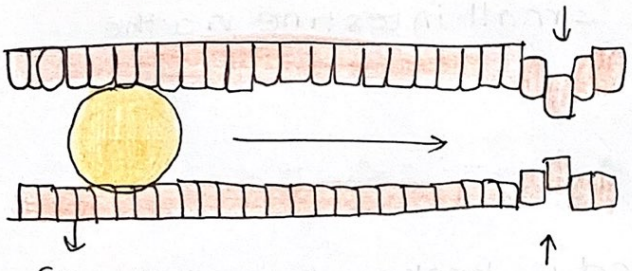
→ stomach lining contains muscles which physically squeeze and mix the food with strong digestive juices.

→ it gets digested in the stomach for several hours & turns into a creamy paste called chyme.

→ chyme enters the duodenum where absorption occurs.

## Movement of food

### Peristalsis



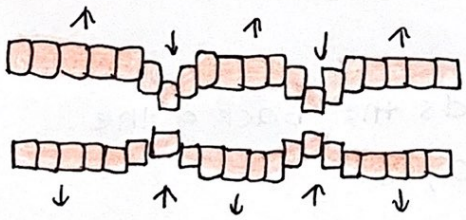

→ principal mechanism of movement in oesophagus

→ continuous segments of longitudinal smooth muscle rhythmically contract and relax

→ food is moved unidirectionally → mouth to anus in a caudal direction.

→ main function is the churning of semi-digested food to mix it with enzymes (to speed up digestion.)

### Segmentation



→ contraction and relaxation of non-adjacent segments of circular smooth muscles

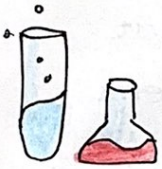
→ move chyme in both directions - allows better mixing of food with digestive juices.

→ the bi-directional propulsion of chyme slows down the overall movement.

# CHEMICAL DIGESTION

Process where acids, bases and enzymes are released into the digestive track to break down the food.

## Stomach acids



→ gastric glands release digestive acids to create an acidic environment (pH ~2)

→ the low pH helps denature the proteins & other macro molecules, aiding in their overall digestion.

→ stomach epithelium contains a mucous membrane which prevents the acids from damaging the lining.


→ pancreas secretes alkaline compounds (bicarbonate ions) which neutralise these acids before they enter the intestine.

## Bile

→ liver produces bile which is stored & concentrated in the gall bladder prior to release in intestine.

→ it contains bile salts which breaks down the large lipid globules into several small lipid globules → emulsification.

→ this increases the total surface area available for enzyme activity.

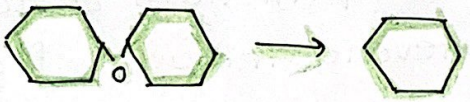
## Enzymes

→ biological catalysts which speed up the chemical reaction by lowering the activation energy without getting altered themselves.

→ allow digestive processes to occur at body temperatures and at sufficient speeds for survival requirements.

→ they are specific for a substrate - allow certain molecules to get digested at distinct locations.

### Carbohydrate digestion



→ begins in the mouth

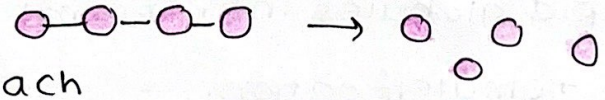
→ amylase (salivary) - acts on polysaccharides and breaks it down into disaccharides.

→ pancreatic amylase - breaks down polysaccharides into disaccharides and monosaccharides.

→ oligosaccharidases - disaccharides are broken down into monosaccharides.

→ humans do not have enzymes capable of digesting cellulose & ∴ it passes through the body undigested.

### Protein digestion



→ begins in the stomach

→ pepsin - acts on proteins and gives peptides.

→ trypsin - breaks down proteins into peptides.

→ endopeptidases - peptides are broken into amino acids.

Lipid digestion

→ lipid breakdown occurs in the intestine

→ pancreatic lipase & lingual lipase & gastric lipase break down triglycerides into fatty acids by the process of emulsification.

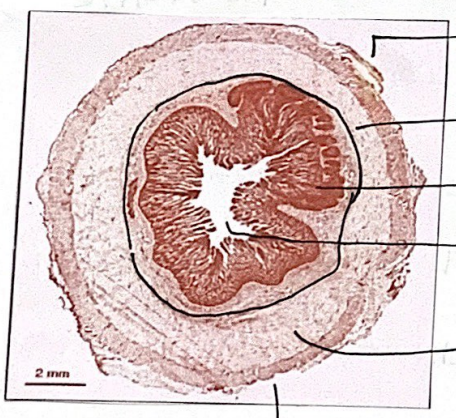
Nucleic acid digestion

→ pancreas releases nucleases which digest DNA & RNA into smaller nucleosides.

# SMALL INTESTINE

Function: to absorb the products of digestion such as monosaccharides, amino acids, fatty acids, vitamins)

Structure




→ serosa (protective layer)
→ submucosa (separation)
→ mucosa (absorption)
→ lumen
circular
→ smooth muscle (segmentation)
→ longitudnal smooth muscle. (peristalsis)

Transverse cross section

Serosa: protective outer layer of cells reinforced by fibrous connective tissue.

Muscle layer: outer longitudnal muscle layer - peristalsis
inner circular muscle layer - segmentation.

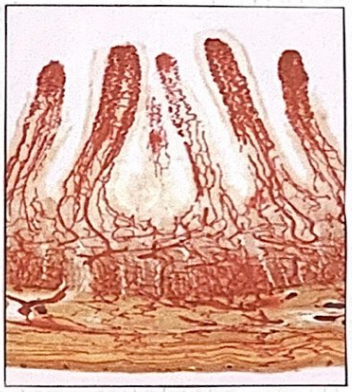
Submucosa: composed of connective tissue.
separates the muscle layer from innermost mucosa.

mucosa: highly folded inner layer which absorbs material through surface epithelium from the intestinal lumen.

# VILLI

The inner lining of the intestine (mucosa) is highly folded into finger-like projections called villi

function: to increase the surface area for absorption of materials.



longitudnal cross section

## Features of villi

Microvilli: ruffling of the epithelial membrane (to increase S.A.)

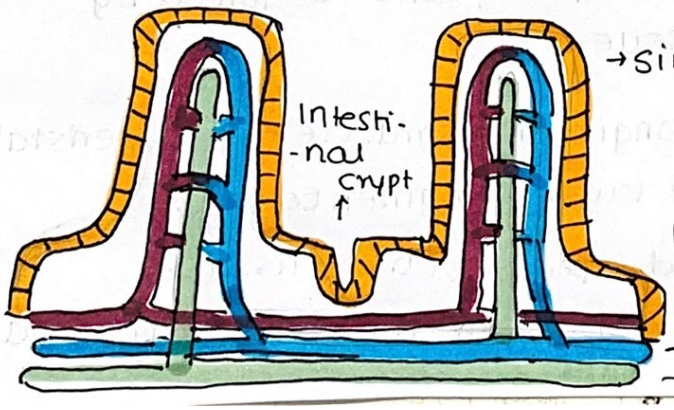
Blood supply: dense capillary network transports the absorbed products.

single layer epithelium: minimises the diffusion distance between lumen and blood.

Lacteals: absorbs lipids into the lymphatic system

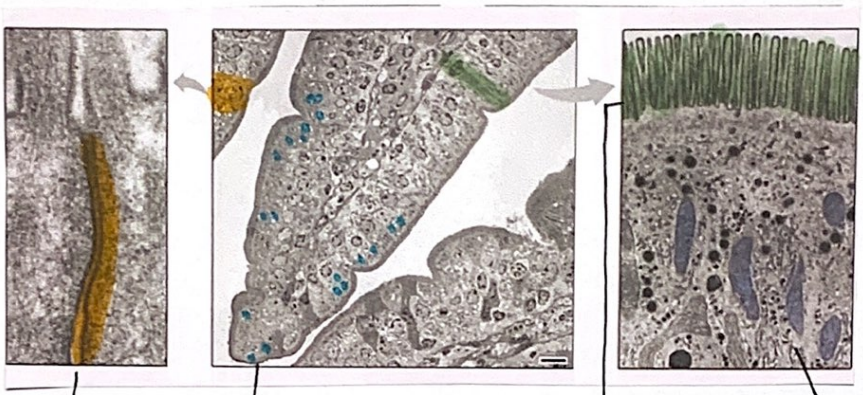
Intestinal glands: exocrine pits that release digestive juices.

Membrane proteins: facilitates transport of digested materials into the epithelial cells.



# STRUCTURE OF VILLUS EPITHELIUM

- contains several features to optimise its capacity to absorb digested materials.



tight junction | pinocytotic vesicles | microvilli | mitochondria

## Tight junction

- occluding associations between the plasma membrane of two adjacent cells.
- create an impermeable barrier
- keep digestive fluids separated from tissues.
- maintain a concentration gradient by ensuring one-way movement.

## Microvilli

- they increase the surface area of the plasma membrane - allows more absorption to occur
- membrane is embedded with immobilised digestive enzymes and channel proteins for material uptake.

## Mitochondria

- epithelial cells of villi have large no. of mitochondria to provide ATP for active transport mechanisms.

## Pinocytotic vesicles

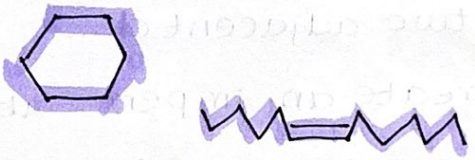
Pinocytosis: non-specific uptake of fluids and dissolved solutes (faster way of bulk transport)

- The materials get ingested via the breaking and reforming of the membrane & ∴ contained within a vesicle.

# ABSORPTION

- The digested food monomers pass from the lumen into the epithelial lining of the small intestine.
- Different monomers take different methods for crossing the membrane.

Villus cells absorb:



→ monosaccharides

→ any of the 20 amino acids

→ fatty acids, monoglycerides and glycerol

→ bases from digestion of nucleotides.

→ vitamins and mineral ions.

### Membrane Transport mechanisms

- secondary active transport


- a transport protein couples the active translocation of one molecule to the passive movement of another.
- glucose & amino acids are co-transported across the epithelial membrane by active translocation of Na+ ions.

• facilitated diffusion

→ channel proteins help hydrophilic food molecules pass through the hydrophobic part of the plasma membrane.

→ these proteins are often situated near specific membrane bound enzymes to create a localised concentration gradient.

→ monosaccharides, vitamins & minerals get transport-ed.

• osmosis

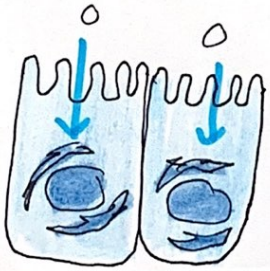
→ water molecules diffuse across the membrane in response to the movement of ions and solutes.

→ absorption of water occurs both in the small and large intestine.


• Simple diffusion

→ only the hydrophobic materials can freely pass through the hydrophobic part of the plasma membrane.

→ after absorption, the lipids first pass in to the lacteals rather than transported by blood.



▸ Bulk transport

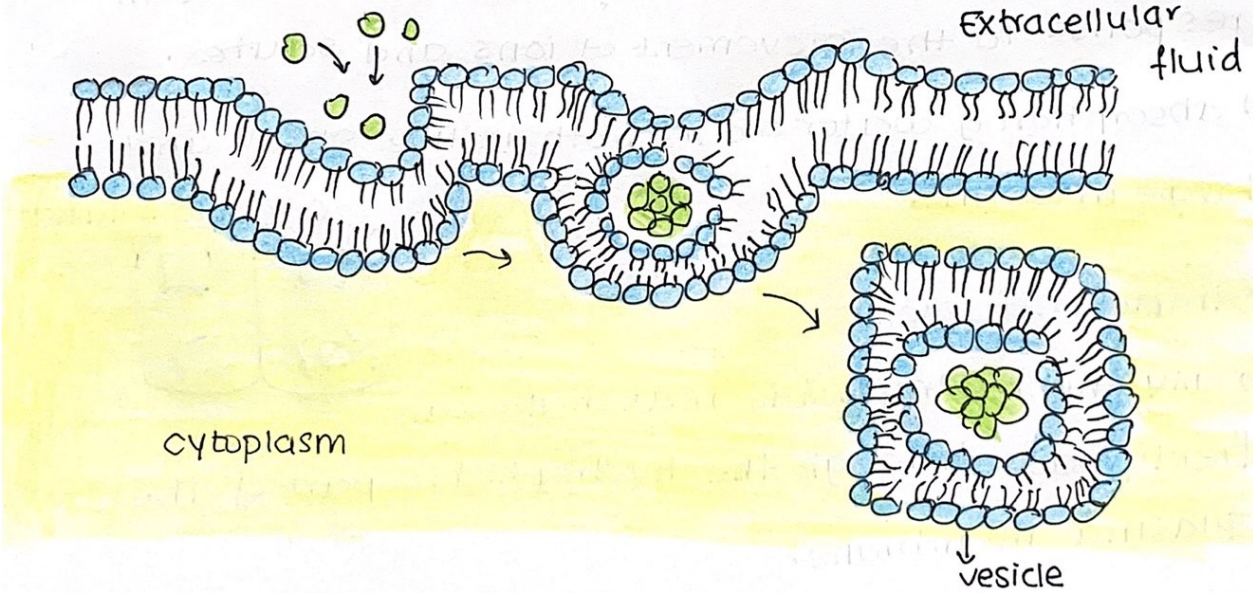
Endocytosis - energy dependent process

→ invagination of the plasma membrane to create an internal vesicle containing extracellular material.

→ requires the breaking and reforming of the phospholipid bilayer.

In the intestine

- vesicles form around fluid containing dissolved materials
- pinocytosis - allows materials to be ingested en masse → takes less time than shuttling via membrane proteins.




# STARCH DIGESTION

Starch can exist in one of 2 forms

- linear chains
- branched chains

amylose

amylopectin

→ The digestion is initiated by salivary amylase in the mouth and continued by pancreatic amylase in the intestine.

→ doesn't occur in the stomach as the pH is not suitable. (the optimal pH ~ 7)

Amylase
↓
amylose ⟶ maltose subunits
amylopectin → dextrins → digested by maltase (fixed to the epithelial lining of the small intestine)

→ hydrolysis of maltose & dextrins → glucose monomers.

Glucose can then be hydrolysed to produce ATP by cell respiration.

Difference between exocrine and endocrine glands -

| ENDOCRINE | EXOCRINE |
|---|---|
| → ductless glands | → have ducts |
| → secretes hormones | → secretes sweat, enzymes, mucus, & sebum. |
| → routed secretion - directly into the bloodstream, reaching the target organ | → secretory products are released to an internal organ or external surface through a duct. |
| → example - adrenal glands, thyroid glands, pituitary glands. | → example - salivary glands, liver, pancreas |