

Human Digestive System

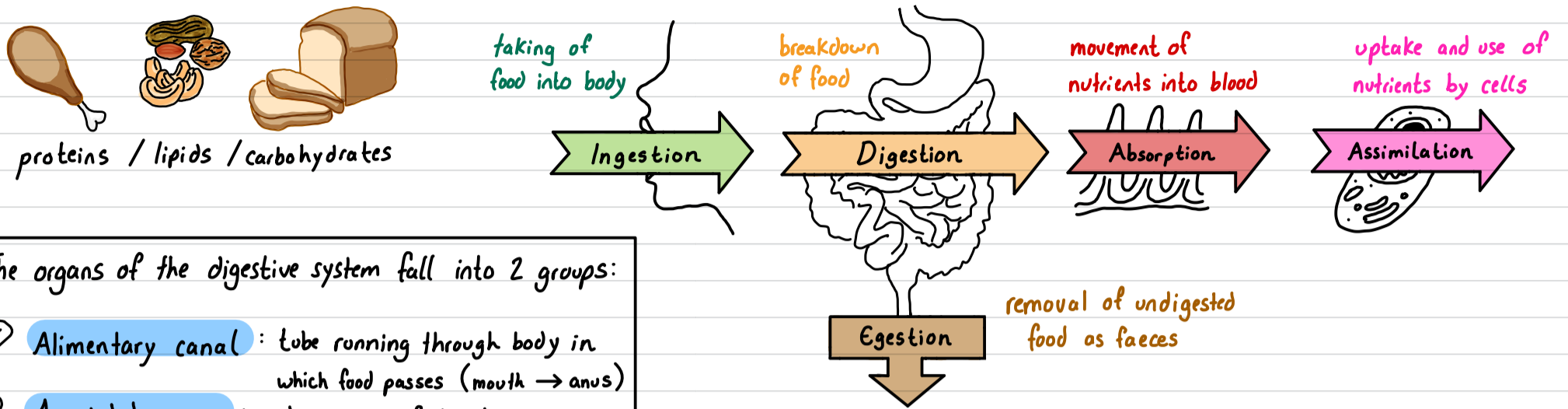
Learning Outcomes



- 7.2.1 – **Identify** in diagrams and images the main organs of the digestive system, limited to:
 - a) Alimentary canal: mouth, oesophagus, stomach, small intestine (duodenum and ileum) and large intestine (colon, rectum, anus)
 - b) Associated organs: salivary glands, pancreas, liver and gall bladder
- 7.2.2 – **Describe** the functions of the organs of the digestive system listed in 7.2.1 in relation to:
 - a) Ingestion – the taking of substances, e.g. food and drink into the body
 - b) digestion – the breakdown of food
 - c) absorption – the movement of nutrients from the intestines into the blood
 - d) assimilation – uptake and use of nutrients by cells
 - e) egestion – the removal of undigested food from the body as faeces
- 7.3.1 – **Describe** physical digestion as the breakdown of food into smaller pieces without chemical change to the food molecules
- 7.3.2 – **State** that physical digestion increases the surface area of food for the action of enzymes in chemical digestion
- 7.3.6 – **Describe** the function of the stomach in physical digestion
- 7.3.7 – **Outline** the role of bile in emulsifying fats and oils to increase the surface area for chemical digestion
- 7.4.1 – **Describe** chemical digestion as the breakdown of large insoluble molecules into small soluble molecules
- 7.4.2 – **State** the role of chemical digestion in producing small soluble molecules that can be absorbed
- 7.4.3 – **Describe** the functions of enzymes as follows:
 - a) amylase breaks down starch to simple reducing sugars
 - b) proteases break down protein to amino acids
 - c) lipase breaks down fats and oils to fatty acids and glycerol
- 7.4.4 – **State** where, in the digestive system, amylase, protease and lipase are secreted and where they act
- 7.4.5 – **Describe** the functions of hydrochloric acid in gastric juice, limited to killing harmful microorganisms in food and providing an acidic pH for optimum enzyme activity
- 7.4.7 – **Describe** the digestion of protein by proteases in the digestive system:
 - a) pepsin breaks down protein in the acidic conditions of the stomach
 - b) trypsin breaks down protein in the alkaline conditions of the small intestine
- 7.5.1 – **State** that the small intestine is the region where nutrients are absorbed
- 7.5.2 – **State** that the most water is absorbed from the small intestine but that some is also absorbed from the colon
- 7.5.3 – **Explain** the significance of villi and microvilli in increasing the internal surface area of the small intestine
- 7.5.4 – **Describe** the structure of a villus
- 7.5.5 – **Describe** the roles of capillaries and lacteals in villi

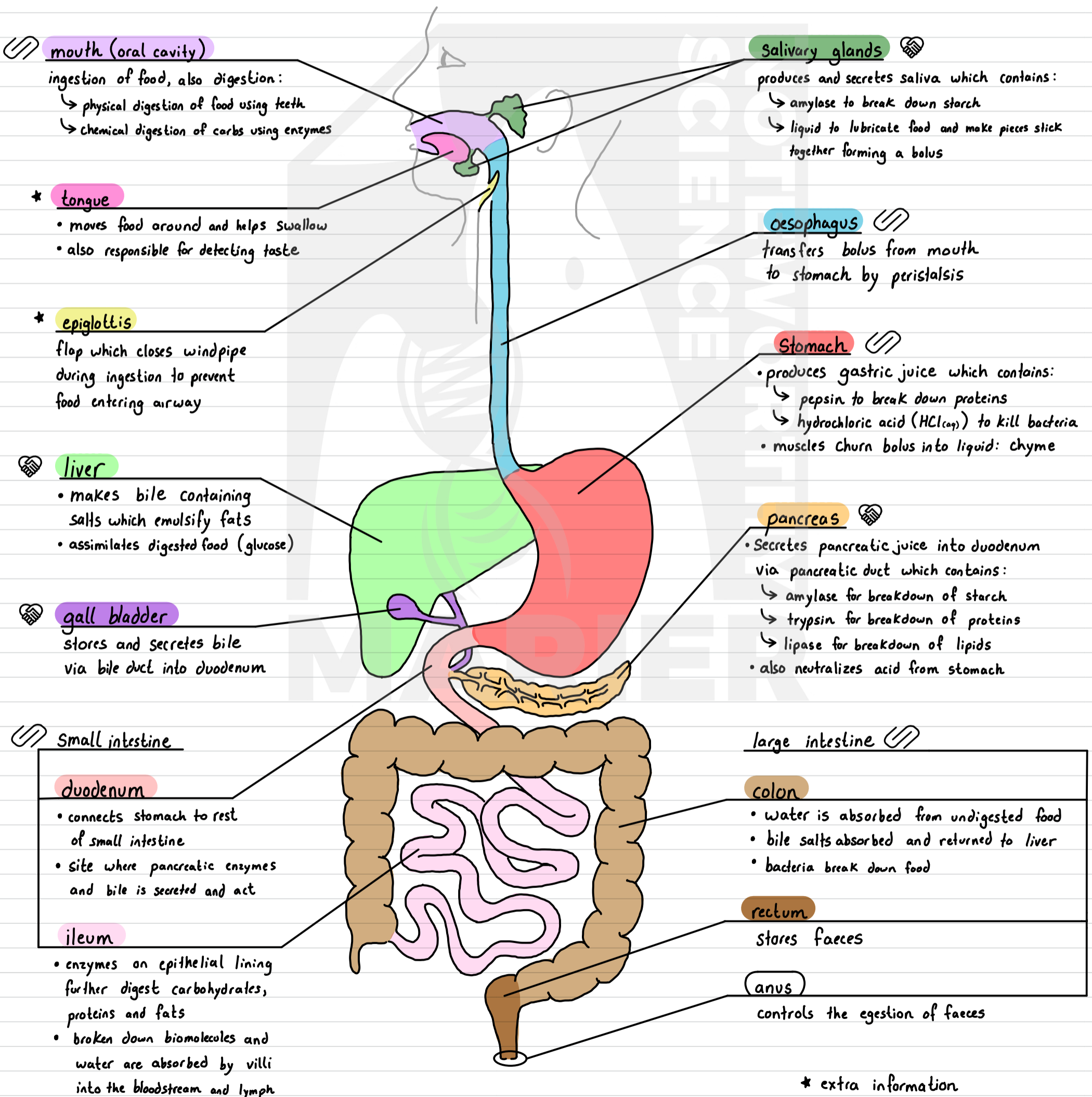
Digestive System - Overview

The digestive system uses many organs to process nutrients (food) in the following ways:



The organs of the digestive system fall into 2 groups:

- Alimentary canal**: tube running through body in which food passes (mouth → anus)
- Associated organs**: aid in process of digestion



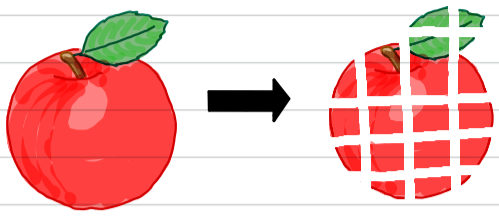
* extra information

Ingestion and Digestion

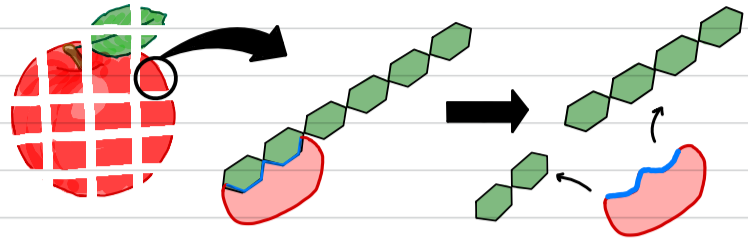
Food is broken down throughout the digestive system both physically and chemically

↳ **Physical digestion**: the breakdown of food into smaller pieces without chemical change to the food molecules

↳ **Chemical digestion**: breakdown of large insoluble molecules into small soluble molecules

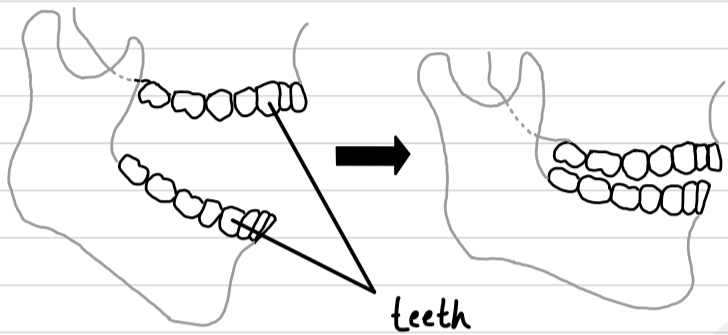


breaking it into smaller parts increases its surface area, facilitating chemical digestion by enzymes



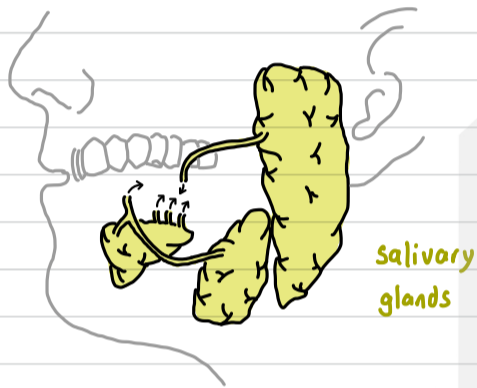
enzymes catalyze the breaking of bonds within molecules, making them small enough for absorption

The Mouth



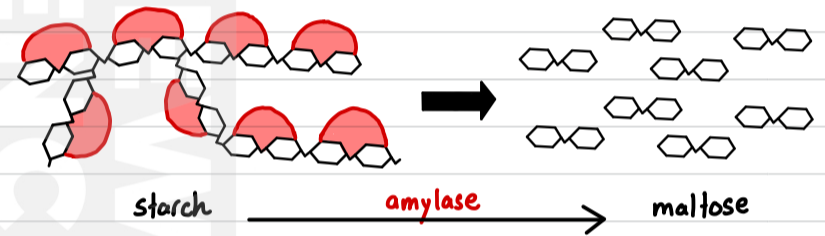
- Mouth ingests food
- Most of physical digestion occurs in the mouth.
- Teeth physically break down food into smaller parts

↳ as humans are **omnivores** (eat animal and plant material) we have specialized teeth: some for tearing and cutting (ex: canines) and some for chewing and grinding (ex: molars)

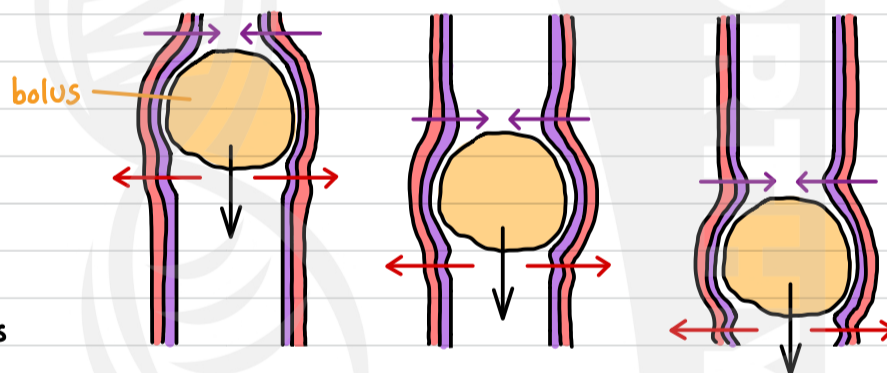
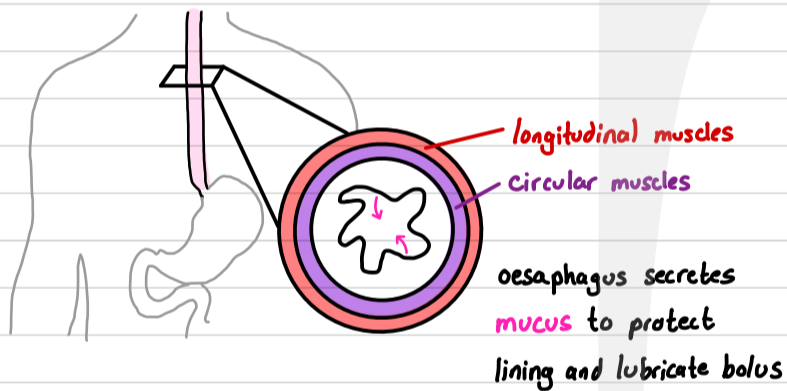


- Chemical digestion of starch occurs in the mouth
- 3 pairs of salivary glands secrete saliva, a juice which lubricates food, causing pieces to stick together (now called a bolus) and contains the enzyme **salivary amylase**

↳ amylase catalyzes breakdown of starch into disaccharides (maltose)



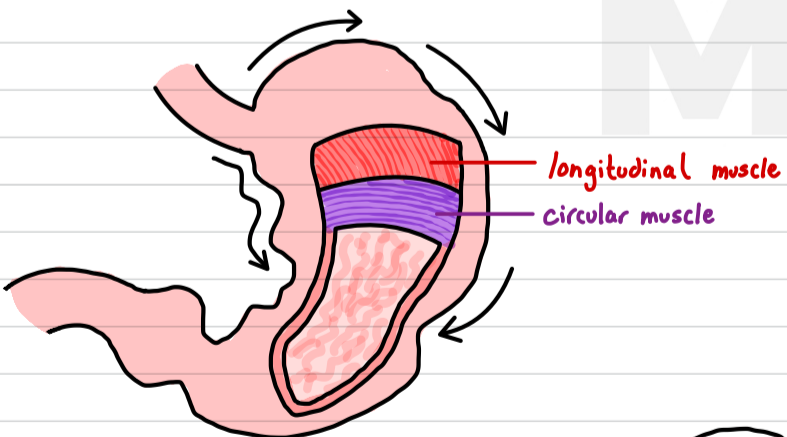
The Oesophagus



the oesophagus propels the bolus from the throat to the stomach using a wave of contractions called **peristalsis**:

- ↳ circular muscles contract behind bolus - squeezing it forward
- ↳ longitudinal muscles contract in front of bolus, widening tube

The Stomach



- Stomach's walls are elastic and stretch: accommodating more food and signals muscle contraction
- The stomach's walls are composed of muscle layers which alternatively contract and relax via peristalsis.

↳ this physical digestion of food increases surface area and keeps it in greater contact with digestive enzymes

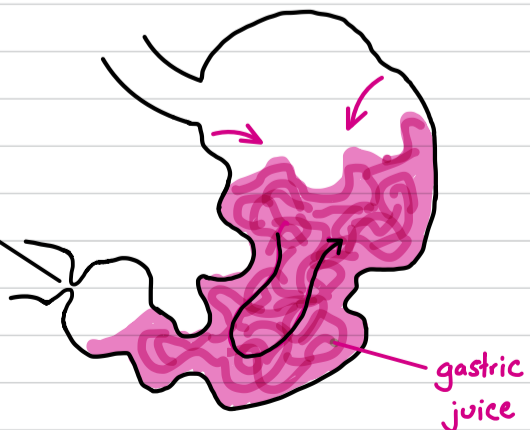
↳ this causes the contents to churn and mix with **gastric juice** becoming a creamy liquid - chyme

• stomach secretes **gastric juice**, which contains:

↳ Hydrochloric acid, HCl (aq) , which kills harmful microorganisms found in or on bolus and provides acidic condition - which is ideal for **pepsin**

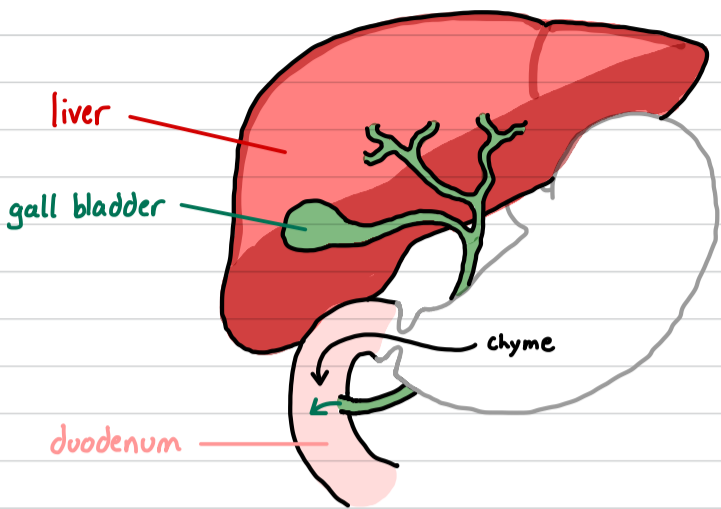
↳ **pepsin** (protease) is an enzyme which catalyzes chemical breakdown of proteins into smaller polypeptide chains (peptides) and amino acids

pyloric sphincter is a valve which controls entry into duodenum, only allowing liquid chyme to enter



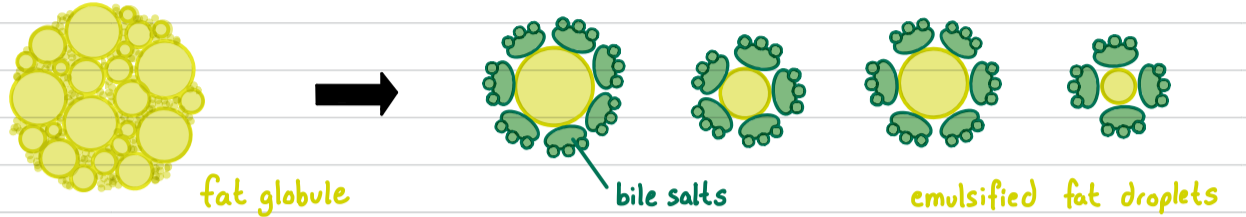
Digestion and Absorption

The Duodenum



- Chyme enters the duodenum from the stomach
- Liver produces **bile** and stores it in the **gall bladder** where it is later secreted into the duodenum

↳ bile contains **bile salts**, which help **physically digest** lipids through **emulsification**. This creates smaller fat droplets, which increases surface area, facilitating enzyme action.



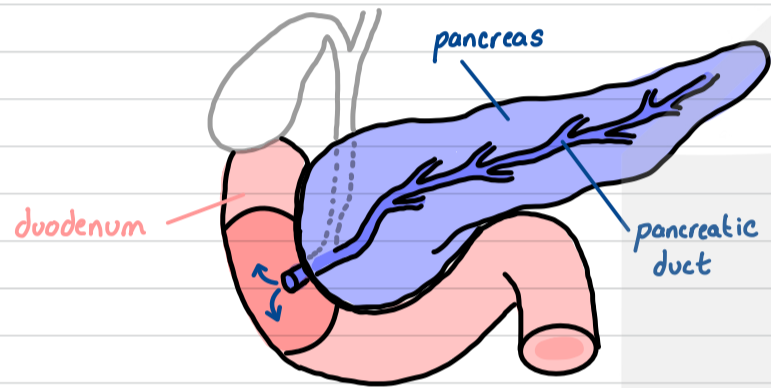
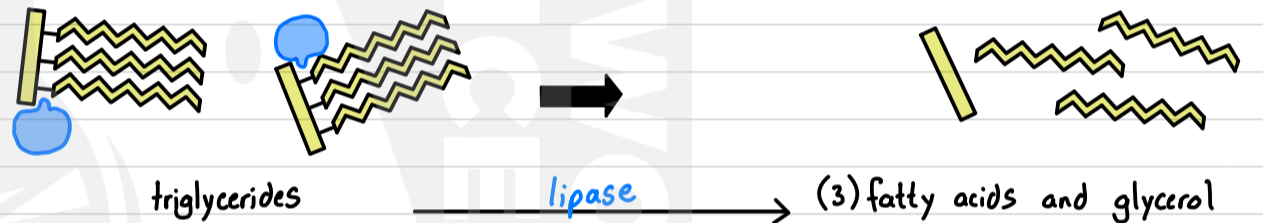
- The **pancreas** secretes pancreatic juice into the duodenum which contains:

↳ Sodium hydrogen carbonate, NaHCO_3 , neutralizes stomach acid for ideal alkaline condition for **trypsin**

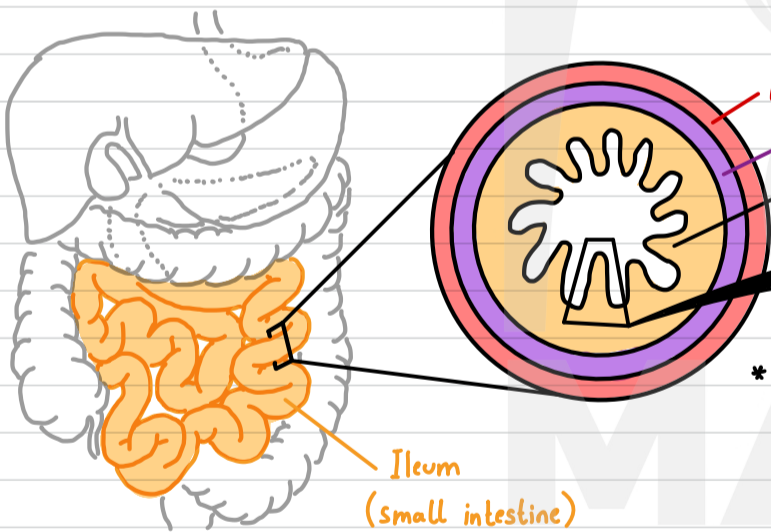
↳ **pancreatic amylase**: catalyzes **chemical breakdown** of starch into maltose

↳ **trypsin** (protease): catalyzes **chemical breakdown** of proteins into smaller peptides

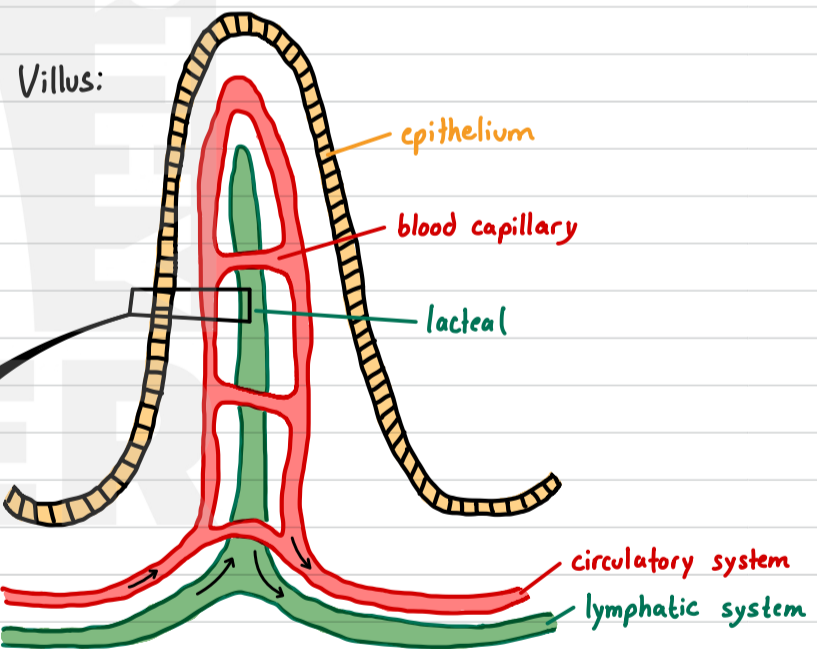
↳ **lipase**: catalyzes **chemical breakdown** of lipids (fats, oils) into fatty acids and glycerol



The Ileum



* muscles contract to propel nutrients; promoting movement, mixing, and absorption

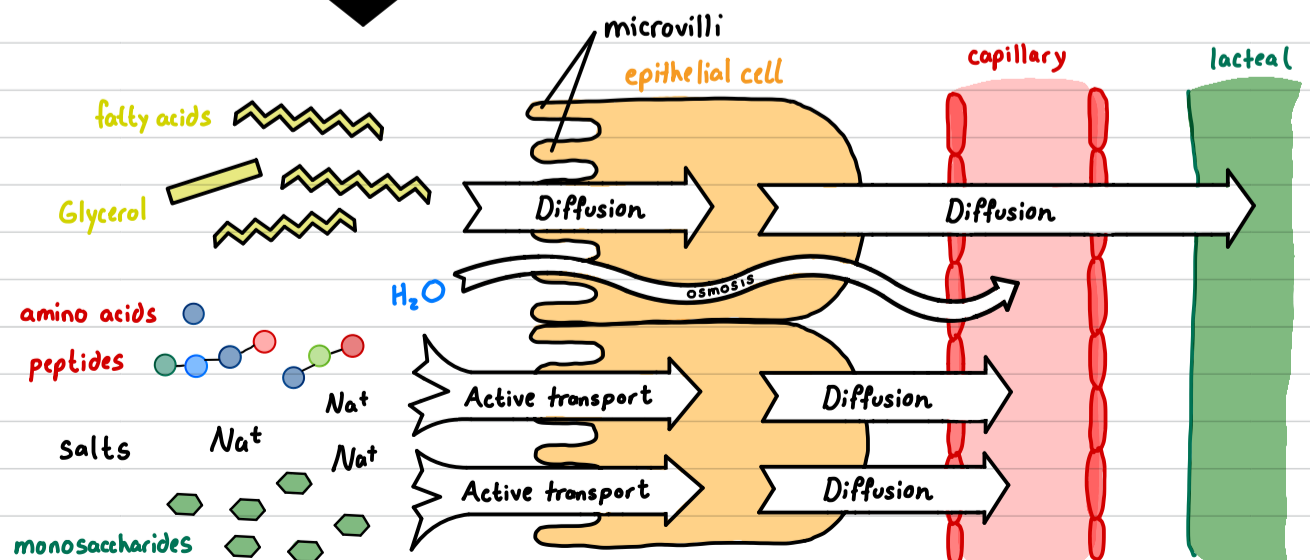


- Most of **absorption** of digested molecules and water occurs in the ileum:

- ↳ sugars, amino acids and salts are actively transported into **epithelial cells** and then diffuse into **capillaries** where they are transported to the liver via the blood
- ↳ lipids diffuse into **lacteals** where they are transported via the lymphatic system and eventually enter bloodstream
- ↳ water enters cells and blood via **osmosis**

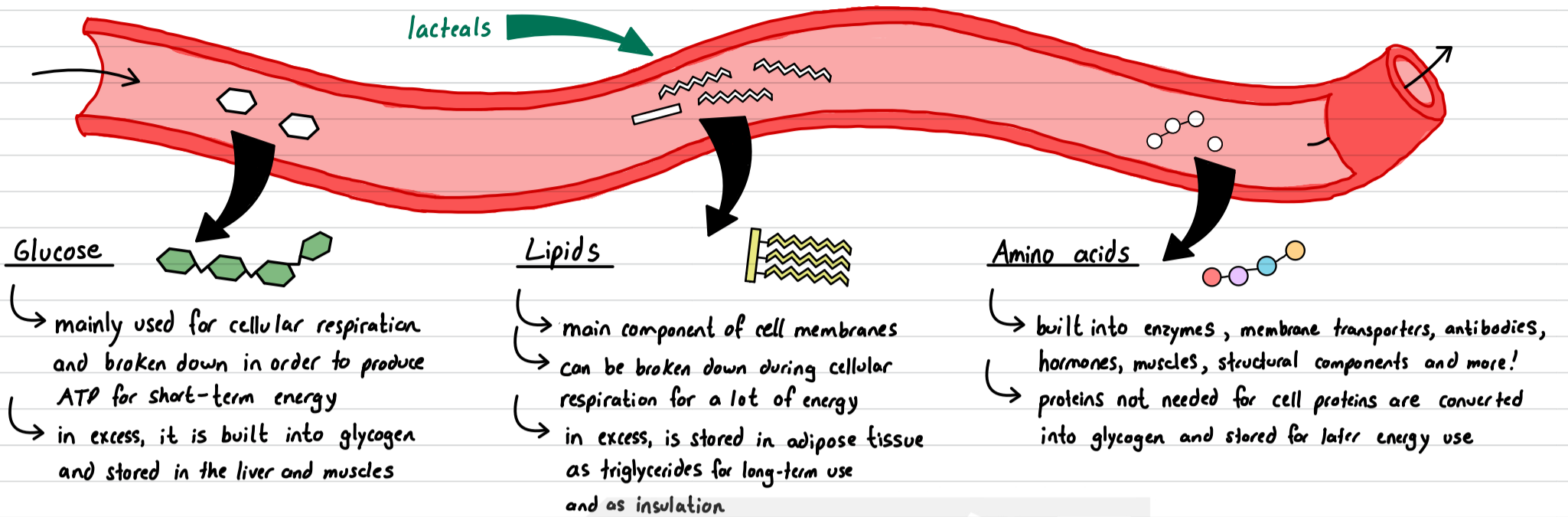
- The ileum is adapted to absorption:

- ↳ outer layer (epithelium) is only 1 cell thick
- ↳ very high surface area: volume as the epithelium is highly folded, **villi**, and each of the **epithelial cells** have many folds, **microvilli**
- ↳ dense network of **capillaries** (tiny blood vessels) in each villus, allowing short distance of travel
- ↳ separate vessel to transport lipids - **lacteal**



Assimilation and Egestion

Once the nutrients enter the bloodstream (from capillaries or lacteals) they are transported to cells in order to be used (Assimilation)



The Colon

• Whatever food particles that were unable to be digested and absorbed in the small intestine enter the colon - main part of large intestine

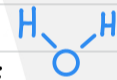
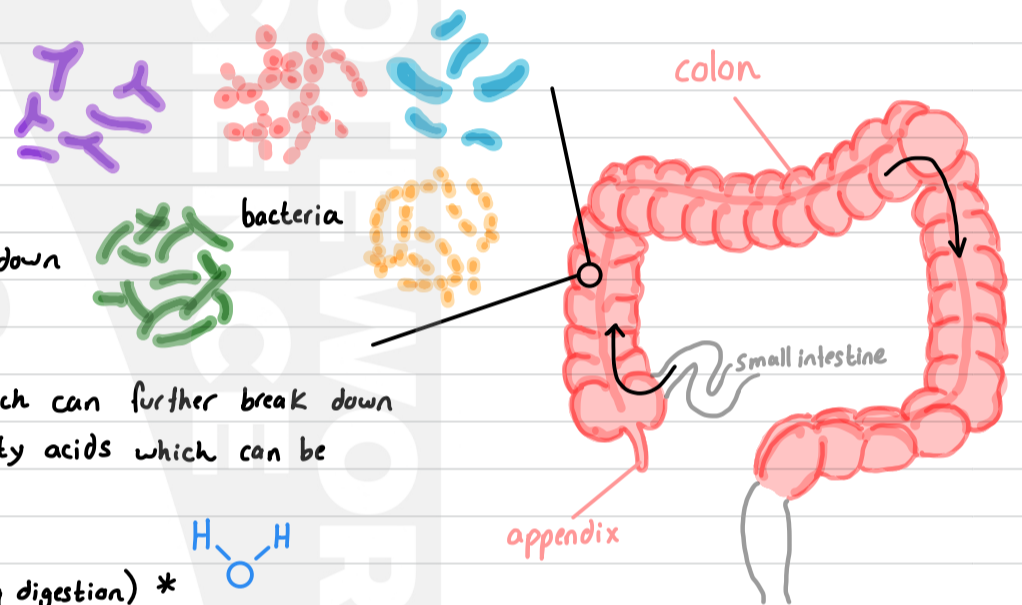
↳ food that is indigestible is mainly due to lacking the enzyme that can break it down
ex: humans lack cellulase and cannot break down cellulose in plants (i.e. fibre)

↳ While the colon does not produce enzymes, it is home to trillions of bacteria which can further break down previously undigested food (such as sugars) which produces monosaccharides and fatty acids which can be absorbed but it also produces gas as a byproduct, i.e. flatulence (fart)

• The primary function of the colon is to **reabsorb water** (as much was used during digestion) *

• Colon absorbs bile salts, returning them to the liver via the blood

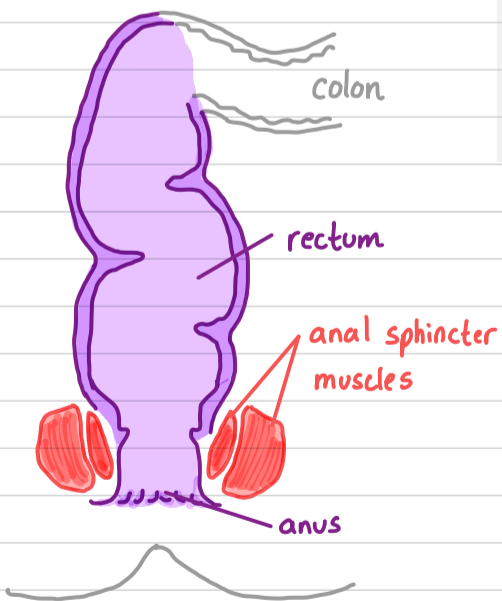
↳ waste moves through colon via peristalsis, becoming more dry and semi-solid, becoming **faeces**



* if the faeces becomes hard + very dry, it passes more difficultly and infrequently → constipation

* if the faeces is too watery, it passes too quickly and as a liquid → diarrhea

The Rectum and Anus



• faeces is stored in the rectum (last part of colon) until a larger volume of faeces is produced

• once a threshold is reached, **egestion** of faeces is initiated:

↳ muscles move faeces down the rectum via peristalsis until it reaches anus

↳ the opening and closing of the anus is controlled by anal sphincter muscles

note: egestion ≠ excretion. Egestion is the removal of undigested food (faeces) whereas excretion is the removal of waste from metabolism (urea)

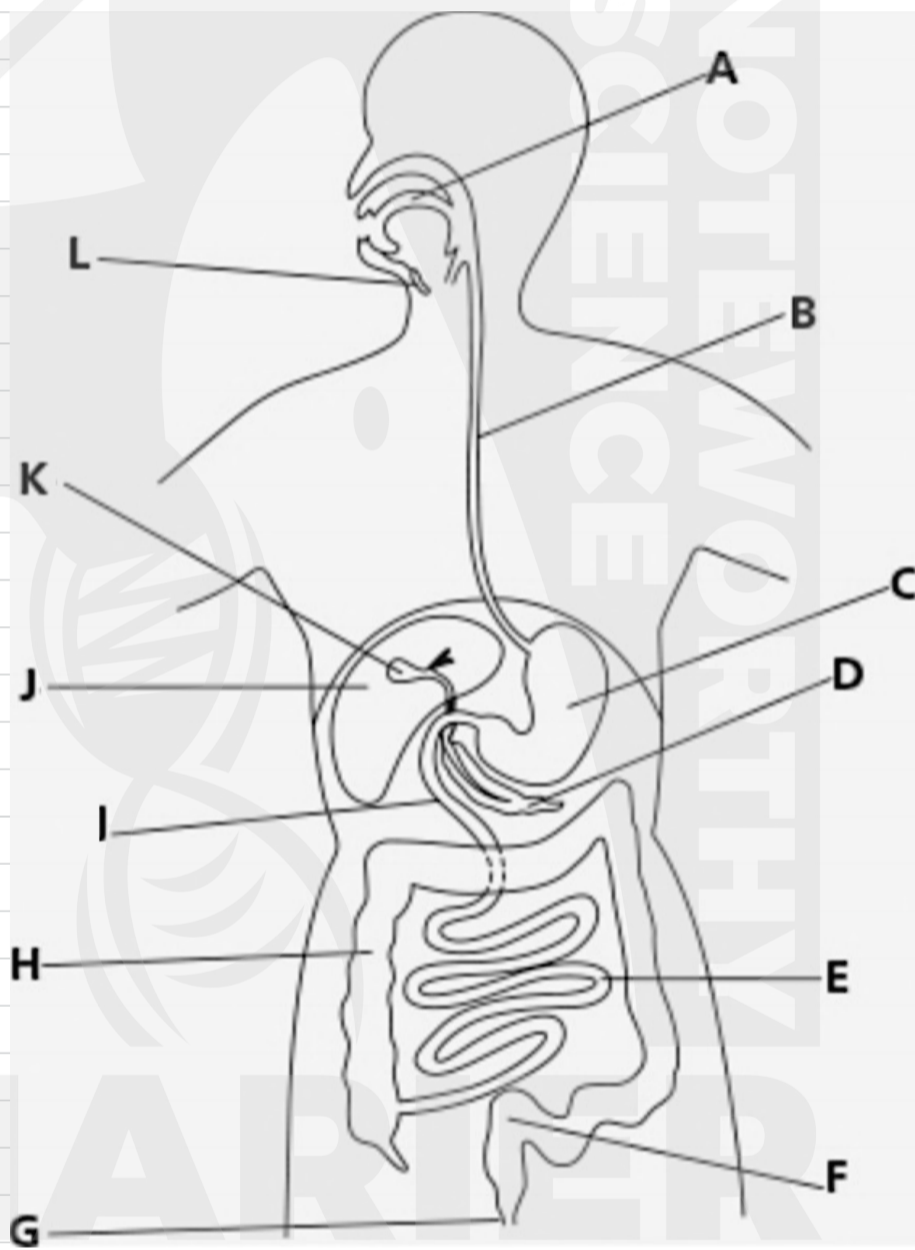
Assessment Tasks

Answer the following questions:

- ① Explain two reasons why enzymes are necessary for digestion.
- ② a) Outline all the places where physical digestion takes place and what is occurring
b) Explain the importance of physical digestion.
- ③ Fill in the table summarizing chemical digestion:

Enzyme	Substrate(s)	product(s)	secreted by	secreted into
salivary amylase	starch	glycerol + fatty acids	stomach	
trypsin			pancreas	

- ④ a) Label the organs on the diagram
b) indicate which organs are accessory organs
c) number the organs in the order food passes from ingestion to egestion (alimentary canal)



- ⑤ Explain how the ileum is adapted to its function
- ⑥ If the lining of the large intestine is ruptured, this is very serious and can lead to serious illness or death. Explain why.
- ⑦ Provide two benefits to the stomach's production of hydrochloric acid
- ⑧ Even though we lack enzymes to break down and assimilate cellulose (fibre) it is recommended as a regular part of diet. Explain why.
- ⑨ Contrast how carbohydrates and lipids are digested, absorbed, stored, and used in the body