NUTRITION IN MAN

Process

- 1. Ingestion (food enters body through the mouth)
- 2. Digestion (process whereby large food molecules are broken down into smaller, soluble food molecules that can be absorbed into the body cells)
 - Physical digestion: Ripping, cutting, grinding, action of teeth, churning action of stomach
 - Chemical digestion: Breakdown of complex substances into simpler substances by the action of enzymes
- 3. Absorption (process whereby digested food substances are absorbed into the body cells)
- 4. Assimilation (process whereby some of the absorbed food substances are converted to new protoplasm or used to provide energy)
- 5. Egestion (removal of undigested food out of the alimentary canal via the anus)

Alimentary canal and associated organs

The organs of the alimentary canal are the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. The associated organs are pancreas, liver and gall bladder.



Mouth: Digestion starts in the mouth (both physical and chemical)

- Food is broken down into smaller chewable pieces through *chewing* (grinding of teeth)
- Saliva, containing water, electrolytes, antibacterial components and enzymes such as salivary amylase (converts starch to maltose), mixes with food to begin breaking it down
- Tongue

+ Rolling action of the **tongue** combined with secretion of saliva (from salivary glands) rolls food into a bolus – mixes food with saliva

+ Taste buds on the tongue identify and select suitable foods

Pharynx

- a) Nasopharynx
- b) Oropharynx: Prevents the food from entering the trachea (windpipe)
- Connects buccal cavity to oesophagus and the larynx (voice-box)
- When food enters the oesophagus, the larynx of the voice box closes, resulting in epiglottis covering the entrance of trachea

Oesophagus

- Narrow, muscular tube. It passes through the thorax (chest) and the diaphragm to join the stomach
 - + Diaphragm: Sheet of muscle separating the thorax from the abdomen
- Swallowing pushes the food bolus through the pharynx (throat) and into the oesophagus
- When food enters the oesophagus, the larynx of the voice box closes
- Peristalsis occurs to push food to the stomach

Stomach

- a) Oesophageal sphincter: At the junction between the oesophagus and the stomach, there is a thick ring of circular-smooth muscle that prevents the movement of food from oesophagus into the stomach
- b) Pyloric sphincter: Ring of circular-smooth muscle that direct the passage of food from stomach small intestine
- c) Function
- A distensible muscular bag, with thick and well-developed muscular walls
- Stomach stores food (2-4 hours) until it is digested, kill microorganisms
- Begins the digestion of proteins

+ When the stomach is fully distended, it sends signals to the brain that it is sated. Stomach wall has pits that lead to gastric glands that secrete gastric juice into the stomach cavity. Stomach secretes gastric juice, hydrochloric acid, water, mucus, pepsinogen and renin

+ Pepsinogen is secreted by chief cells (present in the deep fold of stomach lining) in the gastric glands

+ Low pH level (1-3) of acid helps to convert pepsinogen to pepsin and is the *right pH for pepsin-enzymatic action*

+ Mucus secreted by stomach lines the wall of the stomach and protects them from being digested by HCL and pepsin

- Contractions of the smooth muscles in the walls of the stomach roll around its contents, mixing partially digested food with enzymes and acid

The acidic fluid mixture of gastric juice is called **chyme**. Through peristalsis movements of the stomach walls, chyme is push towards the end of the stomach

Gates of pyloric sphincter relax briefly, hence chyme enters the small intestine (gradual emptying of the stomach over 4 hours)

Liver (bile)



- Dark red, made up of five lobes (three on the right, two on the left)
- Attached to lower surface of the liver are three blood vessels, the hepatic portal vein and the hepatic artery
- The liver cells produce and secret bile alkaline greenish-yellow liquid containing **bile salts** and **bile pigment** (waste products and are removed with faeces and undigested matter)

Gall bladder

- Greenish-yellow bag attached to the liver
- Bile is stored temporarily in the gall bladder
- When gall bladder contracts, the bile flows into duodenum via bile duct

Pancreas



- Gland connected to duodenum by **pancreatic duct** (release pancreatic juice)
- The bile duct joins the pancreatic duct just before pancreatic duct opens into duodenum
- Secretes pancreatic juice into the duodenum, also makes the hormones insulin and glucagon play important role in controlling the concentration of glucose in the blood and carbohydrate metabolism (refer CARBOHYDRATE METABOLSM)

Small intestine: The lining of the walls of the small intestine contains glands which secrete digestive enzymes. Wall of small intestine is also adapted to absorb digested food products and water.

- a) Duodenum: First part of the small intestine (U-shaped)
- Receive pancreatic juice containing trypsin (a protease), lipase and amylase. The juice also contains sodium hydrogencarbonate which neutralizes acid from the stomach.
 - + Trypsin: Protein Polypeptides
 - + Pancreatic amylase: Starch Maltose
 - + Pancreatic lipase: *Emulsified fat* Fatty acids and glycerol
- Receive intestinal juice from intestinal gland containing maltase, sucrase, lactase, peptidase
 - + Maltase: Maltose Glucose
 - + Sucrase: Sucrose Glucose and fructose
 - + Lactase: Lactose Glucose and galactose
 - + Peptidase: Polypeptides Amino acids
 - b) Jejunum: 2nd part of small intestine. Its lining is specialized for the absorption by enterocytes of small nutrients molecules which have been previously digested by enzymes in the duodenum
 - c) Ileum: The last part of the small intestine (coiled). Enzymes in the epithelial digest lactose and peptides. Its surface area is increased by the presence of villi which allow the efficient absorption of digested food molecules https://biology-igcse.weebly.com/human-alimentary-canal.html

The large intestine – NO digestion occurs

- 1. Colon
- Function: Absorb mineral water and salts from the undigested food materials
- Caecum and appendix are at the junction between colon and the small intestine (no specific function)
- 2. Rectum: Temporarily store faeces (undigested and unabsorbed matters). When contract, faeces are expelled through the anus.
- 3. Caecum: Sac-like structure
- 4. Appendix: Tubular, attached to caecum
- Can be inflamed causing appendicitis

Anus

Muscles to control when faeces is egested from the body Egestion/defecation

Absorption

Definition: Process whereby digested food substances are absorbed into the body cells

Adaptation of small intestine (for absorption)

- Surface area of small intestine
- Membrane that separates the food substances from blood capillaries

Glucose and galactose are absorbed directly into the blood stream from the small intestine

Digestion

Definition: Process whereby large good molecules are broken down into smaller, soluble molecules that can be absorbed into the body cells

- Physical: Mechanical break-up of food into small porticles
 - + Mouth: Chew food by the action of the teeth and tongue

+ Stomach: Continual contracts and relaxations of food muscles in stomach wall (longitudinal and circular muscles) Churning action Breaks up food particles and mixes them with digestive enzymes

- Chemical digestion: Breaking down of large molecules in food, such as proteins, starch and fats, into smaller soluble molecules which can be absorbed such as hydrolytic reactions catalyzed by digestive enzymes

+ Hydrolysis: Any chemical reaction in which a molecule of water breaks one or more chemical bonds

<u>Peristalsis</u>

- a) Definition: Rhythmic, wave-like muscular contractions of the walls of the alimentary canal
- b) Process
- Point 1: Circular muscles contract, longitudinal muscles relax, wall of gut constricts, food bolus is pushed forward (diameter of lumen decreases)
- Point 2: Longitudinal muscles contract, circular muscles relax, gut dilates to allow food bolus to enter lumen (diameter of lumen increases)
- c) Muscles
- Longitudinal and circular muscles produce slow, long contracts that move food along the gut via peristalsis and enables food to be mixed with digestive juices
- The circular muscles constrict the lumen, longitudinal muscles shorten and widen the lumen
- Antagonistic muscles When one set of muscles contract, the other set relaxes
- Enables food to be mixed with digestive juices
- d) Structure of transverse section of gut
- Serosa (outermost layer) Longitudinal muscles Circular muscles Sub-mucosa (blood vessels) Mucosa (villi) Lumen



Digestion (carbohydrate + protein)

- 1. Mouth
- <u>Chewing breaks food into smaller pieces (increases surface area to volume ratio for salivary amylase to work on); tongue rolls food into small, slippery, round masses boli (bolus)</u> Boli are swallowed, passed down into the oesophagus via the pharynx
- -___Peristalsis in the walls of oesophagus pushes each bolus of food down into the stomach
- Food stimulates salivary glands to secrete saliva containing salivary amylase that digest starch maltose when mixed with food, mucus softens food
 + pH of salivary is neutral Salivary amylase is active at around pH 7
- 2. Stomach
- -___Pepsin: Some proteins Polypeptides

+ Safety mechanism: Inactive pepsinogen reacts with hydrochloric acid to produce pepsin enzyme. This is to avoid the organs which are protein-based to be digested by pepsin.

- 3. Small intestine (7): Prime Minister Shouts: Look! Look!
- -___Pancreatic amylase: The rest of starch into maltose
- Maltase: Maltose Glucose
- <u>-</u>Sucrase: Sucrose Glucose + Fructose
- Lactase: Lactose Glucose + Galactose
- -___Pancreatic trypsin: Rest of proteins Polypeptides
 - + Enteropeptidase/enterokinase: Trypsinogen Trypsin
- Peptidase: Polypeptides Amino acids
- Pancreatic lipase/intestinal lipase: Tiny fat droplets/globules Fatty acids + glycerol
 - + Big fat droplet/globule **Emulsification** by bile salts from bile released by *pancreas* Tiny fat droplets, globules

- Chyme enters small intestine thus stimulates pancreatic juice containing pancreatic amylase, pancreatic lipase and trypsin (a protease). This juice passes through the pancreatic duct into the duodenum.

Hepatic portal vein

- -___Blood vessel that transports nutrients to the liver from the gastrointestinal tract
- -___Hepatic portal vein experiences the greatest change in blood sugar concentration

Structure of a villus



The surface area of the small intestine is increased for absorption through:

- Inner surface of the small intestine is folded
- The folds bear minute finger-like projections called villi (villus)
- Single layer epithelium of villus allows digested food substances to take a shorter time to pass through
- Each epithelial cell has numerous microvilli to increase surface area
- Lacteal transports fat away from the intestine; blood capillaries transport glucose and amino acids away from the intestine

The continual transport of food molecules maintains the concentration gradient for more absorption of food molecules

Role of the liver (5)

- a) Carbohydrate metabolism
- When the body experiences a high blood glucose level, for example after a heavy meal, the Islets of Langerhans in pancreas detects change and secretes more insulin into blood.

The insulin is carried to liver by blood and **stimulates** liver to convert excess glucose to glycogen, thus blood glucose level falls to normal.

- When the body experiences low blood glucose level (during fasting), the Islets of Langerhans in pancreas detects change and secretes more **glucagon** into blood. The glucagon is carried to liver by blood and stimulates liver to convert stored glycogen to glucose, thus blood glucose level rises to normal.
- There's a finite amount of glycogen that can be stored
- b) Fat metabolism
- Liver produces bile which is later stored in the gall bladder
- Emulsification (by bile)
- c) Detoxification: Process of converting harmful substances into harmless ones
- Liver cells contain an enzyme called alcohol dehydrogenase breaks down alcohol to a compound called acetaldehyde, which can be further broken to compounds that can be used in respiration to provide energy for cell activities.
- d) Iron storage (involves breakdown of red blood cells): Worn out red blood cells get broken down in the spleen (either side of stomach). Haemoglobin is sent to liver and broken down. The iron collected is stored in liver and bile pigments are produced.
- e) Deamination (amino acids urea)
- The breakdown of excess amino acids releases nitrogen-containing amine groups (NH2) such as ammonia, which are toxic to cells
- The liver removes ammonia via the process of deamination and converts them into urea. Urea is removed from the body in urine
- The *carbon residue* is converted into *glucose* which, in excess, is converted into *glycogen* and stored in the *liver and muscles*

Breakdown of alcohol, effects of excessive alcohol consumption

- a) Breakdown of alcohol
 Liver cells Produce enzyme alcohol dehydrogenase Breaks down alcohol to
 acetaldehyde (harmless) Acetaldehyde further broken down Used in respiration
- b) Excess alcohol consumption
 - i) Digestive system: Gastric ulcers and liver cirrhosis
 - ii) Nervous system: Slows down brain function (depressant), reduced self-control, slower reaction due to effects of intoxication (slurred speech, blurred vision, poor muscular contraction)
 - iii) Social implications: Addiction, violence towards family, commit crimes

Artery VS Vein

Arteries are blood vessels responsible for carrying oxygen-rich blood away from the heart to the body. Veins are blood vessels that carry blood low in oxygen from the body back to the heart for reoxygenation

Assimilation

Definition: Process whereby some of the absorbed food substances are converted into new protoplasm or used to provide energy

Hepatic portal vein: The blood capillaries unite to form larger blood vessels, which in turn unite to form larger vein

Fate of glucose: In the liver, most of the absorbed sugars are converted into glycogen and stored. Some glucose is transported by the blood leaving the liver, and distributed around the body.

- Source of energy assimilated and then oxidized during tissue respiration to release energy for vital activities of the cells
- Excess: Returned to liver and stored as glycogen. When the body needs energy, liver convers stored glycogen back into glucose, which is then transported by the blood to the liver

Amino acids

- Converted to new protoplasm used for growth and repair of worn-out parts of the body
- Form enzymes and hormones
- Excess is deaminated in the liver

Constipation

Dietary fiber/roughage refers to indigestible materials in the diet (eg. cellulose). Its bulk stimulates peristalsis which increases the speed of movement of the faeces to prevent over-absorption of water.

- Proper peristalsis doesn't occur undigested matter in large intestine cannot be moved along fast enough, too much water will be absorbed
- Faeces become very dry and hard Constipation

Solution: Taking enough dietary fibre (fresh fruits, vegetables, cran, cereals, whole meal bread) and drinking sufficient water