

CHAPTER 9.1 – DIGESTIVE SYSTEM

Structure of the human digestive system

- ⊞ The human digestive system is made up of a long and muscular alimentary canal that starts from the mouth to the anus
- ⊞ The parts of the alimentary canal include
 - Δ Mouth
 - Δ Oesophagus
 - Δ Stomach

- Δ Small intestine
- Δ Large intestine
- Δ Anus
- ⊞ The other organs in the digestive system are
 - » Liver
 - » Gallbladder
 - » Pancreas
- ⊞ Digestive juices that secreted into the alimentary canal by
 - Salivary
 - Gastric
 - Intestinal glands

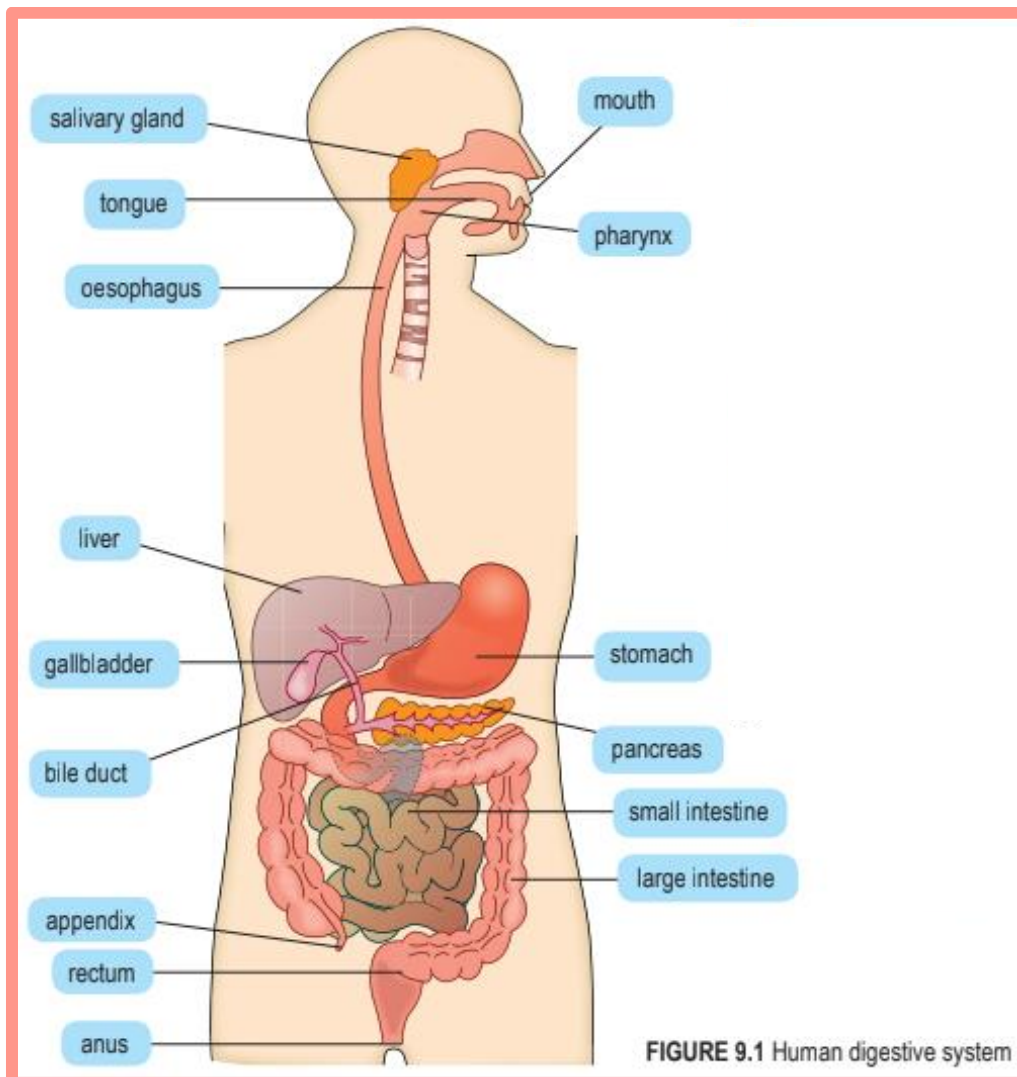


FIGURE 9.1 Human digestive system

CHAPTER 9.2 – DIGESTION

Types of digestion

- Digestion is the process that breaks down large and complex pieces of food into smaller and simple pieces that can be dissolved for easy absorption
- There two parts of digestion
 - 1) Physical digestion
 - 2) Chemical digestion

PHYSICAL DIGESTION

- ⊕ The chemical breakdown of food to form small particles
- ⊕ Involves
 - I Chewing
 - II Peristalsis

CHEMICAL DIGESTION

- ⊕ The decomposition process of complex molecules into simple molecules
- ⊕ Involves enzymes reaction

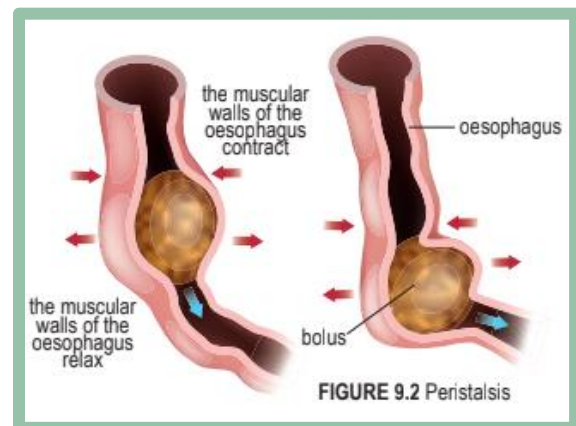
Digestion of carbohydrates in the mouth

- ◇ The digestive process begins in the mouth
- ◇ The presence of food in the mouth stimulates the secretion of saliva from the salivary glands
- ◇ Saliva contains salivary amylase that hydrolyses starch to maltose

- ◇ The pH of the saliva ranges between 6.5-7.5 which is suitable for salivary amylase to act at its optimum



- ◇ Saliva helps food to form bolus and makes it easier to be swallowed
- ◇ When swallowing, the epiglottis will close the trachea opening to prevent food from entering the trachea
- ◇ In oesophagus, the food bolus is moved by peristalsis
- ◇ Peristalsis is the rhythmic contraction and relaxation of muscles along the alimentary canal
- ◇ Peristalsis pushes the bolus through the oesophagus until it enters the stomach.



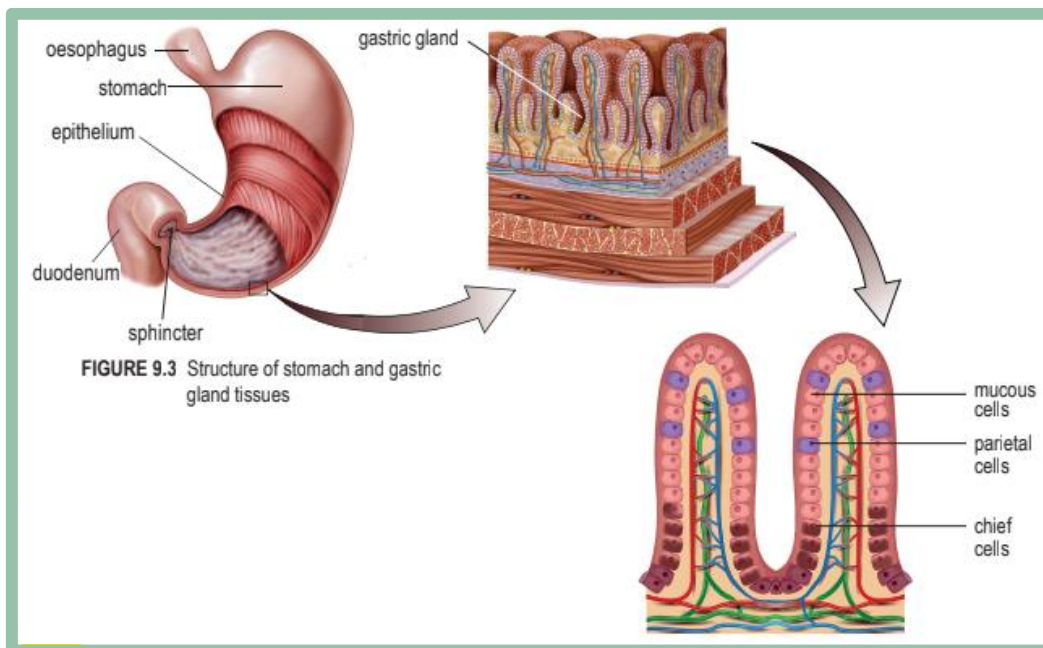
Digestion of protein in the stomach

- The surface of the stomach wall is lined with epithelial cells that have undergone adaptation in structure and function to form gastric glands

- These epithelial cells are
 - a. Chief cells that secrete pepsinogen
 - b. Parietal cells that secrete hydrochloric acid
 - c. Mucous cells that secrete mucus
- Pepsinogen is an inactive enzyme that is activated by hydrochloric acid to become pepsin
- Pepsin then hydrolyses proteins into polypeptides



- The food in the stomach is mixed with gastric juice made up of hydrochloric acid and pepsin
- Food is churned by the peristaltic action of the stomach wall muscles for a few hours
- The contents in the stomach finally change to a semifluid called chyme
- Chyme enters the duodenum slowly when the sphincter muscle relaxes



THE FUNCTIONS OF HYDROCHLORIC ACID

- ❖ To prepare a medium with a suitable pH (pH 1.5-2.0) for pepsin to act
- ❖ To stop the enzymatic action of salivary amylase
- ❖ To kill bacteria in food

THE FUNCTION OF MUCUS

- ↳ To protect the stomach wall from the reaction of hydrochloric acid and digestive enzymes

Digestion of carbohydrates, proteins and lipids in the small intestine

- Δ The small intestine consists of
 - a) Duodenum
 - b) Jejunum
 - c) Ileum

PANCREAS

- Product that **secreted** by the pancreas into the duodenum through the pancreatic duct is
 - 1 Pancreatic amylase
 - 2 Trypsin
 - 3 Lipase

LIVER

- ♥ Produces **bile**
- ♥ The gallbladder **stores** bile
- ♥ The bile **flows** into the duodenum through the bile duct
- ♥ The functions of bile
 - I To **neutralise** the acidic chyme
 - II To **prepare** an alkali condition (pH 7.6-8.6) for enzyme action in the duodenum
 - III To **emulsify** lipids by breaking down lipids into tiny droplets to increase surface area for lipase activity

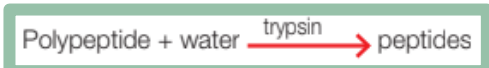
DUODENUM

- Δ Duodenum is the **first part** of the small intestine which **receives** chyme from the stomach
- Δ Duodenum also **receives**
 - i. Bile produced by the liver
 - ii. Pancreatic juice secreted by the pancreas

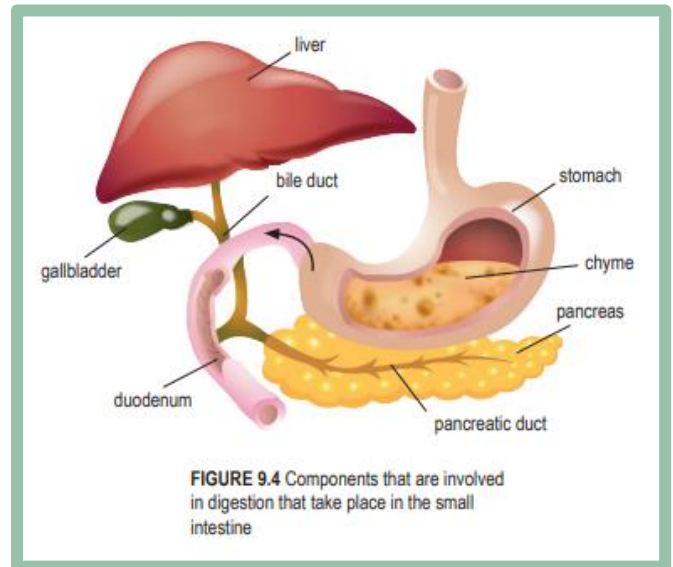
- Δ Pancreatic amylase **hydrolyses** starch to maltose



- Δ Trypsin **hydrolyses** polypeptides into shorter peptides



- Δ Lipase **hydrolyses** lipids into fatty acids and glycerols

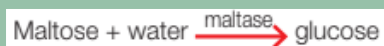


ILEUM

- Glands on the ileum wall **secrete** mucus and intestinal juice that contains
 - a) Maltase
 - b) Sucrase
 - c) Lactase
 - d) Lipase
 - e) Erepsin
- The alkali medium in the ileum **allows** enzymes to act at its optimum

CARBOHYDRATE DIGESTION

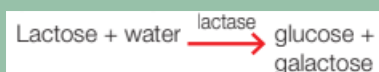
- ☐ Maltase **hydrolyses** maltose into glucose



- ☐ Sucrase **hydrolyses** sucrose into glucose and fructose



- ☐ Lactase **hydrolyses** lactose into glucose and galactose



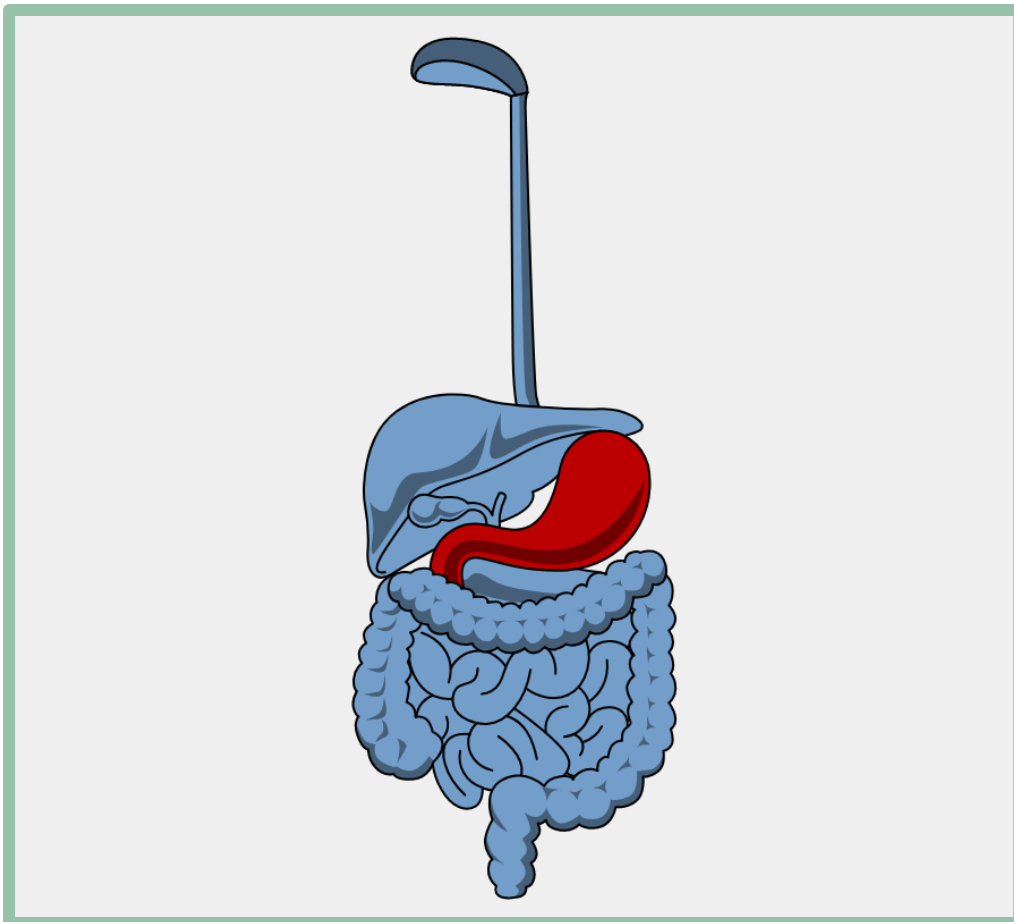
LIPID DIGESTION

- ⊡ Lipase hydrolyses lipids into fatty acids and glycerols



PROTEIN DIGESTION

- ⊕ Erepsin hydrolyses peptides into amino acids



9.3 – ABSORPTION

The adaptation of ileum and villus in the absorption of digested food

- Simple molecules produced from the digested food are absorbed in the ileum of the small intestine

ILEUM

- » The long ileum is adapted to absorb nutrients because its internal layer is folded and covered by tiny projections called villi (singular: villus)



VILLUS (plural: villi)

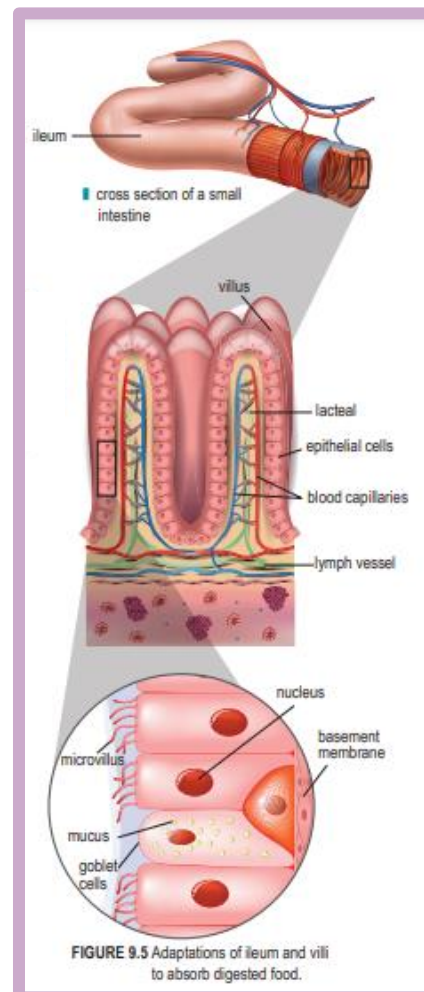
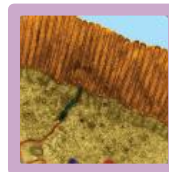
Villus has the following adaptations to absorb nutrients:

- ◇ The epithelial layer of the villus is one cell thick that helps accelerate nutrient absorption
- ◇ Goblet cells secrete mucus to aid digestion
- ◇ The network of blood capillaries helps to transport digestive products to the whole body
- ◇ Lacteal carries droplets of fatty acids and glycerol
- ◇ The intestinal glands secrete intestinal juices that have digestive enzymes

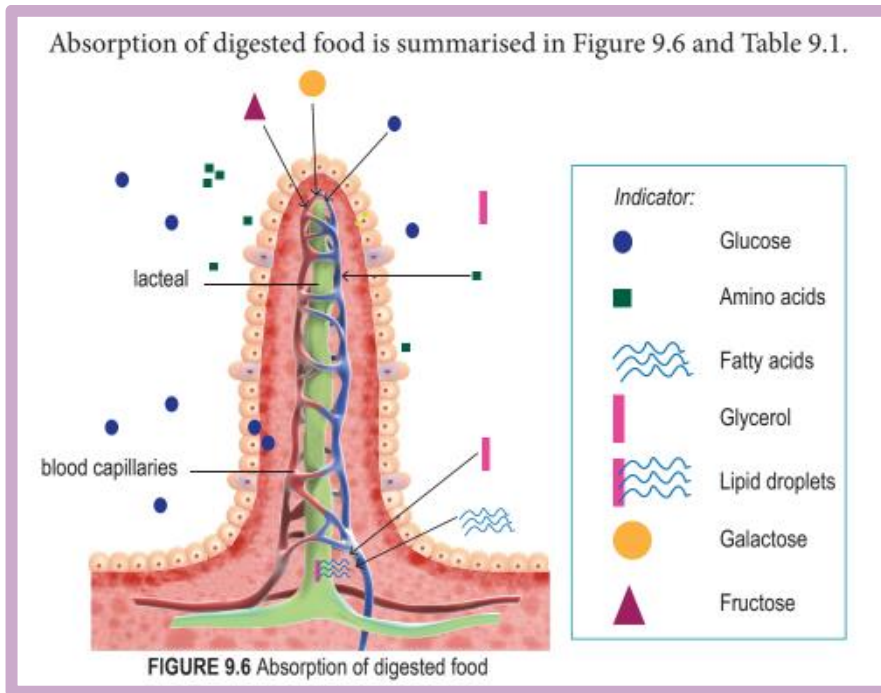


MICROVILLUS

- ♥ On the surface of the villus epithelium, there are many tiny projections called microvillus
- ♥ Microvillus provides a large surface area to increase the rate of nutrient absorption



METHOD OF FOOD ABSORPTION IN THE ILEUM



DIGESTED FOOD	ABSORBED THROUGH	METHODS OF ABSORPTION
Fructose	Epithelial cells into blood capillaries	Facilitated diffusion
Glucose and galactose		Active transport
Amino acids		Active transport
Vitamins B and C		Absorbed with water
Water		Osmosis
Fatty acids and glycerols recombine through the condensation process to form tiny droplets of lipids in the epithelial cells	Epithelial cells into lacteal	Simple diffusion
Vitamin A, D, E, K dissolve in the lipid		Simple diffusion

CHAPTER 9.4 – ASSIMILATION

The role of the circulatory system

- ◇ The human circulatory system consists of the blood circulation system and the lymphatic system to help transport nutrients to be assimilated
- ◇ In the assimilation process that occurs in cells, nutrients are used to form complex compounds or structures of components
- ◇ The blood capillaries in the small intestine combine to form the hepatic portal vein that transports blood to the liver
- ◇ Lacteals combine to form bigger lymph vessels in the lymphatic system
- ◇ Then, the contents of the lymph vessels enter the thoracic duct that flows into the left subclavian vein
- ◇ This lipid is then transported by blood throughout the body

Functions of liver in the assimilation of digested food

- The liver is the regulator that controls the quantity of nutrients that enter the blood circulatory system

METABOLISM OF DIGESTED FOOD

- Glucose is used for cellular respiration
- Amino acids are used for synthesising plasma proteins and enzymes
- Through the deamination process, excess amino acids are turned into urea to be excreted through the urine

DETOXIFICATION

- ↳ Liver cells expel toxic substances from the blood
- ↳ Toxic substances are expelled through the urine

STORAGE OF NUTRIENTS

- Excess glucose is converted to glycogen to be stored
- Glucose $\xrightarrow{\text{insulin}}$ glycogen

LIVER CIRRHOSIS

- ✚ Liver cirrhosis is a type of liver disease caused by factors such as
 - Alcoholic drinks
 - Toxic substances
 - Hepatitis
- ✚ Liver cells are replaced by scarred cells that can cause failure in the liver functions
- ✚ Hepatitis is an inflammation of the liver caused by viral infection, toxic substances or autoimmune reaction



Assimilation process in the liver

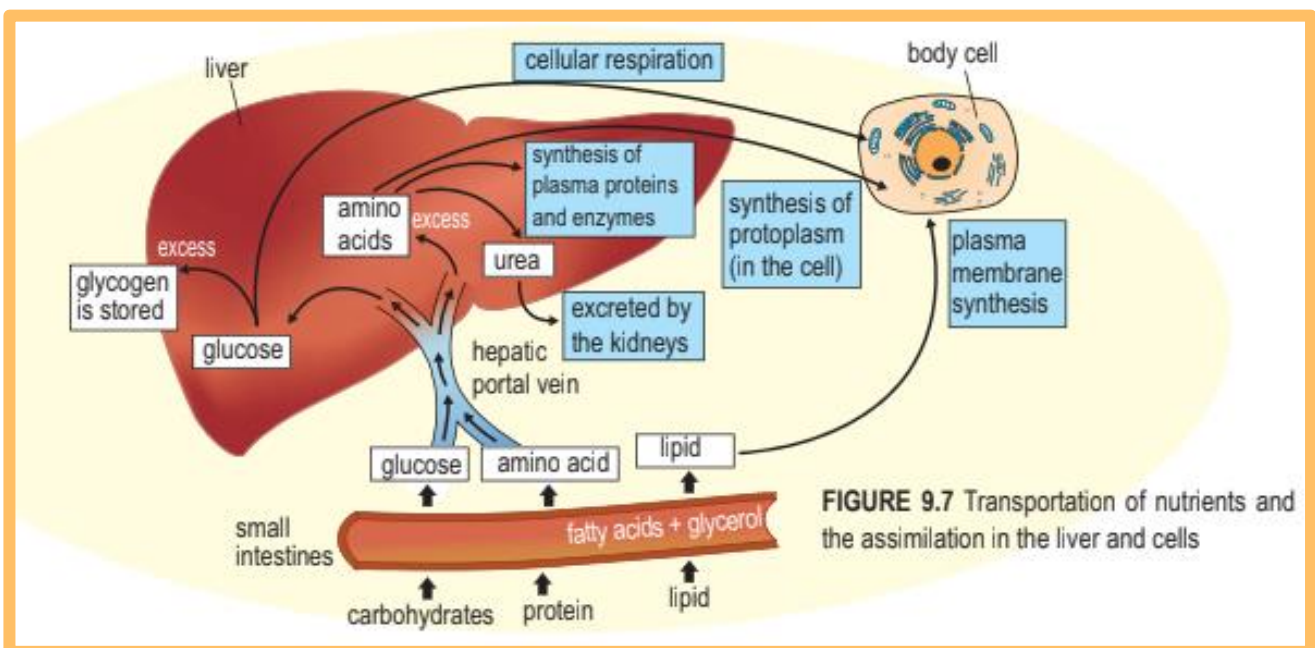
AMINO ACIDS

- Δ The liver **synthesises** plasma protein and enzymes from amino acids
- Δ Excess amino acids **cannot be stored** in the body and are **broken down** through the deamination process to **form urea** which is then **expelled**

- Δ When the glucose supply is **insufficient**, the liver **converts** amino acids into glucose

GLUCOSE

- Glucose in the liver is **used** for cellular respiration when **required** by the body and the excess is **converted** to glycogen and **stored** in the liver
- When the glucose level in the blood **decreases** and the body needs energy, glycogen is **converted** to glucose
- When the glycogen supply **reaches** a maximum level, the excess glucose is **converted** to fats



Assimilation process in cells

AMINO ACIDS

- Amino acids are used to synthesise new protoplasm and also repair damaged tissues
- Amino acids are used to synthesise hormones and enzymes

GLUCOSE

- » Glucose is oxidised through cellular respiration to release energy, water and carbon dioxide

- » Excess glucose is kept as glycogen in muscles
- » Energy is used for cell processes such as protein synthesis

LIPIDS

- ⊕ Lipids such as phospholipid and cholesterol are the primary components that build the plasma membrane
- ⊕ Excess fats are kept in adipose tissues found underneath the skin as stored energy
- ⊕ Fat is oxidised to release energy when there is insufficient glucose

CHAPTER 9.5 – DEFAECATION

Functions of the large intestine

- ⊞ After the absorption of nutrients is completed in the ileum, undigested food, dead cells epithelial cell, fibre and water enter the large intestine and move slowly through peristaltic action
- ⊞ Fibre consists of cellulose walls of plant cells
- ⊞ The large intestine carries out two main functions
 - a) Absorption of water and vitamins
 - b) Formation of faeces

ABSORPTION OF WATER AND VITAMINS

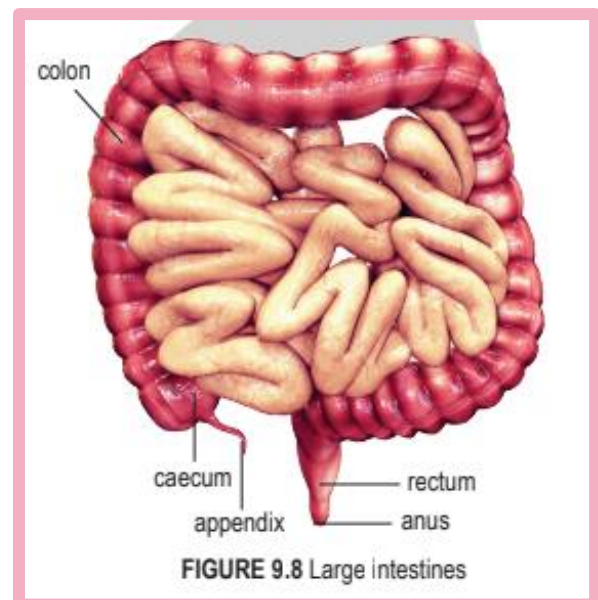
Substances absorbed are

- Water and mineral salts
- Metabolic byproducts of some bacteria such as
 - ✓ Vitamin B
 - ✓ Vitamin K
 - ✓ Folic acid

FORMATION OF FAECES

- ⊞ After the water is absorbed, the remaining waste is a semisolid called faeces

- ⊞ Faeces contains dead cells from the inner layer of the intestine, waste products such as
 1. Bile pigments
 2. Bacteria
 3. Toxic substances
- ⊞ The walls of the large intestine secrete mucus to smoothen the movement of faeces until the anus
- ⊞ The movement of faeces takes about 12 to 24 hours before entering the rectum
- ⊞ The faeces will accumulate in the rectum until the pressure in the rectum increases and triggers the need to expel faeces from the body
- ⊞ The rectum muscles will contract to expel faeces from the anus and this process is called defaecation



CHAPTER 9.6 – BALANCED DIET

Energy value in a food sample

- ◇ A balanced diet refers to a diet that contains of all seven food classes in the correct proportion and balanced quantity according to individual needs so that optimal health can be maintained
- ◇ Seven classes of food
 1. Carbohydrates
 2. Lipids
 3. Proteins
 4. Vitamins
 5. Mineral salts
 6. Fibre
 7. Water

Energy value of food (kJ g^{-1})

$$= \frac{\text{water mass (g)} \times 4.2 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1} \times \text{increase in water temperature (}^{\circ}\text{C)}}{\text{mass of food sample (g)} \times 1000}$$

The contents of vitamin C in fruit or vegetables juices

- ◇ The nutrient content in various types of food is different
- ◇ Therefore, vitamin C contents in each fruit and vegetable is different
- ◇ One of the factors that affect the loss of vitamin C content is temperature

ENERGY VALUE

- ⊕ Energy value is the total amount of energy released when one gram of food is oxidised completely
- ⊕ The energy value in food is measured in the form of heat energy, that is, in kilojoule per gram (kJ g^{-1})
- ⊕ Another unit of heat energy is calorie
- ⊕ 1 calorie or 4.2 joule is defined as the quantity of heat energy needed to raise the temperature of 1 gram water by 1 degree Celsius ($^{\circ}\text{C}$) at a pressure of 1 standard atmosphere
- ⊕ 1 calorie (cal) = 4.2 joule (J)
- ⊕ 1 kilojoule = 1 000 joule
- ⊕ $4.2 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1}$ refers to the specific heat capacity of water, that is, the energy required to increase the temperature of 1 g of water by 1°C

- ◇ Thus, fruit or vegetables must be kept at a suitable temperature range to preserve vitamin C

Diet modifications for specific individuals

- △ A balanced diet for each individual will vary according to lifestyle, health conditions and specific nutritional requirements

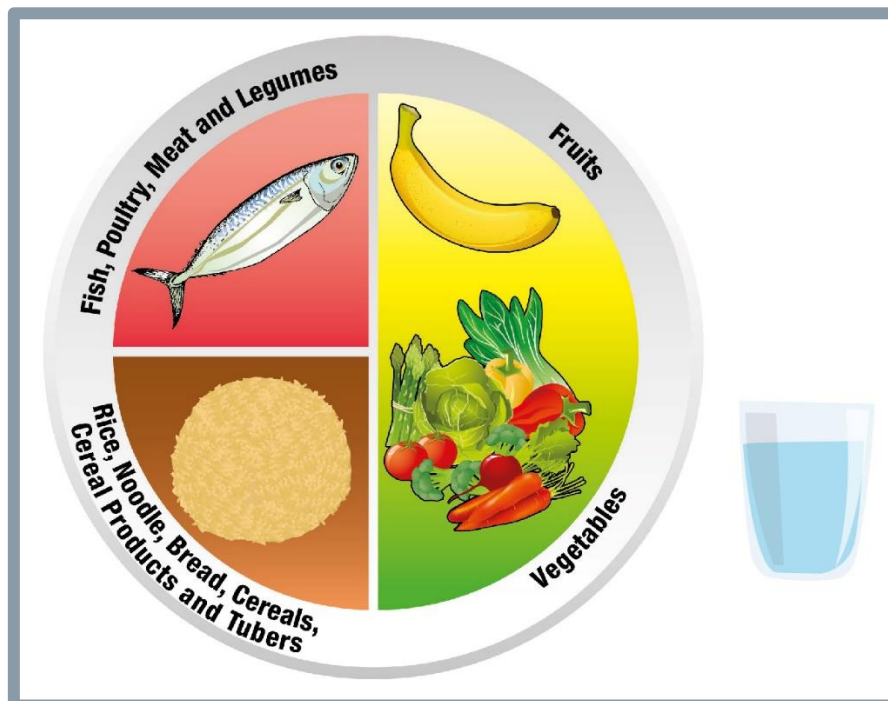
- Δ Each individual must take wise choices based on a nutrition guide
- Δ For example, suggestions for nutritional needs can be made based on *Pinggan Sihat Malaysia*
- Δ *Pinggan Sihat Malaysia* illustrates the relative quantity of various food classes in a balanced diet
- Δ Excessive food intake that is rich in saturated fats can cause health problems such as
 - Obesity
 - Cardiovascular disease
- Δ Cancer patients who are undergoing cancer treatment, need to modify their diet
 - To ensure they receive sufficient energy
 - To reduce the risk of infections
 - to enable quick recovery

THE CAUSE OF OBESITY

- » Obesity caused by the storage of excess of excess fats as a result of imbalanced food intake and use of energy

EFFECTS OF OBESITY

- ↳ Individuals who are obese need to reduce the intake of carbohydrates and fats as well as increase the intake of vegetables and fruits
- ↳ Otherwise, a diet excessive saturated fats and high cholesterol may cause diabetes mellitus and various cardiovascular diseases (atherosclerosis, hypertension) which may result in heart attacks (myocardial infarction) or stroke if not treated



CHAPTER 9.7 – HEALTH ISSUES RELATED TO THE DIGESTIVE SYSTEM AND EATING HABITS

Adaptation of digestive organs

- ✚ Obesity is a health issue on the rise throughout the world
- ✚ Although obesity can be controlled through diet management and routine exercise programmes, at time, obesity requires medical treatment
- ✚ Specialist doctors may suggest surgical procedures to reduce body weight such as gastric bypass
- ✚ A gastric bypass involves a reduction of the stomach size using various methods of surgery
- ✚ Among the short-term side effects of this surgery are
 - 1 Acid reflux
 - 2 Nausea
 - 3 Vomiting
 - 4 Expanded oesophagus
 - 5 Certain food prohibitions
 - 6 Risk of infection
- ✚ The long-term side effects are
 - i. Dizziness
 - ii. Low blood sugar level
 - iii. Malnutrition
 - iv. Stomach ulcer
 - v. Defaecation problems

Health issues related to defaecation

- ♥ The food class that is most important in the defaecation process is fibre. Intake of diet that is high in fibre such as fruits and vegetables can smoothen bowel movements
- ♥ This can prevent health problems such as constipation, colon cancer, rectum cancer and haemorrhoid
- ♥ Some of the functions of the fibre are
 - a. To stimulate peristalsis
 - b. To absorb and expel toxic substances
 - c. To regulate the absorption of glucose especially for diabetes mellitus patients
 - d. To increase the population of beneficial bacteria in the large intestine
- ♥ Besides, the intake of a large amount of water can ensure that the faeces stay soft and move easily along the large intestine to aid the process of defaecation

Health issues related to eating habits

GASTRITIS

- » Gastritis refers to the inflammation and corrosion of the stomach epithelial layer by gastric juice when there is no food in the stomach
- » Untreated gastritis can result in gastric juices
- » The causes of gastritis
 - I Eating irregular quantities of food at irregular hours
 - II Excessive intake of alcohol or painkillers

ANOREXIA NERVOSA

- ❖ Anorexia nervosa is quite common amongst teenage girls who are obsessed with their body weight
- ❖ Anorexics will avoid food to achieve their ideal body weight
- ❖ They also suffer from psychological problems and nutrient deficiency

because of their normal digestive system is affected

BULIMIA NERVOSA

- For people with bulimia nervosa who are also obsessed with controlling their body weight, they will eat a lot and vomit out the food that they have eaten or take laxatives that cause diarrhoea
- In the long run, the patient may suffer from dehydration, nutritional problems and eventually cardiovascular disease or kidney failure

MUSCLE DYSMORPHIA

- ⊞ Some individuals feel their size is small with not enough growth
- ⊞ So, they subject themselves to extreme weightlifting training or exercise
- ⊞ Sometimes, they consume steroids or muscle building supplements
- ⊞ This health issue called muscle dysmorphia

