- 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.

Starch + water $\xrightarrow{\text{Salivary amylase}}$ maltose

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 the 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 (Figure 9.2).

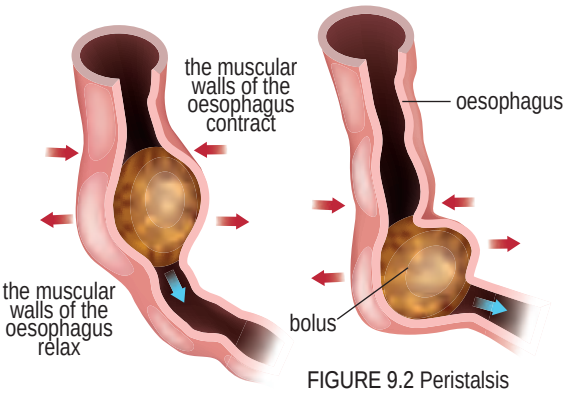


FIGURE 9.2 Peristalsis

Digestion of protein in the stomach

The surface of the stomach wall is lined with epithelial cells that have undergone adaptations in structure and function to form **gastric glands** (Figure 9.3). These epithelial cells are **chief cells**, **parietal cells** and **mucous cells**.

- Chief cells secrete **pepsinogen**.
- Parietal cells secrete **hydrochloric acid**.
- Mucous cells secrete **mucus**.

Brainstorm!

Chew slowly a small piece of bread. Observe the taste when you first started chewing and after a few minutes of chewing. Is there any difference in the taste of the bread?

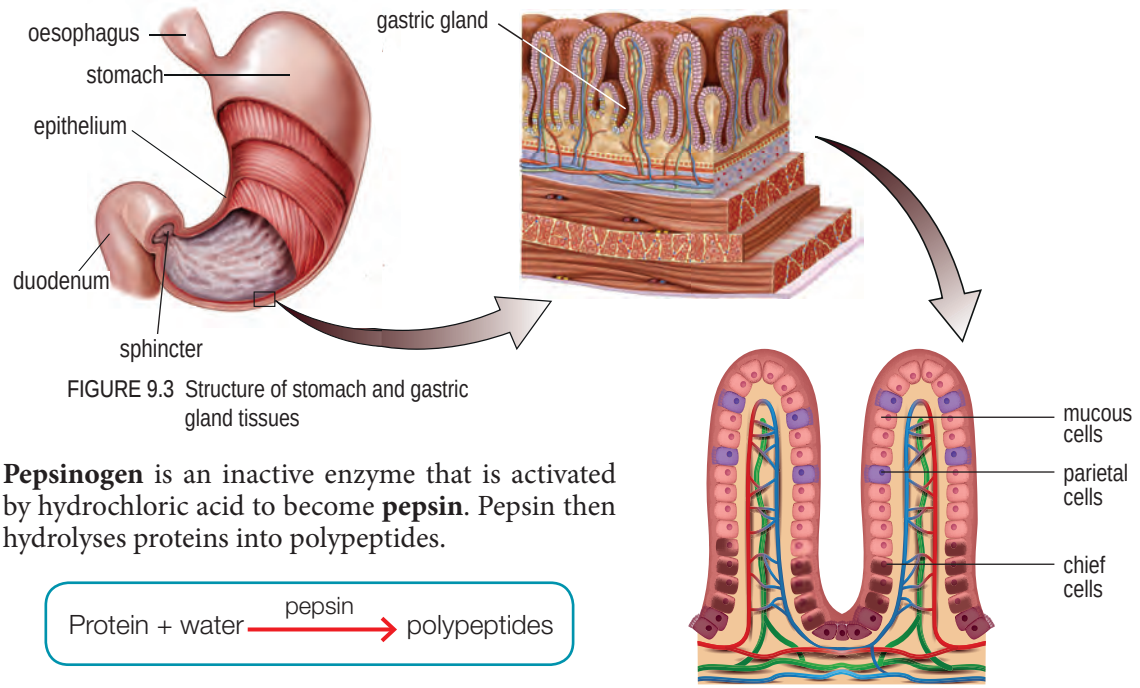


FIGURE 9.3 Structure of stomach and gastric gland tissues

Pepsinogen is an inactive enzyme that is activated by hydrochloric acid to become **pepsin**. Pepsin then hydrolyses proteins into polypeptides.

Protein + water $\xrightarrow{\text{pepsin}}$ polypeptides

9.2.3

The functions of hydrochloric acid are to:

(a) prepare a medium with a suitable pH (pH 1.5–2.0) for pepsin to act

(b) stop the enzymatic action of salivary amylase

(c) kill bacteria in food

The function of mucus is to protect the stomach wall from the reaction of hydrochloric acid and digestive enzymes.

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.

Digestions of carbohydrates, proteins and lipids in the small intestine

The small intestine consists of duodenum, jejunum and ileum. Duodenum is the first part of the small intestine which receives chyme from the stomach. Duodenum also receives **bile** produced by the **liver** and **pancreatic juice** secreted by the **pancreas** (Figure 9.4).

PANCREAS

The pancreas secretes **pancreatic amylase**, **trypsin** and **lipase** into the duodenum through the pancreatic duct.

LIVER

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

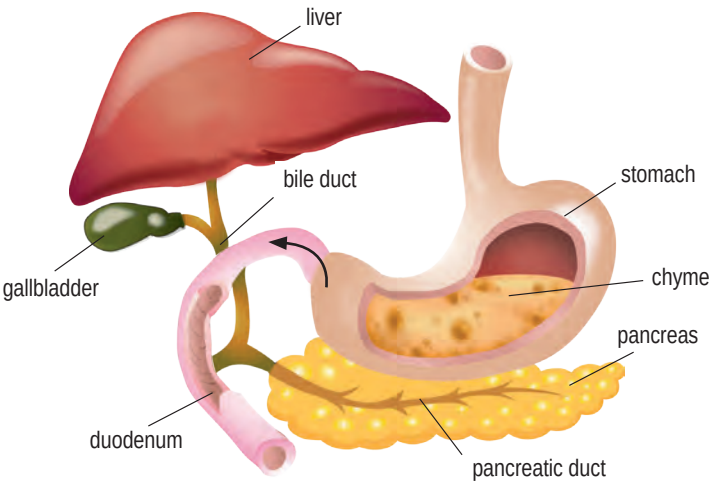


FIGURE 9.4 Components that are involved in digestion that take place in the small intestine

DUODENUM

- Pancreatic amylase hydrolyses starch to maltose
  Starch + water $\xrightarrow{\text{pancreatic amylase}}$ maltose
- Trypsin hydrolyses polypeptides into shorter peptides.
  Polypeptide + water $\xrightarrow{\text{trypsin}}$ peptides
- Lipase hydrolyses lipids into fatty acids and glycerols.
  Lipid + water $\xrightarrow{\text{lipase}}$ fatty acid and glycerol

Glands on the ileum wall secrete mucus and **intestinal juice** that contains **maltase**, **sucrase**, **lactase**, **lipase** and **erepsin**. The alkali medium in the ileum allows enzymes to act at its optimum.

CARBOHYDRATE DIGESTION

- **Maltase** hydrolyses **maltose** into glucose.
  Maltose + water $\xrightarrow{\text{maltase}}$ glucose
- **Sucrase** hydrolyses **sucrose** into glucose and fructose.
  Sucrose + water $\xrightarrow{\text{sucrase}}$ glucose + fructose
- **Lactase** hydrolyses **lactose** into glucose and galactose.
  Lactose + water $\xrightarrow{\text{lactase}}$ glucose + galactose

LIPID DIGESTION

Lipase hydrolyses lipids into **fatty acids** and **glycerols**.

Lipid + water $\xrightarrow{\text{lipase}}$ Fatty acids + glycerol

PROTEIN DIGESTION

Erepsin hydrolyses peptides into **amino acids**.

Peptides + water $\xrightarrow{\text{erepsin}}$ amino acids

ICT 9.1

Video: Processes of digestion, absorption and defaecation (Accessed on 21 August 2019)

Across the fields

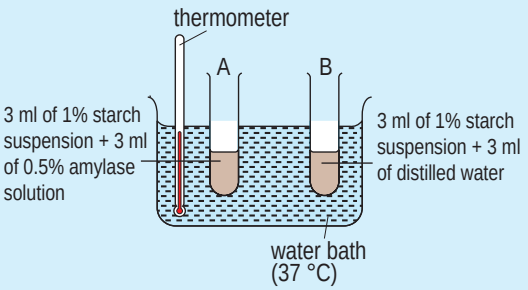
Chemical digestion involves enzyme-catalysed hydrolysis reaction. For example, an enzyme is needed in the decomposition of starch into glucose.

Activity 9.1 Studying the digestion of starch in a food sample

Experiment

Problem statement
What is the effect of amylase on starch?

Hypothesis
Amylase hydrolyses starch to a reducing sugar.



Variables
Manipulated: Presence of amylase
Responding: Presence of reducing sugar
Fixed: Temperature of water bath at 37 °C, concentration of starch suspension and volume of mixture

Materials
0.5% amylase solution, 1% starch suspension, iodine solution, Benedict's solution and distilled water

Apparatus
Tripod stand, Bunsen burner, wire gauze, 500 ml beaker, test tube holder, thermometer, stopwatch, test tube, dropper, glass rod and measuring cylinder

CHAPTER 9

Procedure

1. Label 2 test tubes as A and B.
2. Add 3 ml of 1% starch suspension to each test tube.
3. Fill test tube A with 3 ml of 0.5% amylase solution and test tube B with 3 ml of distilled water.
4. Soak both test tubes in a water bath with a temperature of 37 °C for 10 minutes.
5. After 10 minutes, remove 2 ml of the solution from test tube A and put it into a different test tube. Add 3 drops of Benedict's solution to that test tube and heat the test tube in a boiling water bath for 1 minute. Record the colour of the content.
6. Add 2 drops of iodine solution to the remainder of test tube A. Observe and record the colour of the contents.
7. Repeat steps 5 and 6 for test tube B.

Results

Test tube	Contents	Iodine test	Benedict's test
A	1% starch suspension + 0.5% amylase solution		
B	1% starch suspension + distilled water		

Discussion

1. Explain the reaction that occurs in test tube A.
2. What is the purpose of preparing test tube B?

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion for this experiment.

Activity 9.2 Studying digestion of protein in a food sample

Experiment

Problem statement

What is the effect of pepsin on protein?

Hypothesis

Pepsin hydrolyses proteins in the albumen suspension into polypeptides.

Variables

Manipulated: Presence of pepsin
Responding: Clarity or turbidity of mixture after 20 minutes.
Fixed: Temperature at 37°C, concentration of pepsin solution and dilute hydrochloric acid

Materials

Albumen suspension (egg white), 1% pepsin solution, distilled water and 0.1 M dilute hydrochloric acid

Apparatus

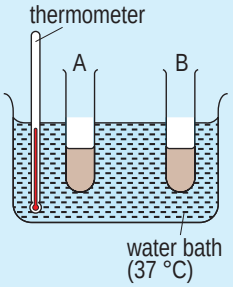
Test tube, measuring cylinder, 500 ml beaker, water bath at 37 °C, dropper, thermometer and stopwatch.

Procedure

1 Prepare an apparatus set-up as follows.

Test tube A: 5 ml of albumen suspension + 1 ml of 0.1 M hydrochloric acid + 1 ml 1% pepsin solution

Test tube B: 5 ml of albumen suspension + 1 ml of 0.1 M hydrochloric acid + 1 ml distilled water



2 Soak all test tubes in a water bath at 37 °C.

3 Observe the condition of mixtures in test tubes A and B at the beginning of the experiment and after 20 minutes.

Results

Test tube	Clarity or turbidity	
	0 minute	20 minute
A		
B		

Discussion

1 Explain the results achieved in test tube A and B.

2 What is the purpose of adding hydrochloric acid into each test tube?

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion for this experiment.

CHAPTER 9

Activity 9.3 Studying the digestion of lipids in a food sample

Experiment

Problem statement

What is the effect of lipase on lipid?

Hypothesis

Lipase hydrolyses lipids into fatty acids and glycerols.

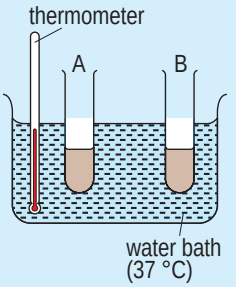
Variables

Manipulated: Presence of lipase
Responding: Time taken for the phenolphthalein indicator to turn from pink to colourless
Fixed: Temperature at 37°C, volume of cooking oil and combined volume

Materials

Cooking oil, 0.2 M sodium carbonate solution, dishwashing liquid, phenolphthalein indicator, distilled water and lipase

Apparatus
Two test tubes, test tube rack, water bath at 37 °C, 5 ml and 1 ml syringes, dropper, stopper and stopwatch

Procedure


1. Prepare two test tubes and label them as A and B.
2. Fill each test tube A and B with the following:
   - 2 ml of cooking oil
   - 1 ml of 0.2 M sodium carbonate solution
   - 1 ml of dishwashing liquid
3. Close both test tubes with stoppers. Shake both test tubes vigorously after adding the dishwashing liquid.
4. Add 3 drops of phenolphthalein indicator to each test tube and shake the test tube.
5. Add 1 ml of lipase into test tube A and 1 ml of distilled water into test tube B.
6. Soak both test tubes in a water bath at 37°C.
7. Record the time taken for the phenolphthalein indicator to turn from pink to colourless.

Results

Test tube	Contents	Time taken for the phenolphthalein indicator to turn from pink to colourless (minute)
A	1 ml of lipase	
B	1 ml of distilled water	

Discussion
1. Why is a phenolphthalein indicator used in this experiment?
2. What is the purpose of adding dishwashing liquid into each test tube?
3. Explain the reaction that happens in test tube A.
4. Explain the results obtained in test tube B.

Conclusion
Is the hypothesis accepted? State the suitable conclusion for this experiment.

Formative Practice 9.1

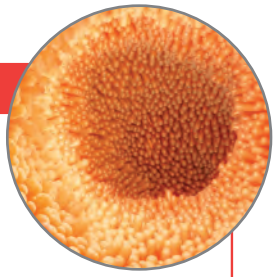
1. Explain the importance of the digestion process for humans.
2. Name the structures in the alimentary canal that are involved in food digestion.
3. Name the main cells in the gastric glands and explain the functions of these cells.
4. The small intestine secretes a few types of enzymes to complete the digestion process. Explain how these enzymes complete the digestion process.

9.3 Absorption

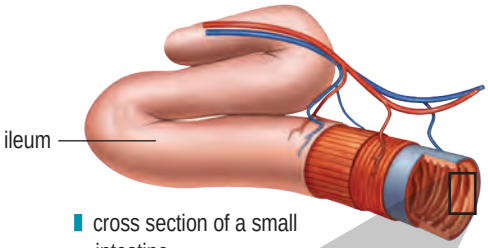
The adaptations of ileum and villus in the absorption of digested food

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

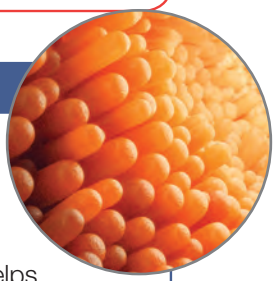
ILEUM



The long ileum is adapted to absorb nutrients because its internal layer is folded and covered by tiny projections called **villi** (singular: villus) (Figure 9.5).

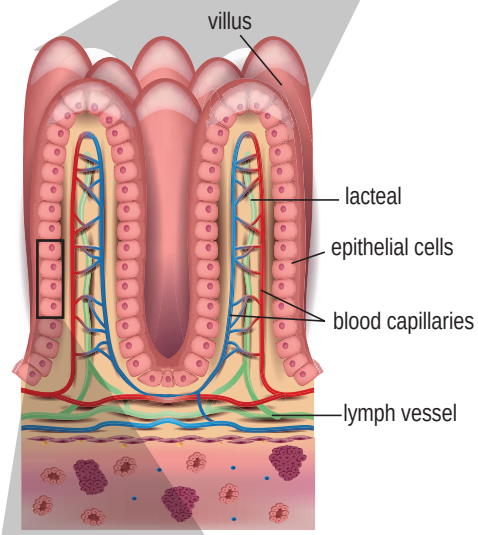


VILLUS (PLURAL: VILLI)

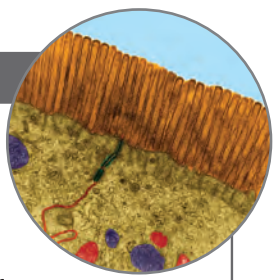


Villus has the following adaptations to absorb nutrients (Figure 9.5):

- The **epithelial layer** of the villus is one cell thick. This 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 (Figure 9.5).

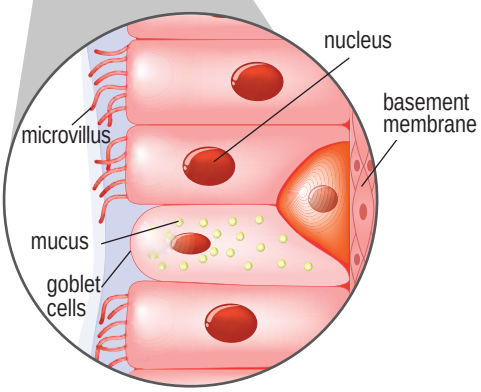


FIGURE 9.5 Adaptations of ileum and villi to absorb digested food.

9.3.1 9.3.2

CHAPTER 9

Absorption of digested food is summarised in Figure 9.6 and Table 9.1.

ICT 9.2

Video: View inside the small intestine (Accessed on 21 August 2019)

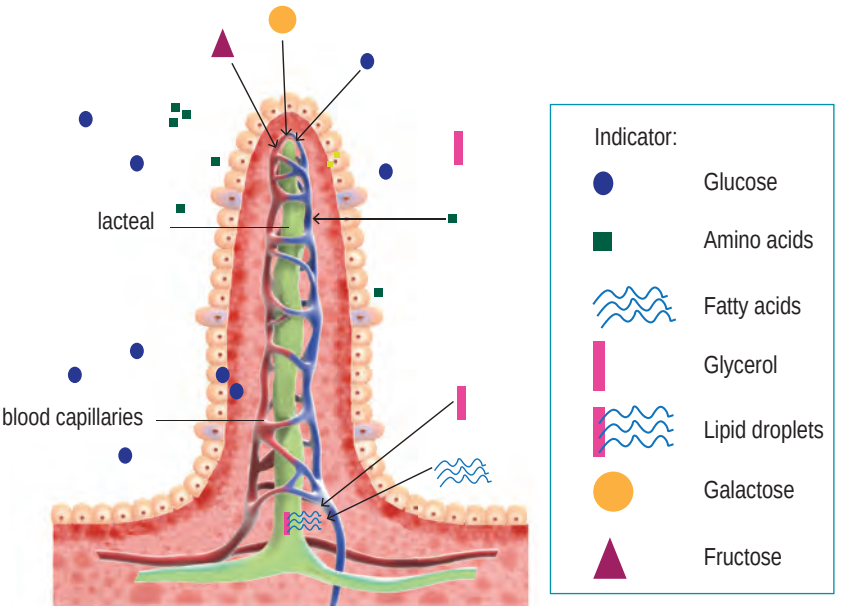


FIGURE 9.6 Absorption of digested food

Millennial Career

A gastroenterologist is a medical specialist who specialises in the human digestive system.

Activity Zone

Gather information about the absorption of alcohol and drugs.

TABLE 9.1 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
Vitamins A, D, E, K dissolve in the lipid		Simple diffusion

Formative Practice 9.2

1 Name the main structures for the absorption of digested food.

2 Name the structure in the villus involved in the transporting of the following nutrients:

(a) amino acids

(b) vitamins A and E

3 Explain the adaptations of the small intestine to increase the surface area for absorption of nutrients.

4 Explain how the following substances can be transported across the plasma membrane.

(a) Glucose, galactose and amino acids

(b) Fatty acids and glycerol

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.

Biological Lens

Liver cirrhosis is a type of liver disease caused by factors such as alcoholic drinks, toxic substances and 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 (Photograph 9.1).

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. The liver carries out the following functions.

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

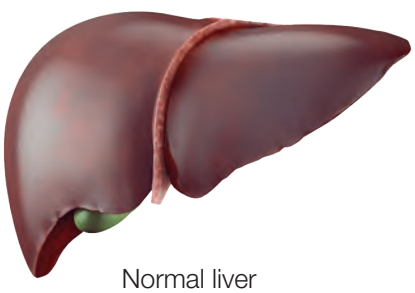
- Liver cells expel toxic substances from the blood.
- Toxic substances are expelled through the urine.

STORAGE OF NUTRIENTS

Excess glucose is converted to glycogen to be stored.

Activity Zone

Conduct a research on the various functions of the liver and produce a scrap book



Normal liver

Liver of a cirrhosis patient

PHOTOGRAPH 9.1 Normal liver and liver of a cirrhosis patient

9.4.1 9.4.2

ASSIMILATION PROCESS IN THE LIVER

AMINO ACIDS

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

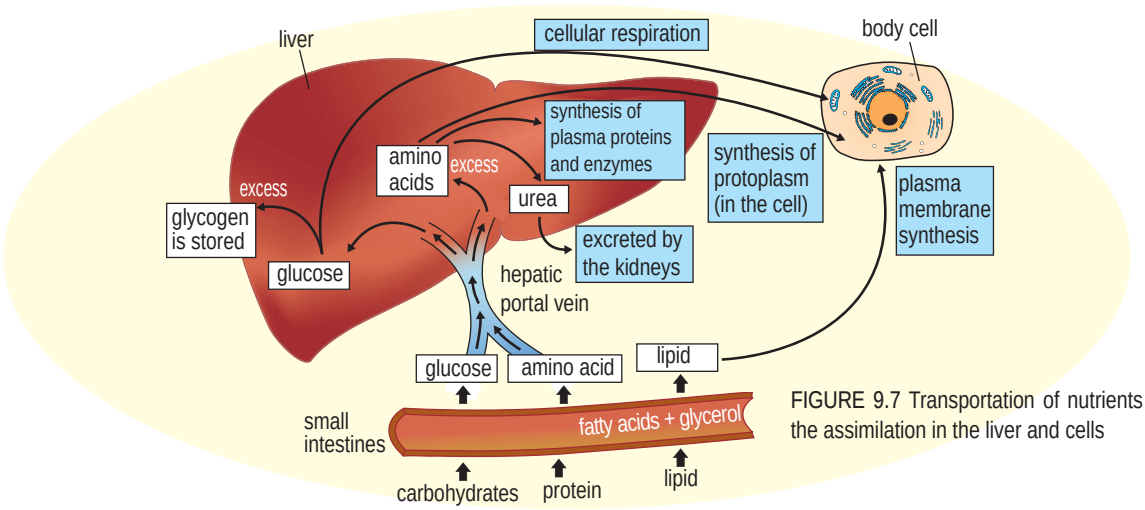


FIGURE 9.7 Transportation of nutrients and the assimilation in the liver and cells

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.

Formative Practice 9.3

1 State the meaning of assimilation.

2 Explain the functions of the liver in the assimilation of digested food.

9.5 Defaecation

Functions of the large intestine

After the absorption of nutrients is completed in the ileum, undigested food, dead cells, epithelial cells, 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:

- absorption of water and vitamins
- formation of faeces

Biological Lens

The large intestine has a huge population of bacteria. There are more than 1000 different species of bacteria in the large intestine and a healthy balance between beneficial and less beneficial bacteria is very important for health and a stable environment in the alimentary canal.

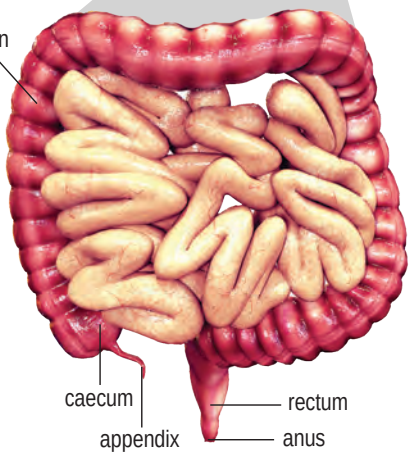


FIGURE 9.8 Large intestines

ABSORPTION OF WATER AND VITAMINS

Substances absorbed are

- water and mineral salts
- metabolic byproducts of some bacteria such as vitamin B, vitamin K and 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 bile pigments, bacteria and 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. This process is called **defaecation**.

Brainstorm!

What is the effect of antibiotics on the large intestine's bacterial population?

Formative Practice 9.4

1 State the main function of the large intestine.

2 What are the substances absorbed in the large intestine?

3 Explain the importance of water absorption and vitamins in the large intestine.

4 Explain the formation process of faeces.

9.6 Balanced Diet

Energy value in a food sample

A balanced diet refers to a diet that consists of all seven food classes (carbohydrates, lipids, proteins, vitamins, mineral salts, fibre and water) in the correct proportion and balanced quantity according to individual needs so that optimal health can be maintained.

Biological Lens

1 calorie (cal) = 4.2 joule (J)

1 kilojoule = 1000 joule

Across the fields

4.2 J g^{-1} $°C^{-1}$ 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.

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 (°C) at a pressure of 1 standard atmosphere.
- Energy value of food (kJ g^{-1})

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

Activity 9.4 Studying the energy value of food samples — Experiment

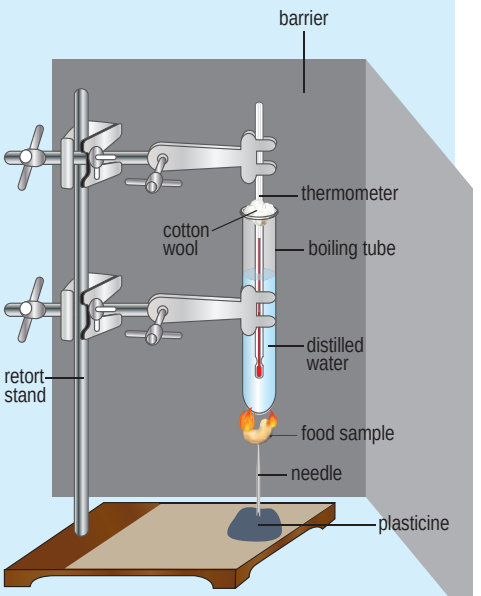
Problem statement
Which food sample has the highest energy value?

Hypothesis
Groundnuts have a higher energy value compared to cashew nuts.

Variables
Manipulated: Types of food samples
Responding: Energy value of food sample
Fixed: Water mass

Materials
Distilled water, food samples (cashew nuts and groundnuts), cotton wool and plasticine

Apparatus
Retort stand with a clamp, thermometer, boiling tube, long needle, electronic weighing scale, barrier, measuring cylinder and Bunsen burner



Procedure

1. Weigh a cashew nut using an electronic weighing scale and record its mass.
2. Measure 20 ml of distilled water using a measuring cylinder and pour it into a boiling tube.
3. Clamp the boiling tube to the retort stand and put in the thermometer.
4. Fix the position of the thermometer using cotton wool.
5. Record the initial temperature of the distilled water.
6. Stick the cashew nut on the needle and hold the needle upright using plasticine.
7. Place the barrier around the apparatus set-up.
8. Light the cashew nut using a Bunsen burner and place it below the boiling tube.
9. Stir the water in the boiling tube slowly and record its highest temperature after the cashew nut has completely burned.
10. Replace the water in the boiling tube.
11. Repeat steps 1 to 9 using groundnuts.
12. Calculate the energy value for each food sample using the following formula:

$$\text{Energy value of food (kJ g}^{-1}\text{)} = \frac{\text{Water mass (g)} \times 4.2\ \text{J g}^{-1}\ ^\circ\text{C}^{-1} \times \text{Increase in water temperature (°C)}}{\text{Food sample mass (g)} \times 1000}$$

13. Record your results in the table below.

Results

Food sample	Food sample mass (g)	Initial temperature of water (°C)	Final temperature of water (°C)	Increase of Temperature (°C)	Energy value of food (kJ g^{-1})
Cashew nuts					
Groundnuts					

Discussion

1. Which food sample shows the highest energy value?
2. State two precautionary steps for this experiment.
3. Compare the energy value of food samples obtained from this experiment with their theoretical energy values. Are there any differences? If yes, explain why.

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion for this experiment.

The contents of vitamin C in fruit or vegetables juices

The nutrient content in various types of food is different. For example, the vitamin C content in fruits and vegetables are different.

Activity 9.5 Determining the contents of vitamin C in fruit juice and vegetable juice.

Experiment

Problem statement
Which fruit juice or vegetable juice has the highest content of vitamin C?

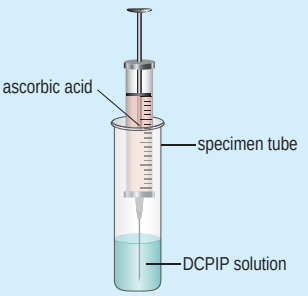
Hypothesis
Orange juice has the highest content of vitamin C compared to lime juice and carrot juice.

Variables
Manipulated: Types of fruit and vegetable juices
Response: Volume of fruit juice or vegetable juice needed to decolourise DCPIP solution
Fixed: Concentration of DCPIP solution and concentration of an ascorbic acid solution

Materials
Orange juice, lime juice and fresh carrot juice, 0.1% ascorbic acid solution, 1% DCPIP solution and distilled water

Apparatus
Syringe needles (1 ml and 5 ml), knife, 50 ml beaker, specimen tube, juicer and sieve

Procedure
1 Put 1 ml of 1% DCPIP solution in a specimen tube.
2 Fill the 5 ml syringe needle with a 0.1% ascorbic acid solution. Ensure that there are no air bubbles trapped in it.
3 Insert the tip of the syringe needle into the specimen tube and drip ascorbic acid drop by drop into the DCPIP solution while stirring slowly until the blue colour of the DCPIP solution is decolourised.
4 Record the volume of the 0.1% ascorbic acid solution needed to decolourise the blue colour of the DCPIP solution.
5 Repeat steps 1 to 4 twice to get the average volume for each different juice.



6 Record the volume of each juice in the table below.
7 Calculate the concentration of vitamin C of each juice using the following formula.

$$\text{Percentage of vitamin C} = \frac{\text{volume of ascorbic acid solution}}{\text{volume of juice used}} \times 0.1\%$$

$$\text{Vitamin C concentration (mg ml}^{-1}\text{)} = \frac{\text{volume of ascorbic acid solution}}{\text{volume of juice used}} \times 1.0\%$$

Results

Solution / Juice	Volume of solution/juice required to decolourise DCPIP solution (ml)				Vitamin C concentration (%)	Vitamin C concentration (mg ml^{-1})
	1	2	3	Average		
0.1% ascorbic acid solution						0.1
Orange juice						
Lime juice						
Carrot juice						

Discussion

1 Which juice has the highest content of vitamin C?

2 Why is a 0.1% ascorbic acid solution used as the standard?

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion for this experiment.

One of the factors that affect the loss of vitamin C content is temperature. Therefore, fruit or vegetables must be kept at a suitable temperature range to preserve vitamin C.

Activity 9.6 Studying the effect of temperature on vitamin C in orange juice

Experiment

Problem statement

What is the most suitable ambient temperature to keep orange juice?

Hypothesis

Orange juice stored at a low ambient temperature has the highest content of vitamin C.

Variables

Manipulated: Ambient temperature
Responding: Volume of orange juice required to decolourise DCPIP solution
Fixed: Volume of DCPIP solution

Take Note!

Ensure that the juice is not exposed too long to avoid oxidation.

Materials

Oranges, 1% DCPIP solution and ice

Apparatus

Specimen tube, knife, syringe needles (1 ml and 5 ml), beakers (50 ml and 100 ml), Bunsen burner, tripod stand, sieve and wire gauze

Procedure

1 Prepare 60 ml of orange juice.

2 Label the beakers A, B and C. Pour 20 ml of orange juice into each beaker.

3 Soak beaker A in ice, leave beaker B at room temperature and soak beaker C in boiling water for 30 minutes.

4 After 30 minutes, determine the vitamin C content in the orange juice as shown in Activity 9.5.

5 Calculate the concentration of vitamin C in the orange juice at each different temperature.

Results

Record your results in an appropriate table.

Discussion

1 Is there a difference in the vitamin C content for the juice at different temperatures?
2 What is the effect of temperature on vitamin C in the orange juice?
3 Based on the results, suggest the best way to ensure that you get a high content of vitamin C from fruit juice or vegetable juice.

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion for this experiment.

PHOTOGRAPH 9.2
A sample serving based on *Pinggan Sihat Malaysia*

Diet modifications for specific individuals

A balanced diet for each individual will vary according to lifestyle, health conditions and specific nutritional requirements. Each individual must make wise choices based on a nutrition guide. For example, suggestions for nutritional needs can be made based on ***Pinggan Sihat Malaysia***. *Pinggan Sihat Malaysia* illustrates the relative quantity of various food classes in a balanced diet (Photograph 9.2).

Excessive food intake that is rich in saturated fats can cause health problems such as obesity and cardiovascular diseases.

The cause of obesity

Obesity is caused by the storage 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 with excessive saturated fats and high cholesterol may cause diabetes mellitus and various cardiovascular diseases such as atherosclerosis and hypertension which may result in heart attacks (myocardial infarction) or stroke if not treated.

Millennial Career

Nutritionists are specialists in the field of nutrition who advise specific individuals on suitable diets.

Activity Zone

Plan meals based on *Pinggan Sihat Malaysia* for different individuals such as obese individuals, cancer patients and heart patients.

Cancer patients who are undergoing cancer treatment, need to modify their diet to ensure they receive sufficient energy, reduce the risk of infections and enable quick recovery.

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 times, obesity requires medical treatment. Specialist doctors may suggest surgical procedures to reduce body weight such as **gastric bypass** (Figure 9.9). 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 acid reflux, nausea, vomiting, expanded oesophagus, certain food prohibitions and risk of infection. The long-term side effects are dizziness, low blood sugar level, malnutrition, stomach ulcer and defaecation problems.

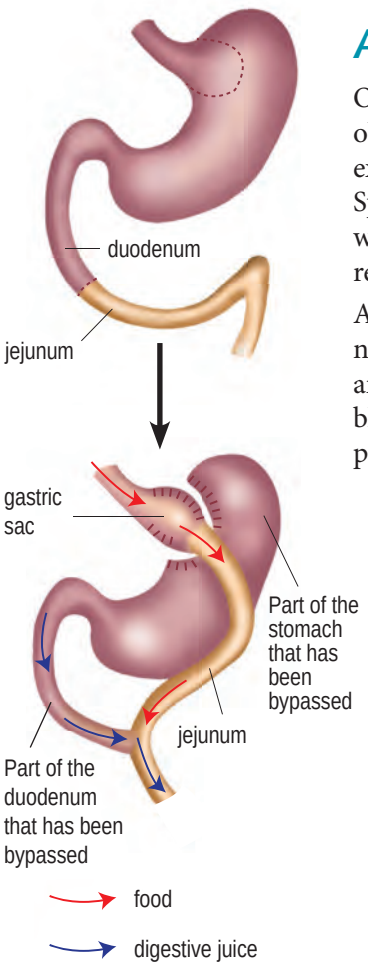


FIGURE 9.9 Gastric bypass

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 fibre are to:

- stimulate peristalsis
- absorb and expel toxic substances
- regulate the absorption of glucose especially for diabetes mellitus patients
- 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

Apart from a balanced diet, eating habits also play an important role in fulfilling our energy requirements and maintaining our health. Poor eating habits and an imbalanced diet can cause numerous health problems such as gastritis, muscle dysmorphia, anorexia nervosa and bulimia nervosa.

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 ulcers. The causes of gastritis include eating irregular quantities of food at irregular hours and excessive intake of alcohol or painkillers.

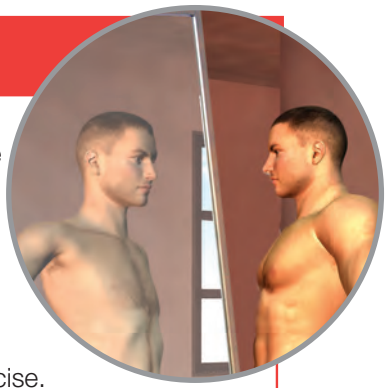
ANOREXIA NERVOSA

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 that their size is small with not enough growth. So, they subject themselves to extreme weightlifting training and exercise. Sometimes, they consume steroids or muscle building supplements. This health issue is called **muscle dysmorphia**.

Activity Zone

Do a case study about the following health issues related eating habits:

- diabetes type 2
- obesity
- acid reflux
- pica

Formative Practice 9.5

1 In your opinion, why is fibre important in the defaecation process. Explain your answer.

2 Predict the effect of modifying digestive organs such as gastric bypass on human health.

Summary

NUTRITION AND THE HUMAN DIGESTIVE SYSTEM

Digestive System

- Digestion
- Absorption
- Assimilation
- Defaecation

Balanced Diet

- Energy value
- Contents of vitamin C in fruit or vegetables juices
- Diet modifications for specific individuals

Health Issues Related to the Digestive System and Eating Habits

- The effects of modifying digestive organs on human health
- Health issues related to defaecation
- Health issues related to eating habits

Self Reflection

Have you mastered the following important concepts?

- Structure of the human digestive system
- Mechanism of digestion
- Process and products of carbohydrate digestion in the mouth
- Process and products of protein digestion in the stomach
- Digestions of carbohydrates, proteins and lipids in the small intestine
- Adaptations of ileum and villus in the absorption of digested food
- Assimilation of digested food and liver functions
- Defaecation
- Balanced diet and energy value in food samples
- Diet modifications for specific individuals
- Health issues related to the digestive system and eating habits

Summative Practice 9

1 Some people cannot drink milk because it causes diarrhoea and a bloated stomach. Explain why.

2 Amin had some meat dishes for lunch. Explain how the protein is digested in Amin's stomach.

3 An individual has the following eating habits:

> Overeating in a short period of time followed by intentional throwing up on purpose after each meal.

Explain how this eating habit can affect the health of this individual.

4 Figure 1 shows the alimentary canal in humans.

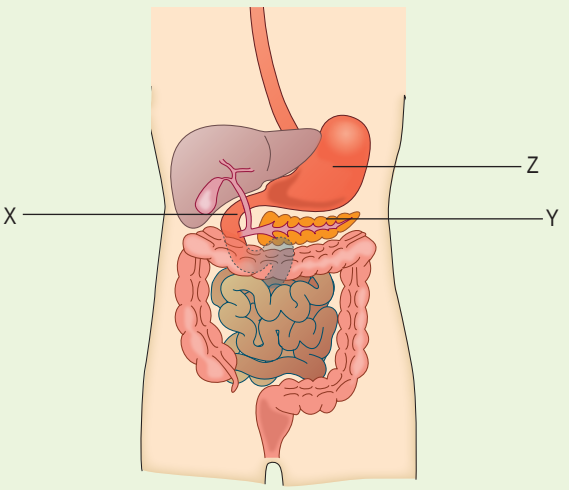


FIGURE 1

(a) Name structures X and Y.

(b) (i) The enzymes in X are only effective in an alkaline environment. Explain how an alkaline environment is maintained in X.

(ii) Explain how Y is involved in the digestion of carbohydrates in X.

(c) Name the enzyme found in Z. Explain how this enzyme functions in the digestion of proteins.

(d) A student enjoys eating a lot of oranges. Explain the effect of eating too many oranges on the digestion of starch in X.

Essay Questions

5 Explain the processes that fat molecules undergo starting from the duodenum until it is finally used by body cells.

6 A teenager had the following for his breakfast.

Buttered bread – 2 pieces	Fresh milk – 1 glass
Hard-boiled eggs – 2	Apple – 1

Explain what happens to the final digested products of his breakfast in his body cells.

7 (a) Explain why a diet rich in fats is not good for health.

(b) Suggest suitable types of food for someone who wants to reduce weight and reduce the risk of contracting cardiovascular disease. Explain your answer.

(c) Explain the processes of starch digestion, absorption and assimilation in the human body.

Enrichment

8 Medicines in the form of capsules are not broken down in the stomach but absorbed easily by the small intestine. When the blood sample of the patient is taken and analysed, it is found that the molecular structure of this medicine is different from its original molecular structure. Explain why.

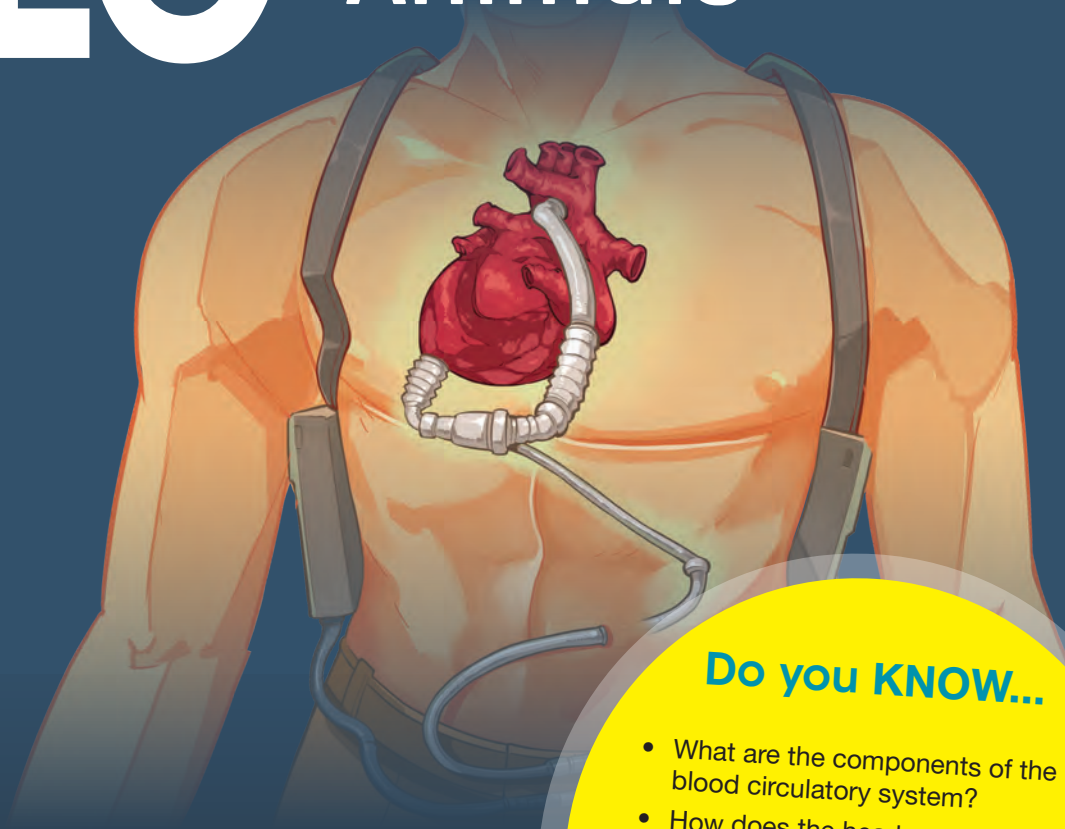
9 How are drinks with added artificial sweeteners produced and marketed?

10 Nowadays, many individuals prefer ready-to-eat or frozen food products due to their busy lifestyles. Predict the health risks that may arise if these foods are taken continuously for a long period of time and in large quantities.

Complete answers are available by scanning the QR code provided

CHAPTER

10 Transport in Humans and Animals



What is a mechanical heart?

Do you KNOW...

- What are the components of the blood circulatory system?
- How does the heart pump blood?
- How does the lymphatic system return tissue fluids into the blood circulatory system?
- What are the health issues related to the human circulatory and lymphatic systems?

10.1 Types of Circulatory System

10.1.1 Justify the necessity of transport systems in complex multicellular organisms.

10.1.2 Identify substances that are transported by the transport system: • substances required by a cell • waste products of a cell

10.1.3 Conceptualise types of circulatory system in complex multicellular organisms.
- open circulatory system
- closed circulatory system

10.1.4 Compare and contrast circulatory systems in complex multicellular organisms: • insects • fish • amphibians • humans

10.2 Circulatory System of Humans

10.2.1 Describe components of the human circulatory system: • heart • blood vessel • blood

10.2.2 Explain the composition of blood: • blood plasma • blood cells

10.2.3 Compare and contrast the types of blood vessels: • artery • vein • capillary

10.2.4 Label the structure of a human heart and associated blood vessels: • aorta • vena cava • pulmonary artery and pulmonary vein • coronary artery and coronary vein. • semilunar valve • bicuspid valve and tricuspid valve • septum

10.2.5 Describe the functions of parts of the heart.

10.3 Mechanism of Heartbeat

10.3.1 Describe the human heartbeat mechanism: • sinoatrial node (pacemaker) • atrioventricular node • bundle of His • Purkinje fibres

10.3.2 Communicate about forces that cause the blood to circulate in humans: • pumping of the heart • contraction of skeletal muscles

10.4 Mechanism of Blood Clotting

10.4.1 Justify the necessity for blood clotting mechanism.

10.4.2 Describe blood clotting mechanism.

10.4.3 Describe health issues related to blood clotting: • thrombosis • embolism • haemophilia

10.5 Blood Groups of Humans

10.5.1 Describe ABO blood group.

10.5.2 Correlate ABO blood group with blood donation.

10.5.3 Describe the Rhesus factor.

10.5.4 Reason out the incompatibility of Rhesus factor in pregnancies.

10.6 Health Issues Related to the Human Circulatory System

10.6.1 Justify the necessity for a healthy circulatory system.

10.6.2 Communicate about cardiovascular diseases.

10.7 Lymphatic System of Humans

10.7.1 Synthesise the process of formation of tissue fluid and lymph.

10.7.2 Compare and contrast the contents of lymph and: • tissue fluid • blood

10.7.3 Describe components of the lymphatic system: • lymph • lymphatic capillaries • lymphatic vessels• lymph nodes • lymphatic organs

10.7.4 Justify the necessity of the lymphatic system:
- complements the blood circulatory system
- transports lipid-soluble substances
- body defence

10.8 Health Issues Related to the Human Lymphatic System

10.8.1 Describe health issues related to the lymphatic system.

10.1 Types of Circulatory System

The necessity for transport systems in complex multicellular organisms

Each living cell requires **essential substances** such as oxygen and nutrients, and expels **cellular waste products** such as carbon dioxide and nitrogenous wastes.

In Chapter 2, you learned how unicellular organisms such as *Amoeba* sp. get their essentials and expel wastes by diffusion from and to its external surroundings. Unicellular organisms have a small body mass. Therefore, the total surface area to volume ratio (TSA/V) of the organism is large. As such, *Amoeba* sp. does not require a specialised transport system to transport substances in and out of the cell.

What about multicellular organisms? Can multicellular organisms obtain all essential substances and expel wastes by simple diffusion like unicellular organisms?

Substance exchange can occur by diffusion because the cells are in the environment.

Large complex multicellular organisms cannot obtain essential substances and expel wastes by diffusion because their TSA/V is small. The distance between the external environment and the cell is too far for direct substance exchange. So, how do complex multicellular organisms get essential substances for their cells?

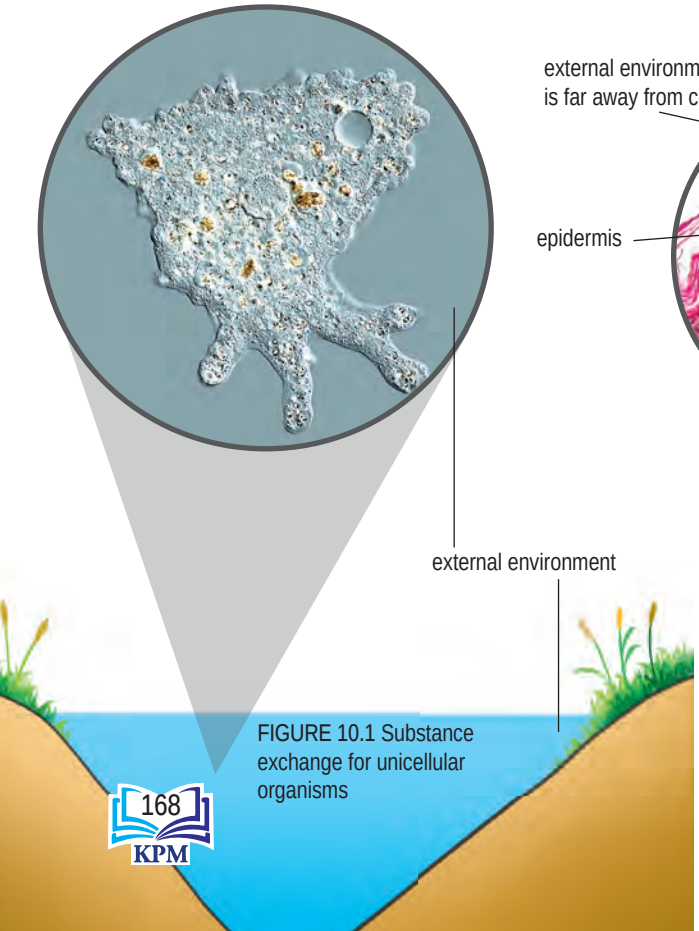
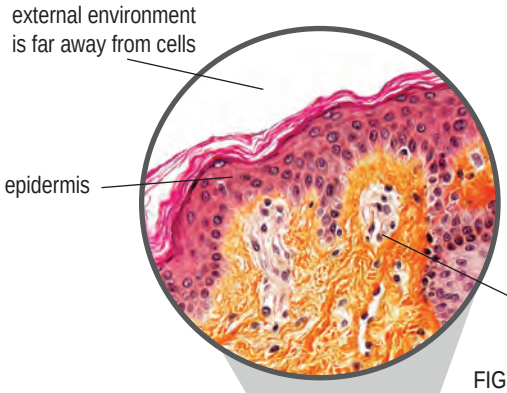


FIGURE 10.1 Substance exchange for unicellular organisms



Substance exchange cannot occur by diffusion because the cells are too far away from the environment.

FIGURE 10.2 Substance exchange for multicellular organisms

10.1.1 10.1.2

To address this problem, multicellular organisms have an internal **transportation system**. In vertebrates, the transportation system is called the **blood circulatory system**.

Before studying further the blood circulatory system, conduct an experiment to study the effects of changes in TSA/V on the diffusion rate.

ICT 10.1

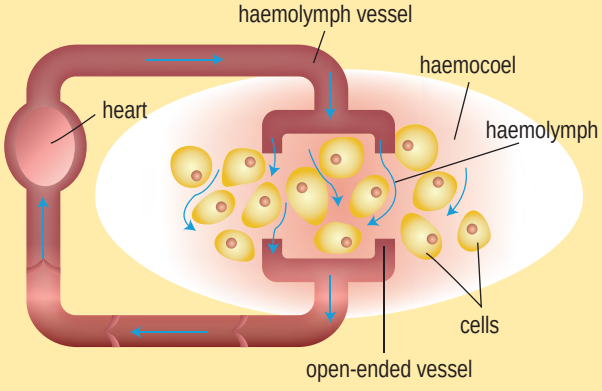
Activity: Studying the effects of changes in total surface area to volume ratio (TSA/V) on the diffusion rate.

Types of circulatory systems in multicellular organisms

The circulatory system in multicellular organisms is divided into two types: **open circulatory system** and **closed circulatory system**.

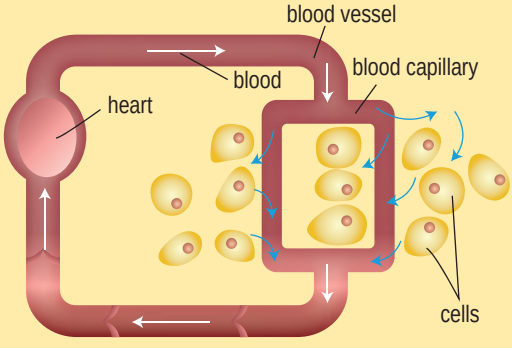
OPEN CIRCULATORY SYSTEM

- In an open circulatory system, haemolymph flows directly into the body cavity (**haemocoel**) and bathes the cells.
- **Haemolymph** is a blood-like nutritious liquid found in most invertebrates such as insects and molluscs.



CLOSED CIRCULATORY SYSTEM

- In a closed circulatory system, blood is always contained in a continuous closed blood vessel and is distributed to the whole body.
- The exchange of substances that are essential to cells such as oxygen and nutrients occurs across the walls of blood capillaries.



CHAPTER 10