Cambridge OL

Biology

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Chapter 07 and chapter 08

Transport in flowering plants and human nutrition

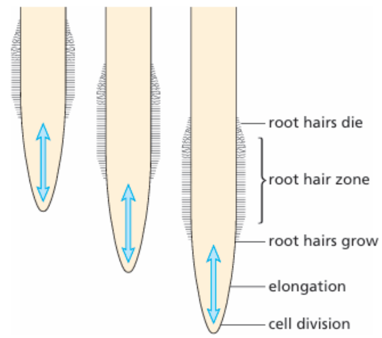
Water uptake

Root hair cells

In a region above the root tip, where the root has just stopped growing, the cells of the outer layer produce tiny, tube-like outgrowths called root hairs (Figure 7.3). These look like a white furry layer on the roots of seedlings if you grow them in moist air (Figure 7.1).

▲ **Figure 7.1** Root hairs (×5) as they appear on a root grown in moist air

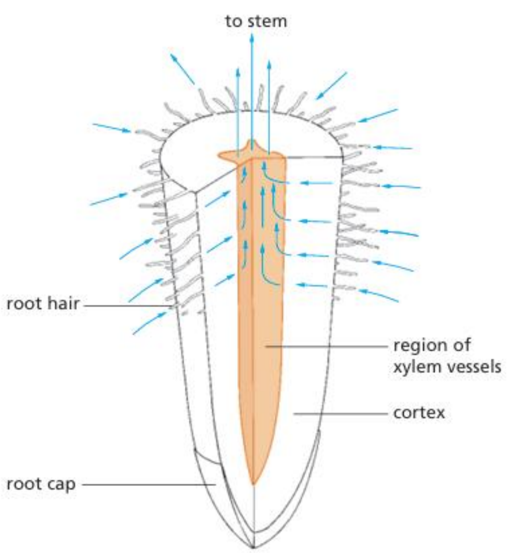
Above the root hair zone, the cell walls of the outer layer become less permeable. This means that water cannot get in so easily.



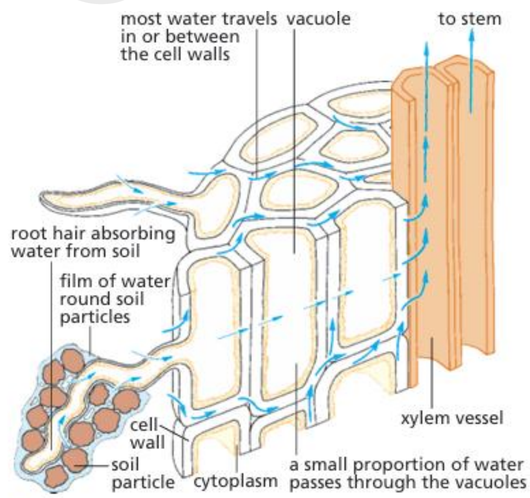
▲ **Figure 7.2** The root hair zone changes as the root grows

Uptake and transport of water and ions

Rapid transpiration in plants causes water to move through the root, entering root hair cells, root cortex, xylem vessels, stem, and leaves. The water may pass through cell walls rather than cytoplasm and is likely easier to pass through the xylem than through the cytoplasm.



▲ **Figure 7.4** Diagrammatic section of root to show passage of water from the soil



▲ **Figure 7.3** The likely pathways of water through a root

Stem and root structure

Stem

In Figure 7.6 a stem is shown cut across (transversely) and down its length (longitudinally) to show its internal structure.

Epidermis

Like the leaf epidermis, this is a single layer of cells that helps to keep the shape of the stem and cuts down the loss of water vapour. There are stomata in the epidermis, which allow the tissues inside to take up oxygen and get rid of carbon dioxide.

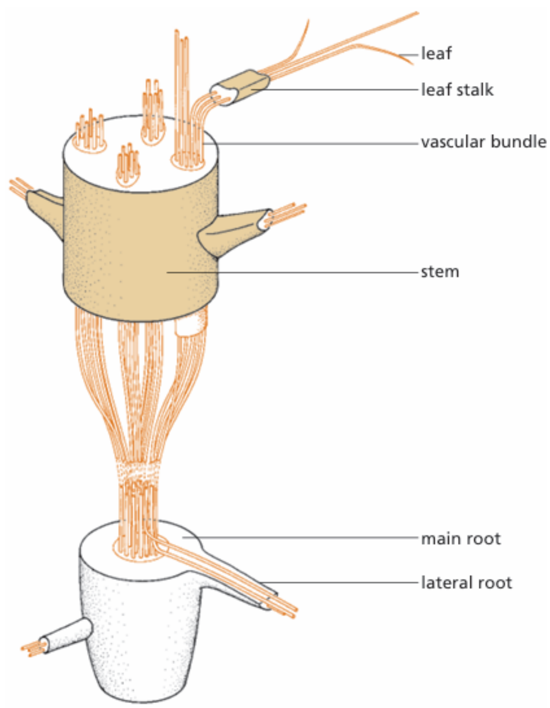
Vascular bundles

These are made up of groups of specialised cells that carry water, dissolved mineral salts and food up or down the stem. The vascular bundles in the roots, stem, leaf stalks and leaf veins all join to form a transport system through the whole plant (Figure 7.7).

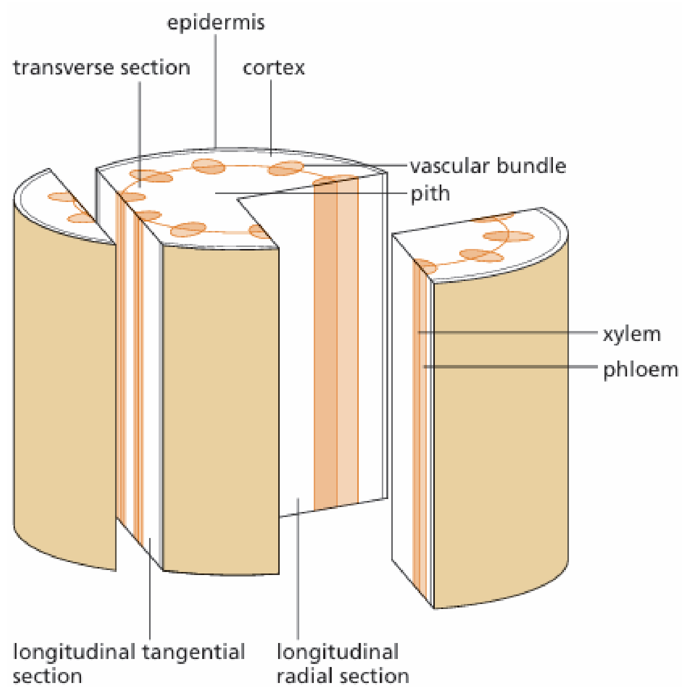
The two main tissues in the vascular bundles are called xylem and phloem (Figure 7.8).

Vessels

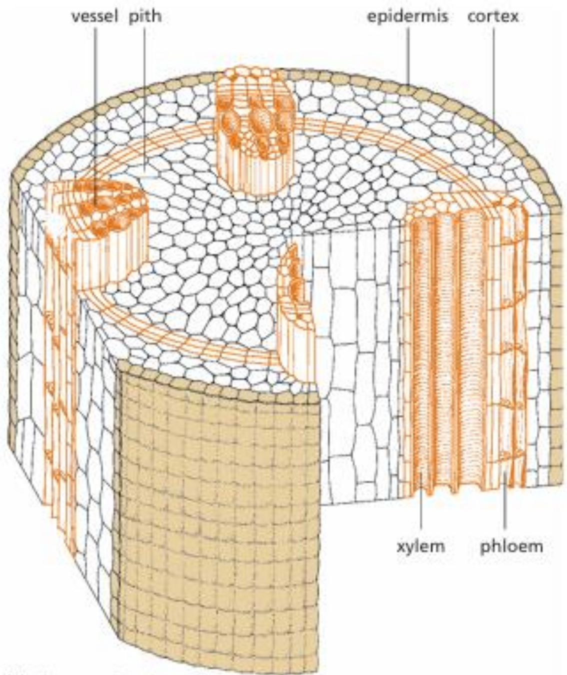
The cells in the xylem that carry water become vessels. A vessel is made up of a series of long cells joined end to end (Figure 7.9). A vessel is hollow and has no cell contents. Once a region of the plant has stopped growing, the end walls of these cells are digested away to form a long, continuous tube (Figure 7.8(c)).



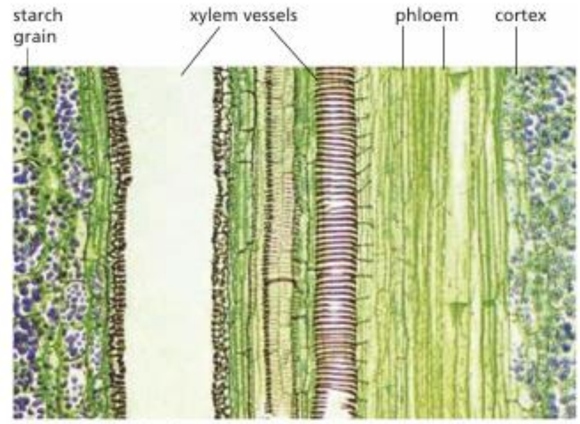
▲ **Figure 7.7** Distribution of veins from root to leaf



▲ **Figure 7.6** Structure of a plant stem



(a) diagram showing cells

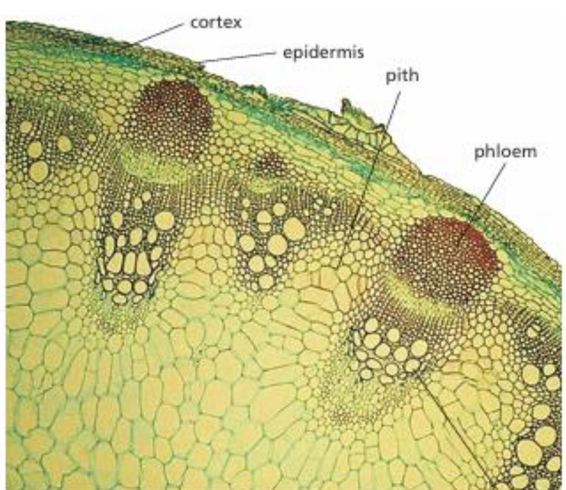


(c) longitudinal section through sunflower stem (x200)

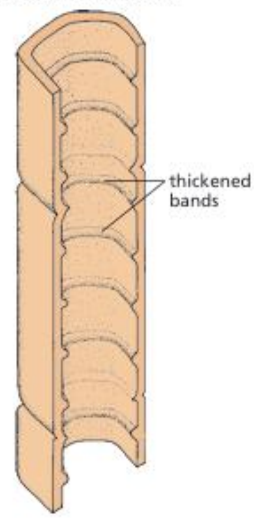
▲ **Figure 7.8** Structure of plant stem

Cortex

The tissue between the vascular bundles and the epidermis is called the **cortex**. Its cells often store starch. In green stems, the outer cortex cells contain chloroplasts and make food by photosynthesis. Within the cortex is the central tissue of the stem, called pith.



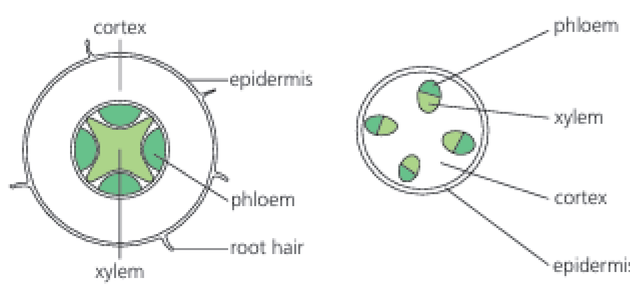
(b) transverse section through sunflower stem (x40)



▲ **Figure 7.9** Cells forming a xylem vessel

Root

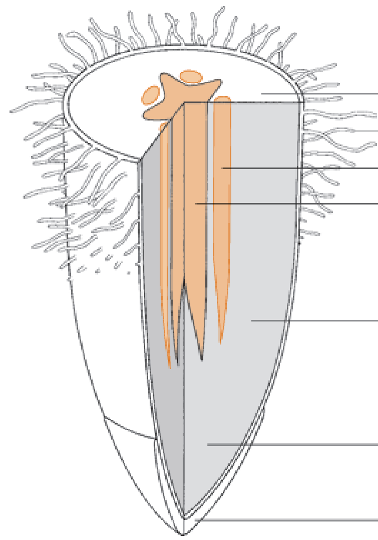
The internal structure of a typical root is shown in Figure 7.11. The vascular bundle is made up of groups of specialised cells in the centre of the root. They conduct water, dissolved mineral ions and food (Figure 7.10). This is different from the stem, where the vascular bundles form a cylinder in the cortex.



▲ **Figure 7.10** Section through a root (left) and stem (right)

Outer layer

There is no distinct epidermis in a root. At the root tip there are several layers of cells forming the root cap. These cells are being replaced as fast as they are worn away when the root tip is pushed through the soil.



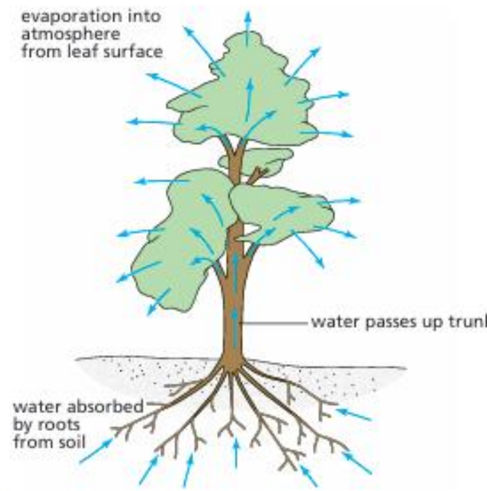
▲ **Figure 7.11** Root structure

Transpiration and translocation

Transpiration

> **Key definitions**
> **Transpiration** can be defined as the loss of water vapour from leaves.

Water evaporates from the surfaces of the spongy mesophyll cells of the leaves into the air spaces. It then diffuses out of the leaves through the stomata as water vapour.



▲ **Figure 7.12** The transpiration stream

Rate of transpiration

Transpiration is the evaporation of water from the leaves, so any change that increases or reduces evaporation will have the same effect on transpiration.

Humidity

If the air is very humid, i.e. contains a large amount of water vapour, it can accept very little more from the plants and so transpiration slows down. In dry air, the diffusion of water vapour from the leaf to the atmosphere will be rapid.

Air movements

In still air, the region round a transpiring leaf will become saturated with water vapour so that no more can escape from the leaf. In these conditions, transpiration would slow down.

Temperature

Warm air can hold more water vapour than cold air. So, evaporation or transpiration will take place more rapidly into warm air. Also, when the Sun shines on the leaves they will absorb heat as well as light.

Water loss from leaves

The cells in part of a leaf blade are shown in Figure 7.16. As explained in 'Osmosis' in Chapter 3, the cell sap in each cell is applying a turgor pressure outward on the cell wall. This pressure forces some water out of the cell wall, evaporating into the air space between the cells. The water vapour passes through the air spaces in the mesophyll and out of the stomata by diffusion.

▲ **Figure 7.15** Yellow meranti tree. Some of these Malaysian trees are over 80 metres tall. Transpiration from their leaves pulls hundreds of litres of water up the trunk

Water movement in the xylem

You may have learned that you cannot draw water up by suction to a height of more than about 10 metres. Many trees are taller than this, but they can draw up water effectively.

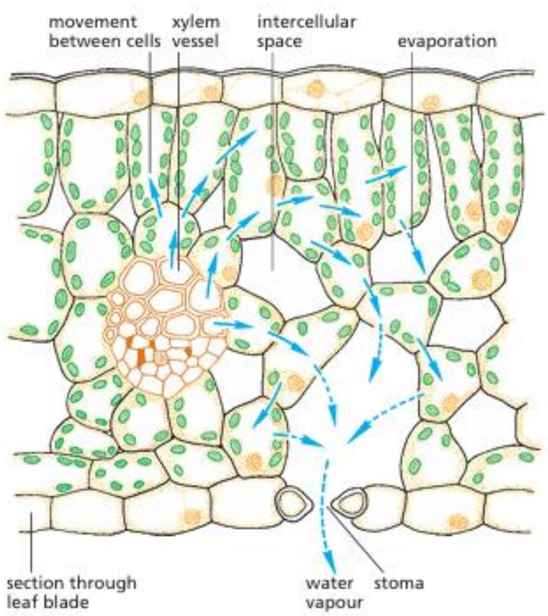
However, there are still problems. It is likely that the water columns in some of the vessels do have air pockets in them and yet the total water flow is not affected.

Evidence for the pathway of water

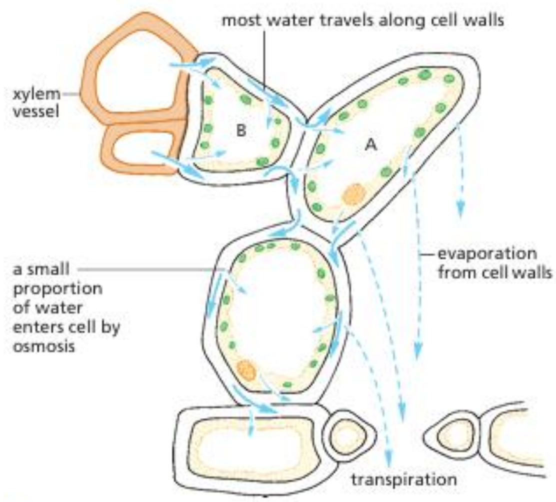
The experiment on page 102 uses a dye to show that in a cut stem the dye, and so also the water, travels in the vascular bundles. Closer study using a microscope would show that it travels in the xylem vessels.

wilting

Water passes through cell walls and through cells, causing turgor pressure to fall in leaf cell A. This allows water to enter the vacuole and restore pressure. In water shortage, cell A may absorb more water than cell B, leading to leaf wilting. Water loss from cell vacuoles causes cells to lose turgor and become flaccid, causing limp leaves and drooping stems.



▲ **Figure 7.16** Movement of water through a leaf



▲ **Figure 7.17** Probable pathway of water through leaf cells

On hot days, trees draw up hundreds of litres of water from the soil, with most evaporating from the leaves. Scientists are unsure how this loss of water benefits plants, as it may help obtain mineral ions and cool the leaf when exposed to strong sunlight. However, some plants have stomata that close at midday, reducing transpiration significantly. Transpiration is an unavoidable consequence of photosynthesis, as a leaf needs to take in carbon dioxide from the air to photosynthesise.

The role of stomata

Stomata, which control water vapor loss and carbon dioxide uptake, open and close based on light intensity, carbon dioxide concentration, and humidity. They interact with each other, affecting the balance between water vapor loss and carbon dioxide uptake. Stomata also react to water stress, closing before wilting.

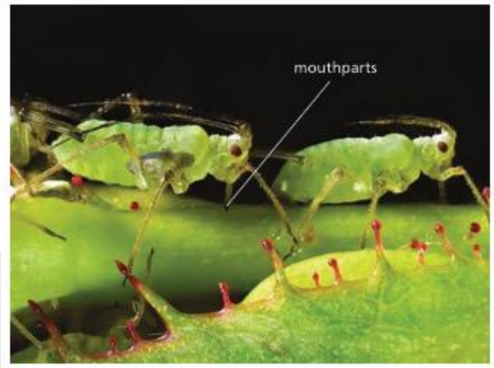
Translocation

The xylem sap is always a very dilute solution, but the phloem sap may contain up to 25% of dissolved solids, most of which is sucrose and amino acids. There is plenty of evidence to support the view that sucrose, amino acids and other substances are transported in the phloem.

Key definitions

Translocation is the movement of sucrose and amino acids in the phloem.

The carbohydrates made in the leaf during photosynthesis are converted to sucrose and carried out of the leaf (the **source**) to the stem. From here, the sucrose may pass upwards to growing buds and fruits or downwards to the roots and storage organs (**sink**).



▲ **Figure 7.19** Aphids feeding on a rose plant

Chapter 08 - Human nutrition

Diet

The need for food

All living organisms need food. An important difference between plants and animals is that green plants can make food in their leaves, but animals need to take it in 'ready-made' by eating plants or the bodies of other animals.

For growth

It gives the substances needed for making new cells and tissues.
As a source of energy
Energy is needed for the chemical reactions that take place in living organisms to keep them alive. When food is broken down during respiration, the energy from the food is used for chemical reactions like building large molecules

For replacement of worn and damaged tissues

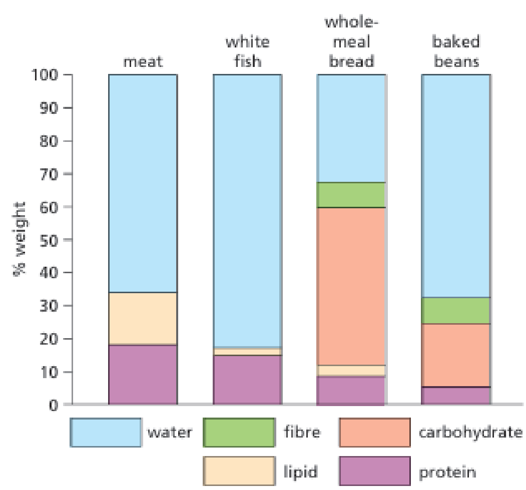
We need the substances provided in food to replace the millions of red blood cells that break down each day, to replace the skin that is worn away and to repair wounds.

Balanced diets

A balanced diet must contain enough carbohydrates and lipids to meet our energy needs. It must also contain enough protein to provide the essential amino acids to make new cells and tissues for growth or repair.

Key definitions

A **balanced diet** is a diet that contains all the essential nutrients in the correct proportions to maintain good health. The nutrients needed are carbohydrate, lipid, protein, vitamins, mineral salts, fibre (roughage) and water.



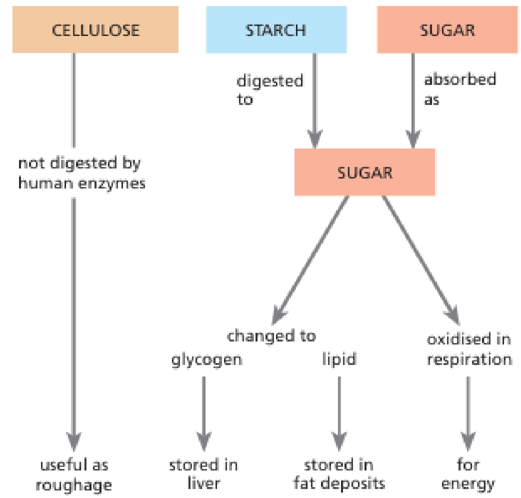
▲ **Figure 8.1** An analysis of four food samples

Classes of food

There are three classes of food: carbohydrates, proteins and lipids. The chemical structure of these substances is described in Chapter 4. These substances are present in a balanced diet and do not normally have to be taken in separately.

Carbohydrates

Carbohydrates, such as sugar and starch, are essential for our diet. They provide energy through carbon, hydrogen, and oxygen. When oxidized, carbohydrates can provide 16 kJ of energy. Excess carbohydrates are converted into glycogen or lipid in the liver and muscles, while cellulose, found in plant tissues, is important as fiber. Cellulose is not digestible but is important in the diet as a source of fibre.



▲ **Figure 8.3** Digestion and use of carbohydrate

Lipids

Animal lipids are found in meat, milk, cheese, butter and egg-yolk. Sources of plant fats are oils in fruits (e.g. palm oil) and seeds (e.g. sunflower seed oil). They are used for cooking and making margarine. Lipids are used in the cells of the body to make part of the cell membrane and other membrane systems.

▼ **Table 8.2** Comparing the protein content of foods [various sources]

Food	Protein content/g per 100 g
soybeans	35
chicken breast	31
pumpkin seeds	30
peanuts	26
fish, e.g. rawas	24
bacon	20
cheese, e.g. paneer	19
Tofu	18
chicken sausage	17
Quorn sausage	14
eggs	13
falafel	13
wheat flour	13
yoghurt	4

Proteins

Proteins are a key part of the diet because they supply the amino acids needed to build up our own body structures. Lean meat, fish, eggs, milk and cheese are important sources of animal protein. All plants contain some protein, but soybeans, seeds like pumpkin, and nuts are the best sources (see Table 8.2).

Chemically, proteins are different from both carbohydrates and lipids because they contain nitrogen and sometimes sulfur as well as carbon, hydrogen and oxygen.

Vitamins

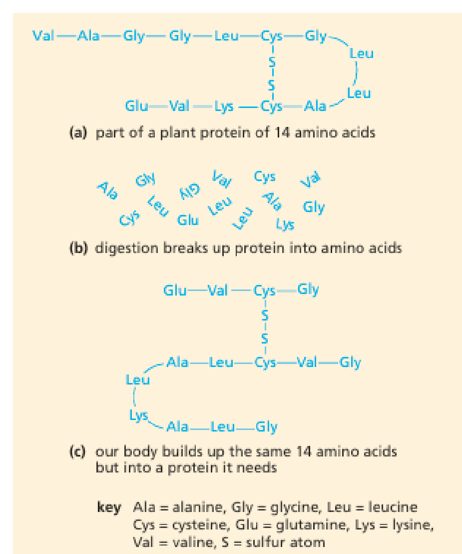
All proteins are like each other in their chemical structure, as are all carbohydrates. However, vitamins are a group of organic substances that have a different chemical structure. There are some features that are shared by all vitamins:

» They are not digested or broken down for energy.

» Usually, they are not built into the body structures.

» They are vital in small quantities for health.

» They are needed for chemical reactions in the cells, working with enzymes.



▲ **Figure 8.4** An example of the digestion and use of a protein molecule

▼ **Table 8.3** Summary table for carbohydrates, lipids and proteins

Nutrient	Good food sources	Use in the body
carbohydrate	rice, potato, yam, cassava, bread, millet, sugary foods (cake, jam, honey)	storage; source of energy
lipids (oils are liquid at room temperature, but fats are solid)	butter, milk, cheese, egg-yolk, animal fat, groundnuts (peanuts)	source of energy (twice as much as carbohydrate); insulation against heat loss; some hormones; cell membranes; insulation of nerve fibres
protein	meat, fish, eggs, soya, groundnuts, milk, Quorn, cowpeas, falafel	growth; tissue repair; enzymes; some hormones; cell membranes; hair; nails; can be broken down to provide energy

Vitamin C

Vitamin C is present in all citrus fruits (oranges, lemons, limes), blackcurrants, guava, mango and cabbage. It is needed to maintain healthy skin and gums. A deficiency results in **scurvy** (Figure 8.5). Fibres in connective tissue of skin and blood vessels do not form properly, leading to bleeding under the skin.

Vitamin D

Vitamin D is the only vitamin that the body can make, when the skin is exposed to sunlight. However, for 6 months of the year (October to April), much of western Europe does not receive enough UV rays in sunlight to make vitamin D in the skin. So, many people living there are at risk of a vitamin D deficiency unless they get it in their diet.

The weight of the body can deform bones in the legs, causing the condition called **rickets** in children (Figure 8.6). Adults deficient in vitamin D are in danger of fracturing bones if they fall.

▲ **Figure 8.5** Symptoms of scurvy

▲ **Figure 8.6** A child with rickets

▼ **Table 8.4** Vitamins

Name and source of vitamin	Importance of vitamin	Diseases and symptoms caused by lack of vitamin	Notes
Vitamin C; water-soluble: oranges, lemons, grapefruit, tomatoes, fresh green vegetables, potatoes	Prevents scurvy.	Fibres in connective tissue of skin and blood vessels do not form properly, leading to bleeding under the skin, particularly at the joints, swollen, bleeding gums and poor healing of wounds. These are all symptoms of scurvy (Figure 8.5).	May act as a catalyst in cell respiration. Scurvy is only likely to occur when fresh food is not available. Cows' milk and milk powders contain little vitamin C so babies may need other sources. Cannot be stored in the body; daily intake needed.
Vitamin D; fat-soluble: butter, milk, cheese, egg-yolk, liver, fish-liver oil	Prevents rickets.	Calcium is not deposited properly in the bones, causing rickets in young children. The bones remain soft and are deformed by the child's weight (Figure 8.6). Fractures are more likely in adults who are deficient.	Vitamin D helps the absorption of calcium from the intestine and the deposition of calcium salts in the bones. Natural lipids in the skin are changed to a form of vitamin D by sunlight.

Mineral ions

These are sometimes called mineral salts or minerals. Proteins, carbohydrates and fats provide the body with carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus, but there are several more elements that the body needs. These mineral ions are present in the food we eat.

Iron

Red blood cells contain the pigment haemoglobin (see 'Blood' in Chapter 11). Part of the haemoglobin molecule contains iron.

Most of the iron is recycled, but some is lost in the **faeces** and needs to be replaced. Adults need to take in about 15 mg each day. Without sufficient iron, your body is unable to produce enough haemoglobin, the protein in red blood cells responsible for transporting oxygen to respiring tissues.

Calcium

Calcium, in the form of calcium phosphate, is deposited in the bones and the teeth and makes them hard. Many calcium salts are not soluble in water and may pass through the **alimentary canal** without being absorbed. Simply increasing the calcium in the diet may not have much effect unless the calcium is in the right form, the diet is balanced and the intestine is healthy.

▼ **Table 8.5** Minerals

Name and source of mineral	Importance of mineral	Diseases and symptoms caused by lack of mineral	Notes
calcium: milk, cheese, fish, some sources of water, e.g. 'hard' water	Needed to form healthy bones and for normal blood clotting.	Early signs are muscle aches, cramps and spasms, with numbness of hands, feet and around the mouth. Teeth and bones become soft and more easily breakable. Deficiency can lead to rickets (linked to vitamin D deficiency) and osteoporosis.	Most foods contain small amounts of calcium. A shortage of calcium in the diet at first results in calcium being removed from bones so no symptoms are apparent.
iron: red meat, liver, kidney, eggs, green vegetables (spinach, cabbage, cocoyam, groundnut leaves), chocolate	Needed for formation of haemoglobin in red blood cells (for transport of oxygen).	Anaemia. The symptoms are constant tiredness and a lack of energy.	In women, heavy periods can result in a loss of iron, which can result in anaemia.

Dietary fibre (roughage)

When we eat vegetables and other fresh plant material, we take in a large quantity of plant cells. The cell walls of plants are made of cellulose, but we do not have enzymes for digesting this substance. The result is that the plant cell walls reach the large intestine (colon) without being digested. This undigested part of the diet is called fibre or roughage.

Digestion uses water in a chemical reaction to break down insoluble substances to soluble ones. These products then pass, in solution, into the bloodstream.

Human digestive system

Feeding involves taking food into the mouth, chewing it and swallowing it down into the stomach. However, for food to be of any use to the whole body it needs to be **digested**. The soluble products then need to be **absorbed** into the bloodstream. The blood delivers dissolved food to the living cells of all the tissues and organs.

Digestion

Physical digestion and teeth

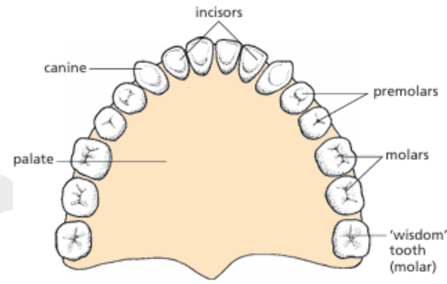
The process of **physical digestion** mainly occurs in the mouth. The teeth are used to chew the food. This increases the surface area of food for the action of enzymes in **chemical digestion**. Other examples of physical digestion include the action of muscles in the stomach and the emulsification of fats by **bile**.

Key definitions

Physical digestion is the breakdown of food into smaller pieces without chemical change to the food molecules.

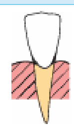
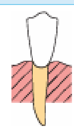
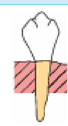
Chemical digestion is the breakdown of large molecules into small molecules.

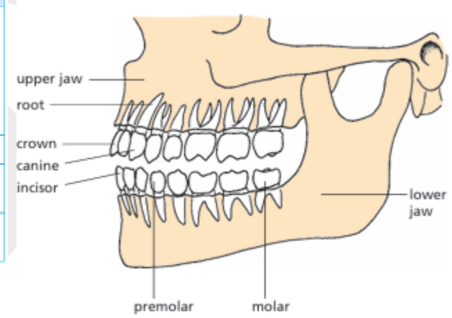
Table 8.6 gives a summary of the types of human teeth and their functions. Our top incisors pass in front of our bottom incisors. They cut pieces off the food, for example, when biting into an apple or taking a bite out of a piece of toast.



▲ **Figure 8.10** Teeth in human upper jaw

▼ **Table 8.6** Summary of types of human teeth and their functions

Type	Incisor	Canine	Premolar	Molar
Diagram				
Position in mouth	front	either side of incisors	behind canines	back
Description	chisel-shaped (sharp edge)	slightly more pointed than incisors	have two points (cusps); have one or two roots	have four or five cusps; have two or three roots
Function	biting off pieces of food	similar function to incisors	tearing and grinding food	chewing and grinding food



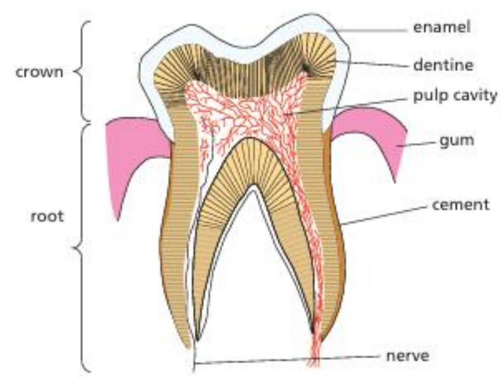
▲ **Figure 8.11** Human jaws and teeth

Our canines are more pointed than the incisors and are slightly larger. They behave like extra incisors. Our premolars and molars are similar in shape and function. Their knobbly surfaces, called cusps, meet when the jaws are closed.

Tooth structure

The part of a tooth that is visible above the gum line is called the crown.

This layer is replaced by **cement** in the root, which enables the tooth to grip to its bony socket in the jaw. Below the enamel is a layer of **dentine**. Dentine is softer than enamel. Inside the dentine is a **pulp** cavity, containing nerves and blood vessels.



▲ **Figure 8.12** Section through a molar tooth

Peristalsis

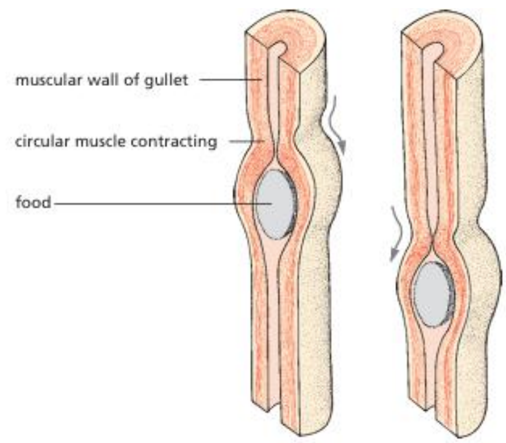
The alimentary canal has layers of muscle in its walls (Figure 8.9). The fibres of one layer of muscles run around the tract (**circular muscle**) and the others run along its length (longitudinal muscle).

The wave of contraction, called peristalsis, is shown in Figure 8.13. The process of swallowing involves **peristalsis**. For food to enter the **oesophagus** (gullet), it passes over the windpipe

The beginning of the swallowing action is voluntary, but once the food reaches the back of the mouth, swallowing becomes a **reflex action.**

Chemical digestion

Digestion is mainly a chemical process and involves breaking down large molecules to small molecules. The large molecules are usually not soluble in water, but the smaller ones are.



▲ **Figure 8.13** Diagram to illustrate peristalsis

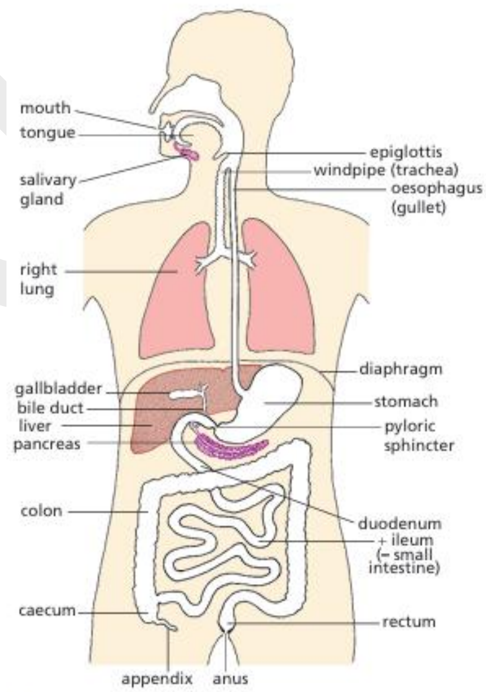
Lipids are digested to soluble molecules called glycerol and fatty acids (see Chapter 4). Five main processes linked with digestion happen in the digestive system. These are **ingestion,** digestion, absorption, **assimilation and egestion.** The main parts of the digestive system are shown in Figure 8.14. An outline of the functions of its main parts is given in Table 8.7

The mouth

The act of taking food into the mouth is called ingestion. In the mouth the food is chewed and mixed with saliva.

Saliva is a digestive juice produced by the **salivary glands**, which have ducts that lead into the mouth.

Saliva contains one enzyme, **salivary amylase**, which acts on starch and begins to break it down into simple sugars



▲ **Figure 8.14** The digestive system

The stomach

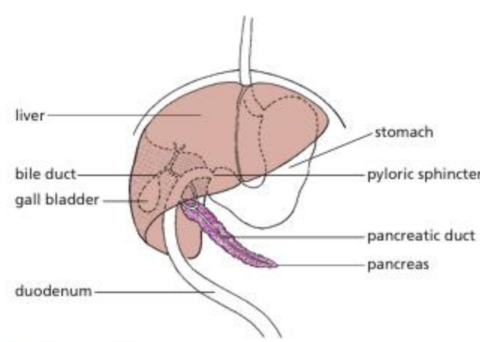
The stomach has elastic walls, which stretch as the food collects in it. . The muscles alternately contract and relax, churning and squeezing the food in the stomach and mixing it with **gastric secretions.**

There is a valve at the base of the stomach. This valve stops solid pieces of food from passing through and lets the liquid products of digestion pass, a little at a time, into the **duodenum**, which is the first part of the small intestine.

Duodenum

Pancreatic juice (digestive juice from the pancreas) and bile from the liver are released into the duodenum to act on food there.

Pancreatic amylase digests starch to **maltose**. Maltase breaks down maltose into glucose. Lipase digests lipids to fatty acids and glycerol.



▲ **Figure 8.15** Relationship between stomach, liver and pancreas

All the digestible material is changed to soluble compounds, which can pass through the lining of the intestine and into the bloodstream. The final products of digestion are:

Food		**Final products**
starch	→	glucose (a simple sugar)
proteins	→	amino acids
lipids	→	fatty acids and glycerol

Bile

The action of bile is an example of physical digestion. **Bile** is a green, watery fluid made in the liver. These act on lipids in a similar way to a detergent. The bile salts **emulsify** the lipids.

Ileum and colon

The large intestine secretes no enzymes but the bacteria in the colon digest part of the fibre to form fatty acids, which the **colon** can absorb. Bile salts are absorbed and returned to the liver in the blood. The colon also absorbs water from the undigested material.

Rectum and anus

The semi-solid waste is called the **faeces**. It is passed into the **rectum** by peristalsis and is passed out at intervals through the **anus**. The undigested material may spend from 12 to 24 hours in the intestine

▼ **Table 8.7** Functions of the main parts of the digestive system

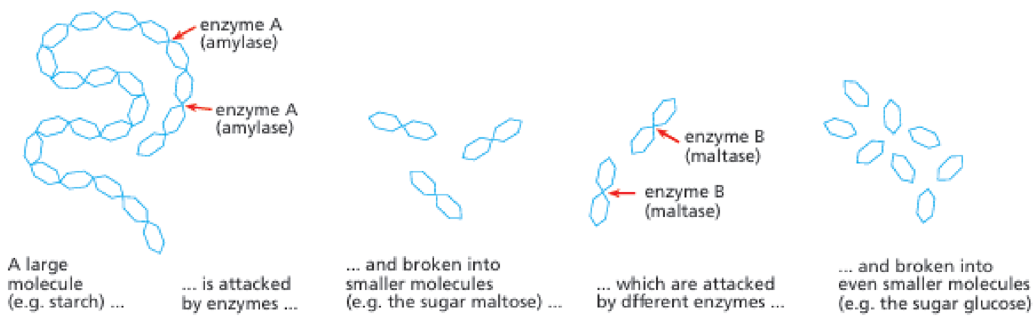
Region of digestive system	Function
mouth	ingestion of food; physical digestion by teeth; chemical digestion of starch by amylase; formation of a bolus for swallowing
salivary glands	produces saliva, which contains amylase for the first stage of the chemical digestion of starch in food; also, liquid to lubricate food and make small pieces stick together
oesophagus (gullet)	transfers food from the mouth to the stomach by peristalsis
stomach	produces gastric juice containing protease, for chemical digestion of protein; also, hydrochloric acid to kill bacteria; peristalsis churns food up into a liquid
duodenum	first part of the small intestine; receives pancreatic juice for chemical digestion of proteins, lipids and starch as well as neutralising the acid from the stomach; receives bile to emulsify lipids (a type of physical digestion)
ileum	second part of the small intestine; enzymes in the epithelial lining carry out chemical digestion of starch into simple reducing sugars using pancreatic amylases; proteins to amino acids by proteases; and fats and oils into fatty acids and glycerol by lipases; very long and has villi (see Figures 8.18 and 8.19) to increase surface area for absorption of digested food molecules and water
pancreas	secretes pancreatic juice into the duodenum through the pancreatic duct (see Figure 8.15 for chemical digestion of proteins, lipids and starch)
liver	makes bile containing salts to emulsify lipids (physical digestion); assimilation of digested food like glucose; **deamination** of excess amino acids (see Chapter 13), storage of glycogen (Chapter 14)
gall bladder	stores bile made in the liver, to be secreted into the duodenum through the bile duct (see Figure 8.15)
colon	first part of the large intestine; absorption of water from undigested food; absorption of bile salts to pass back to the liver
rectum	second part of the large intestine; stores faeces
anus	egestion of faeces

Digestion of starch

A starch molecule is made up of hundreds of carbon, hydrogen and oxygen atoms. Starch is digested in two places in the alimentary canal: by salivary amylase in the mouth and by pancreatic amylase in the duodenum.

Maltose is broken down to glucose by the enzyme maltase, which is present in the membranes of the epithelial cells of the villi.

starch → maltose → glucose



▲ **Figure 8.16** Enzymes acting on starch

Digestion of protein

Protein molecules are digested first to smaller molecules called **peptides** and then into completely soluble molecules called **amino acids**

protein → peptide → amino acid

Another protease is called **trypsin**. Trypsin is secreted by the pancreas in an inactive form, which is changed to an active enzyme in the duodenum.

However, the epithelial cells of the villi contain enzymes in their cell membranes that complete the break-down of sugars and peptides before they pass through the cells to the bloodstream. For example, **peptidase** breaks down polypeptides and peptides into amino acids.

Digestion of lipids

The pancreas produces lipase which is secreted into the duodenum in pancreatic juice. It works best in slightly alkaline conditions (pH 8). Lipase digests lipids to fatty acids and glycerol.

Absorption and assimilation

The second part of the small intestine is called the ileum. The ileum is efficient in the absorption of digested food for several reasons:

» It is quite long and provides a large surface to absorb the digested food.

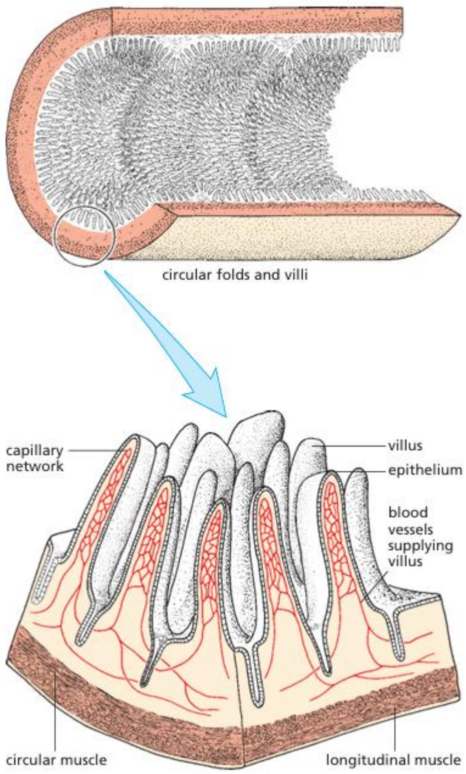
» Its internal surface is increased even more by circular folds (Figure 8.19) bearing thousands of tiny projections called villi (singular = **villus**) (Figures 8.17 and 8.18). These villi are about 0.5 mm long and may be finger-like or flattened in shape.

» The lining epithelium is very thin and the fluids can pass rapidly through it. The outer membrane of each epithelial cell has microvilli, which increase ×20 the exposed surface of the cell (see Chapter 3, Figure 3.3). This makes the small intestine much more efficient in the absorption of nutrients.

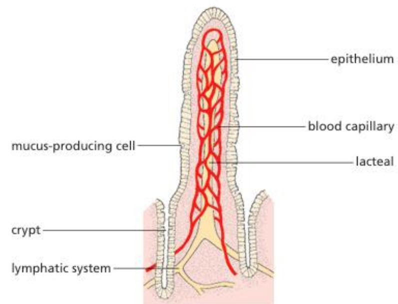
» There is a dense network of blood capillaries (tiny blood vessels, see Chapter 11) in each villus (Figure 8.18).

These veins come together to form one large vein, the **hepatic portal vein.**

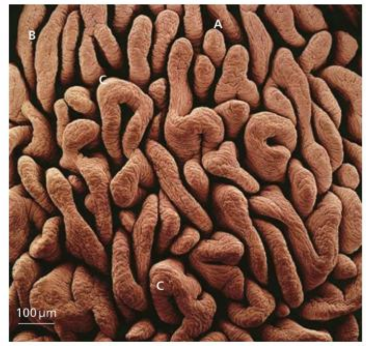
However, a large proportion of the fatty acids and glycerol combine again to re-form lipids in the intestinal epithelium. These lipids then pass into the lacteals (Figure 8.18).



▲ **Figure 8.17** The absorbing surface of the ileum



▲ **Figure 8.18** Structure of a single villus



▲ **Figure 8.19** Scanning electron micrograph of the human intestinal lining (×60). The villi are about 0.5 mm long. In the duodenum they are mostly leaf-like (C), but further towards the ileum they become narrower (B), and in the ileum they are mostly finger-like (A). This micrograph is of a region in the duodenum

Use of digested food

The products of digestion are carried around the body in the blood. From the blood, cells absorb and use glucose, lipids and amino acids. This uptake and use of nutrients by cells is called **assimilation.**

Glucose

During respiration in the cells, glucose is oxidised to carbon dioxide and water (see 'Aerobic respiration' in Chapter 10). This reaction provides energy to drive the many chemical processes in the cells, which result in, for example, the building-up of proteins, contraction of muscles or electrical changes in nerves.

Lipids

These are built into cell membranes and other cell structures. Lipids also form an important source of energy for cell metabolism. Fatty acids produced from stored fats or taken in with the food are oxidised in the cells to carbon dioxide and water. This releases energy for processes such as muscle contraction. Lipids can provide twice as much energy as sugars.

Amino acids

These are absorbed by the cells and built up, with the aid of enzymes, into proteins. Some of the proteins will become plasma proteins in the blood (see 'Blood' in Chapter 11). Others may form structures such as cell membranes or they may become enzymes that control the chemical activity within the cell.

Revision questions

1. Fig. 3.1 shows part of the thoracic and abdominal cavities of a human.

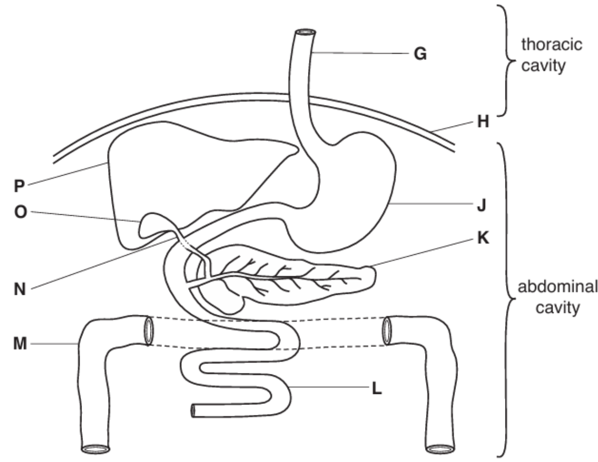


Fig. 3.1

(a) (i) Name the structures labelled G, H and M.

(ii) Table 3.1 shows five functions of organs in the abdominal cavity. Complete the table by:

• naming the organ that carries out each function

• using the letters from Fig. 3.1 to identify the organ named. One row has been completed for you.

Table 3.1

function	name	letter from Fig. 3.1
conversion of glucose to glycogen		
secretion of insulin and glucagon	pancreas	K
absorption of products of digestion		
storage of bile		
chemical digestion of protein in an acidic pH		

(b) Fat is particularly difficult to digest as it is not water soluble and forms spherical globules in the alimentary canal.

Fig. 3.2 is a diagram showing what happens to fat globules when mixed with bile.

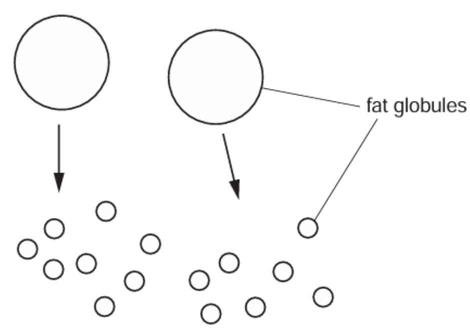


Fig. 3.2

i) Name the process shown in Fig. 3.2.
(ii) Explain the advantage of the process shown in Fig. 3.2.

(c) Insulin and glucagon are hormones secreted by the pancreas to control the concentration of glucose in the blood.

(i) Complete Table 3.2 to show how the uptake of glucose by cells and the concentration of glucose in the blood respond when the two hormones are secreted. Use the words increases, decreases and stays the same to complete the table

Table 3.2

hormone	uptake of glucose by cells	concentration of glucose in the blood
insulin		
glucagon		

(ii) State another hormone that influences the concentration of glucose in the blood

(d) Explain why the control of the concentration of glucose in the blood is an example of negative feedback.

2. (a) Describe how food is moved along the small intestine.

The small intestine is lined by many villi. Fig. 5.1 shows a longitudinal section of a villus.

Fig. 5.2 shows a cross-section of the same villus at V – W.

The diagrams are not drawn to the same scale.

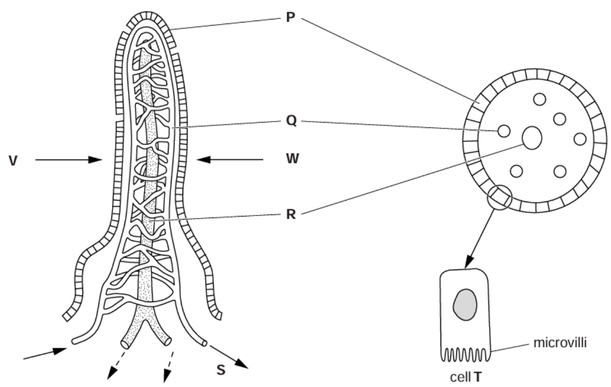


Fig. 5.1 Fig. 5.2

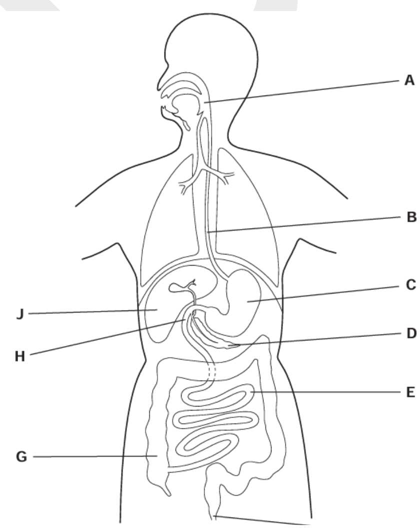
(i) Name structures P, Q, and R.

(ii) The blood that flows from S enters a vein. Name the vein that transports blood away from the small intestine.

(iii) Cell T is an example of the cells that form the surface of the villi. Explain why there are many microvilli on cell T.

(iv) Some of the cells on the surface of the villi secrete mucus for protection. Suggest what the villi need to be protected against.

3. The alimentary canal is adapted for chemical and mechanical digestion.
(a) Explain how chemical digestion differs from mechanical digestion
Fig. 5.1 is a diagram of the human alimentary canal.



(b) Table 5.1 shows four functions of the alimentary canal. Complete the table by:

• naming the part of the system that carries out each of the functions;

• using the letters from Fig. 5.1 to identify the part of the system named. One row has been completed for you.

Table 5.1

function	name of part	letter from Fig. 5.1
produces bile	liver	**J**
most soluble food is absorbed into the blood		
indigestible food is egested		
hydrochloric acid is produced		
protease, lipase and amylase are produced		

(c) Some people develop gallstones, made of cholesterol, that accumulate in the gall bladder and the bile duct. Gallstones block the flow of bile.

Explain how gallstones can affect the digestion of fat.

(d) Cholesterol can also accumulate in the walls of the coronary arteries. Explain the effects that this might have.

4. (i) Explain the term balanced diet.

(ii) State three factors that influence a person's nutritional needs.

(b) Glucose is absorbed in the small intestine and transported in the blood. The kidneys filter the blood and reabsorb the glucose. If the blood contains more than 180 mg of glucose per 100 cm^3, the kidney cannot reabsorb it all and some is present in the urine.

This figure is called the renal threshold. A doctor suspects that a patient has diabetes because a urine test is positive for glucose. The patient takes a glucose tolerance test by drinking a solution of glucose.

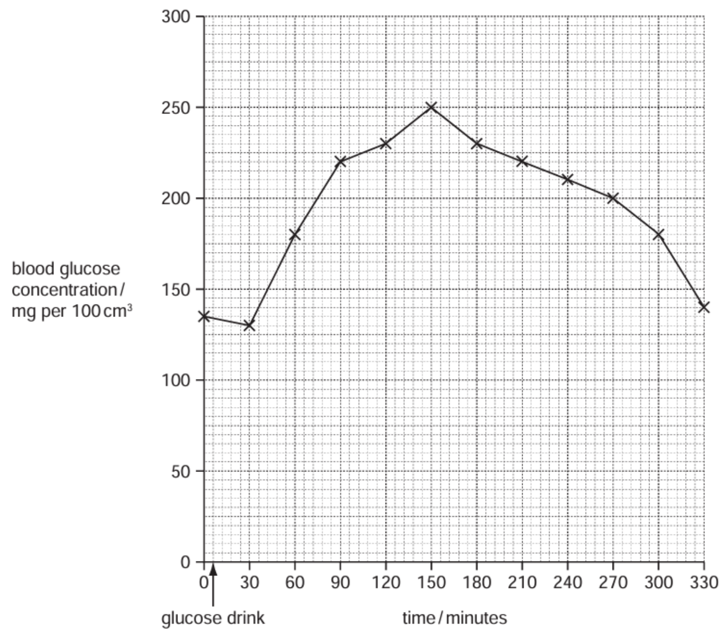


Fig. 2.1

The doctor records the patient's blood glucose concentration at 30-minute intervals for five and a half hours. The results are plotted on Fig. 2.1.

i. Draw a horizontal line on Fig. 2.1 to show the renal threshold.
II. State the time period when the kidney will produce urine containing glucose.
III. State the time period when the kidney will produce urine containing glucose.

c) People who do not have diabetes maintain their blood glucose concentration below 180 mg per 100 cm^3. Explain how the body does this.

5. Fig. 1.1 A shows a cell from the lining of the alimentary canal.

Fig. 1.1 B shows a cell from the lining of a kidney tubule.

Both cells absorb substances into the blood.

(a) Name the structures labelled C on the cells in Fig. 1.1.

(b) List three substances that are absorbed by both cells shown in Fig. 1.1.

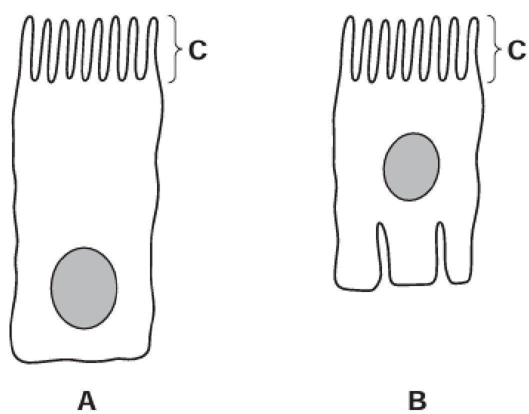


Fig. 1.1

(c) Explain how both cells shown in Fig. 1.1 are adapted for absorption of substances into the blood

(d) Name the part of the alimentary canal that is lined by the cells shown in Fig. 1.1 A.

6. Australia has added fluoride to much of its drinking water since 1953. Other countries, such as Chile, do not add fluoride to their drinking water.

(a) Outline the arguments for and against the addition of fluoride to public drinking water.

Studies of the relationship between sugar consumption, tooth decay and fluoridation of drinking water have been carried out. Data was collected on tooth decay in 12 year-old children in Australia and Chile.

Fig. 5.1 shows changes in sugar consumption in Australia and Chile between 1970 and 2006. Fig. 5.2 shows changes in tooth decay in the same countries over a similar time period.

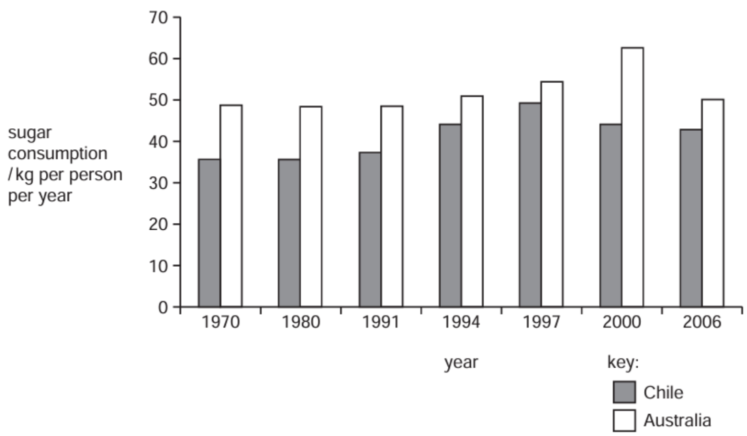


Fig. 5.1

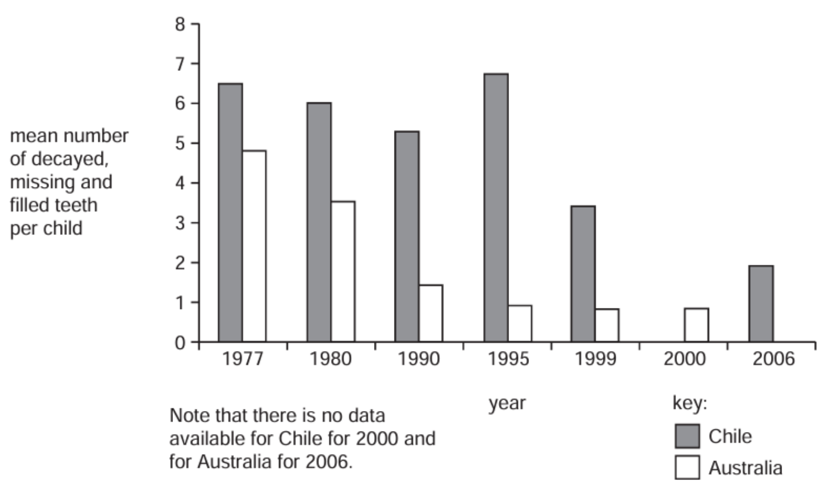


Fig. 5.2

(b) Describe the changes in sugar consumption and tooth decay in Australia and Chile between 1970 and 2006

(c) The peaks for sugar consumption and tooth decay in 12-year-old children in Chile occurred at about the same time. It has been suggested that an increase in sugar consumption in children caused an increase in tooth decay. Explain how an increase in sugar consumption may cause tooth decay

7. Water moves into plants from the soil and exits through the leaves.
(a) Explain how water moves from the soil into the root.

Water reaches the leaves from the roots through the xylem. Fig. 4.1 shows images of stomata on the lower surfaces of leaves of two varieties of olive plant, A and B. Both are shown at the same magnification.

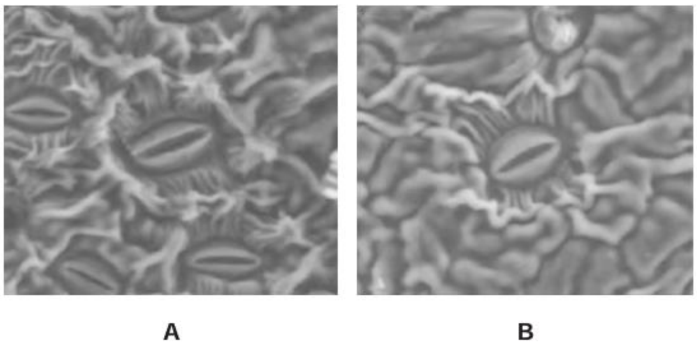


Fig. 4.1

(b) (i) Describe the function of stomata

(ii) Compare the density of stomata between the two varieties of olive plant, A and B, shown in Fig. 4.1.

(iii) Under identical environmental conditions the rate of water uptake in plant A is higher than plant B. Explain why.

(c) The density of stomata is an example of a leaf adaptation to the environmental conditions. State two other adaptations of leaves for survival in a dry environment.

(d) Water lost from the leaves enters the atmosphere. Describe how water is recycled from the atmosphere back to the roots.

8. Ecologists study plants and animals in their natural environment. Some ecologists inserted probes into the water-conducting tissue in trees, as shown in Fig. 4.1. The ecologists measured the time taken for water to move up from probe 1 to probe 2.

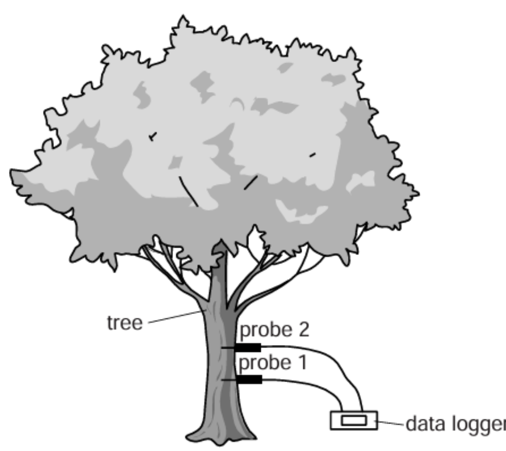


Fig. 4.1

(a) (i) Name the water-conducting tissue into which the two probes were inserted.

(ii) Describe how the structure of this water-conducting tissue is adapted to its function.

(b) Explain the mechanism of water movement from the roots up the tree to the leaves.

9. Fig. 4.1 shows a cross section of part of a stem of buttercup, Ranunculus. Fig. 4.2 is an outline drawing of one vascular bundle from the stem of Ranunculus.

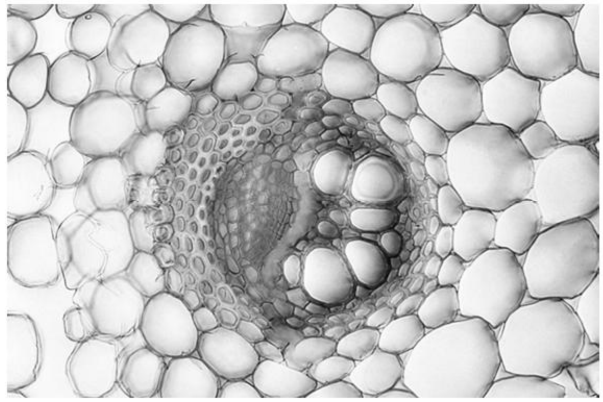


Fig. 4.1

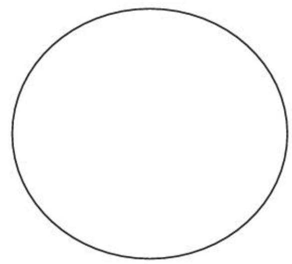


Fig. 4.2

(a) Draw and label the position of the xylem and the phloem in the outline of the vascular bundle in Fig. 4.2.

(b) Name the carbohydrate that is transported in the phloem.

(c) Substances transported in the phloem are carried upwards in the stem at some times of the year and downwards at other times.

Explain why substances are transported in the phloem upwards at one time of the year and downwards at another.

(d) Define the term transpiration.

(e) The rattan palm is a plant that climbs on rainforest trees to heights of about 40 metres. Explain how water is moved to the tops of tall plants, such as the rattan palm