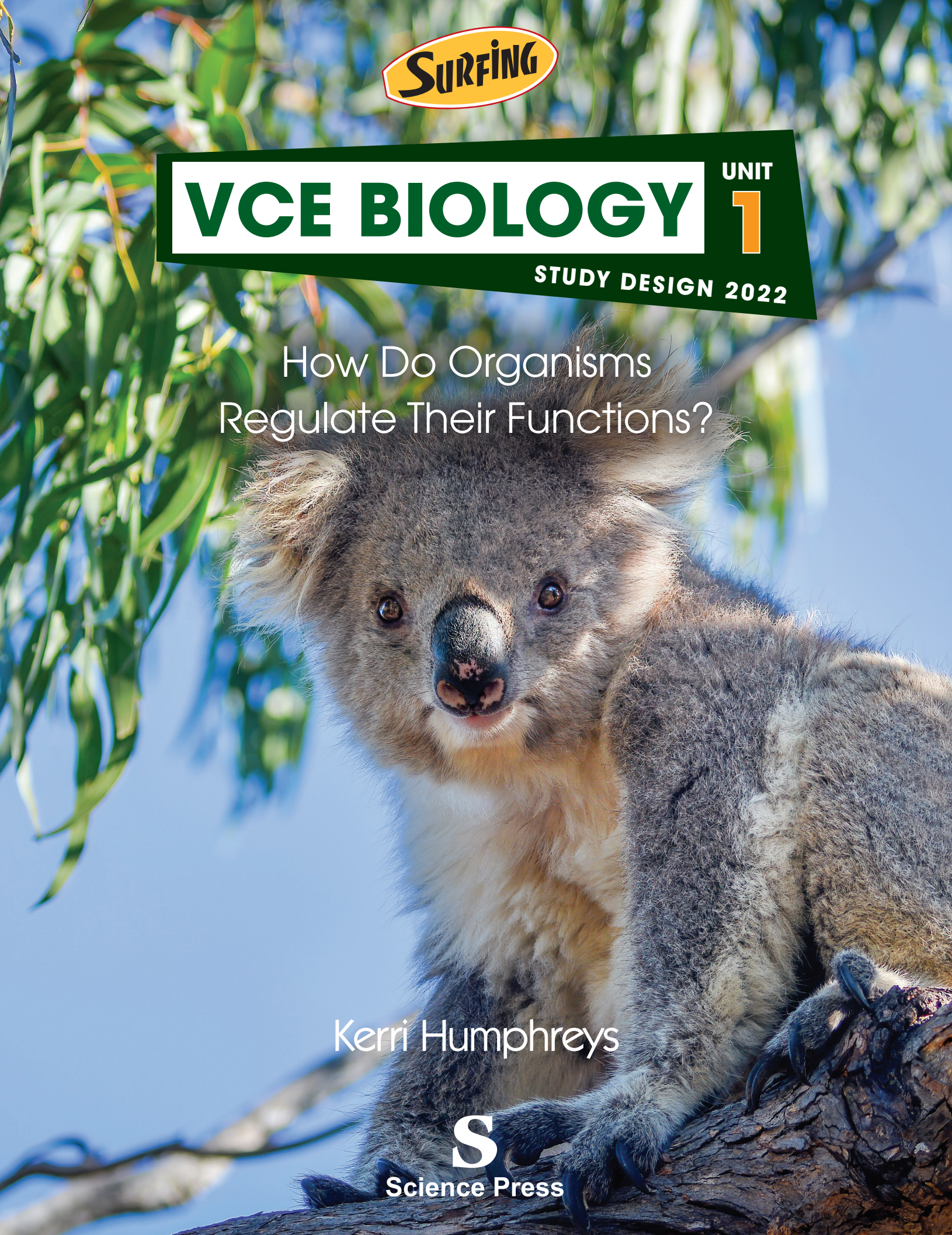
SURFING
VCE BIOLOGY
UNIT 1
STUDY DESIGN 2022
How Do Organisms Regulate Their Functions?
Kerri Humphreys
Science Press

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SURFING

VCE BIOLOGY UNIT 1

STUDY DESIGN 2022

Area Of Study 1

How Do Cells Function?

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1 Assumed Knowledge

QUESTIONS

1. Identify seven properties of living organisms.
2. The cell is the basic unit of life. What structural features of cells are possessed by all living things?
3. Draw a fully labelled diagram of a plant cell as seen under a light microscope.
4. Draw a fully labelled diagram of an animal cell as seen under a light microscope.
5. Identify the following parts of a light microscope and use by a person.

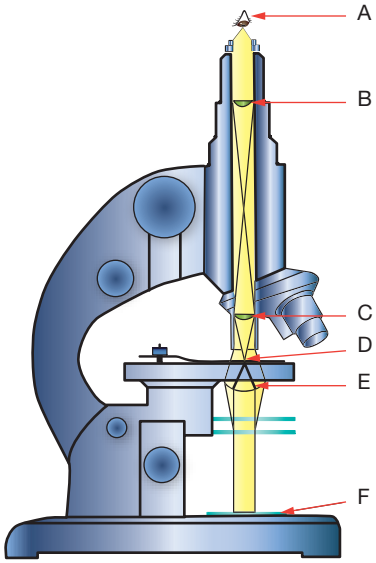

Figure 1.1 Light microscope.

6. Describe one safety precaution you should follow while using a light microscope.
7. What is the function of the nucleus of a cell?
8. What is the function of the cell membrane?
9. What is cytoplasm?
10. Define protoplasm.
11. Describe a chloroplast.
12. Define photosynthesis.
13. Which group of organisms can photosynthesise?
14. Identify the materials required by multicellular organisms for photosynthesis.
15. What is the function of the digestive system?
16. Figure 1.2 shows the human digestive tract. Identify each part.
17. For each of the following parts of the digestive system, outline its structure and its main function.
    (a) Mouth. (b) Oesophagus.
    (c) Stomach. (d) Small intestine.
    (e) Large intestine. (f) Anus.

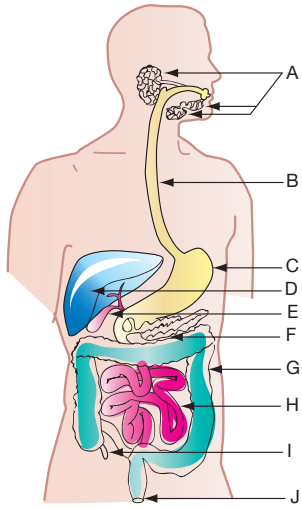

Figure 1.2 Human digestive tract.

18. In plants, what is the function of each of the following?
    (a) Xylem. (b) Phloem.
    (c) Leaves. (d) Roots.
19. The diagram shows a simple model of digestion.

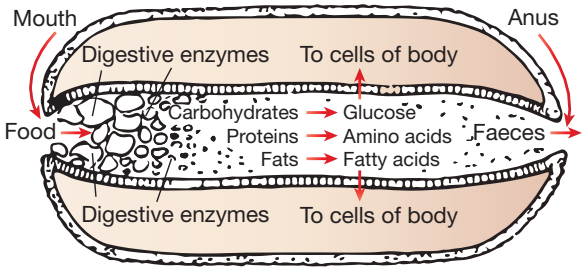

Figure 1.3 Simple model of digestion.

    (a) From this model identify what foods are broken down into:
        (i) Glucose.
        (ii) Amino acids.
        (iii) Fatty acids.
    (b) Explain why scientists make simple models such as this simple model of digestion.
20. What is meant by cellular differentiation?
21. Define osmosis.

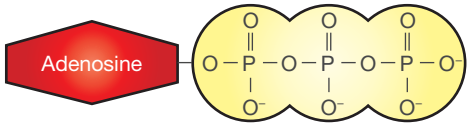

Figure 1.4 Biomolecule.

22. Identify the chemical in Figure 1.4 and explain why it is important in active transport and many cellular chemical reactions.

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2 Characteristics Of Living Things

There are nine characteristics of living things. These characteristics are used to define life.

1. Growth and development

Growth involves an increase in mass. This can occur due to an increase in the size of individual cells and/or an increase in the number of cells.

2. Reproduction

Reproduction is the ability to produce offspring. Reproduction can be asexual or sexual. **Asexual reproduction** involves one parent producing offspring that are genetically identical to the parent, e.g. by binary fission, budding or vegetative propagation. **Sexual reproduction** involves the union of two **gametes** in **fertilisation** to form a **zygote**.

3. Respiration

All living things can respire. Cellular respiration is a series of chemical reactions in which cells obtain energy from food. Each step in the series of reactions is controlled by enzymes with the energy being released at different stages in the process. Some of the energy is transferred to other molecules becoming available for other reactions.

4. Respond to stimuli

All living things respond to stimuli from both their external environment and their internal environment. The stimuli can be physical or chemical changes in the environment, e.g. a response to the intensity and direction of light or a change in the carbon dioxide levels in body fluids.

5. Movement and locomotion

Movement can be very obvious, e.g. a running animal or very slow and involve only part of the organism, e.g. a plant leaf moving to catch the maximum amount of sunlight. Locomotion is the ability to move from one place to another.

6. Nutrition or feeding

Nutrition is a process by which organisms obtain **matter** to produce their physical structure and **energy** to continue the functions of life. **Autotrophs** can make their own organic nutrients from inorganic materials, e.g. plants and cyanobacteria can use the energy from sunlight in **photosynthesis** and bacteria living in hot springs or oceanic hydrothermal vents use the energy in hydrogen sulfide (H_2S) in chemosynthesis. **Heterotrophs** consume other organisms to obtain organic nutrients. Their food needs to be broken down before it can be used.

7. Assimilation

Assimilation is the process of converting food into the living material of life.

8. Metabolism

Metabolism is the sum of all chemical reactions within the organism. In **anabolic reactions** small molecules are combined to form complex molecules, e.g. photosynthesis. In **catabolic reactions** chemical bonds are broken and complex molecules are broken down into smaller units, e.g. digestion. Sometimes energy is released.

9. Excretion

Excretion is the removal of unwanted waste products of metabolic reactions.

QUESTIONS

1. Construct a table to summarise the nine characteristics of living things.
2. Distinguish between asexual reproduction and sexual reproduction.
3. Define fertilisation.
4. Crystals can grow in size. Explain why crystals are not considered to be living though they show a characteristic of living things.
5. Distinguish between autotrophic and heterotrophic nutrition.
6. Distinguish between photosynthesis and chemosynthesis.
7. The diagram shows one of the features of living things.

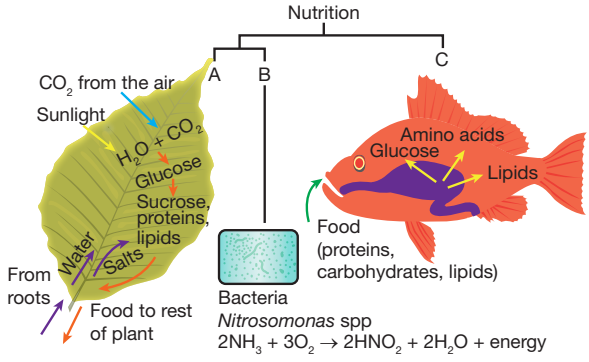

Figure 2.1 A feature of living things.

   (a) For the types of nutrition labelled A, B and C, which are autotrophic and which are heterotrophic?
   (b) What is the energy source for the bacteria *Nitrosomas* spp?
8. Distinguish between an anabolic reaction and a catabolic reaction.
9. Is respiration a catabolic or anabolic reaction? Explain your reasoning.

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3 The Modern Light Microscope

The compound light microscope operates on the main principle that an objective lens with a very short focal length can form a highly magnified real image of the object. Visible light passes through the specimen and then a series of lenses. The resolution of the microscope is limited by the shortest wavelength of light used to view the specimen.

Images from a light microscope can be captured with a camera to produce a **photomicrograph**. Digital images can be shown directly on a computer screen.

Table 3.1 Features of the modern light microscope.

Feature	Light microscope
Magnification	Effective up to 1000×.
Resolution	Up to 0.2 μm.
Stains	Allows the use of many different coloured stains to identify substances, structures and provide contrast for easier viewing.
Living specimen	The light microscope allows viewing of living specimen and processes occurring within a cell or within an organism.
Mounting	The specimen is mounted on a glass slide in air.
Focusing	By glass lenses.
Energy source for viewing	A beam of light is passed through the specimen.

How a light microscope works

The objective lens is brought close to the specimen to create an enlarged image of the object. The image is inverted. In most modern light microscopes the eyepiece is a compound lens near the back of an eyepiece tube. Light travels from the light source up the microscope to form an image at the eye.

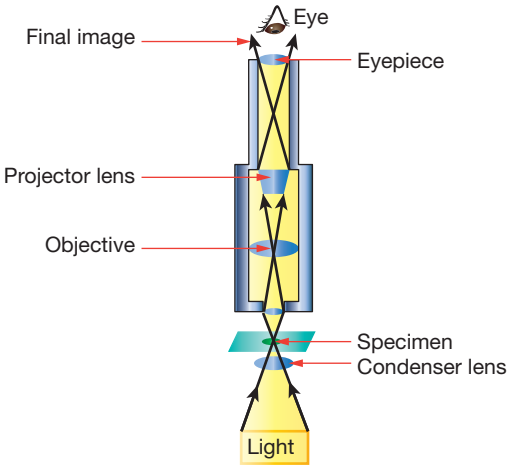

Figure 3.1 How light travels through a light microscope.

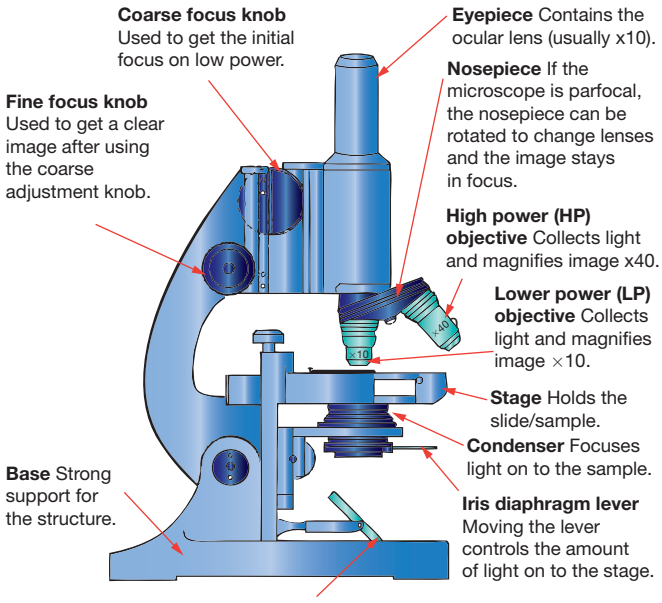

Figure 3.2 Features of the modern light microscope.

Advantages of a light microscope

The main advantages of light microscopes are that:

- Living cells can be observed.
- Coloured stains can be used.
- The specimens are easy to prepare.
- The microscopes are relatively inexpensive (compared to the cost of an electron microscope).
- Their size means they are relatively easy to store.

Disadvantages of a light microscope

The main disadvantages of the light microscope are:

- Its limited magnification (effective magnification begins to reduce after 1000×).
- Its limited resolution.

During the 20th century many different illumination techniques and other developments have increased the detection power of the light microscope for observing living cells.

Phase contrast microscopes

The phase contrast microscope uses interference rather than absorption of light to increase the contrast in unstained cells by amplifying variations in density within the cell. It improves our ability to study living, unpigmented cells in biological and medical research. Many dyes and stains stop chemical processes in cells which means the phase contrast microscope has improved our ability to see detail in living cells, e.g. the process of cell division. Frits Zernike was awarded with the Nobel Prize in Physics, 1953 for the development of phase contrast illumination.

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4 The Electron Microscope

The electron microscope provides greater detail about cell structure. The electron microscope sends a stream of electrons through a vacuum. The electron beam is focused by electromagnets, magnified by an objective lens and projected onto a fluorescent screen or photographic film. Since the beam of electrons has a much shorter wavelength than visible light resolution is greatly improved, e.g. approximately 0.002 nm, although in practical situations it can be limited to 2 nm. Typically they provide a resolution of 0.5 nm (400 times better than a light microscope) and magnify up to 500 000 times.

Transmission electron microscopes

The transmission electron microscope (TEM) uses the same basic principles as the light microscope with a beam of electrons passing through the specimen instead of a beam of light. The TEM is used to study the internal ultrastructure of cells. The specimen is stained with heavy metal atoms which attach to particular cellular structures, preserved by a chemical fixative, embedded in plastic then cut into exceedingly thin slices (50 to 100 nm). You can see objects to the order of several nanometres (10^{-9} m) increasing the capacity for medical, biological and materials research. Many organelles were discovered using the TEM, e.g. ribosomes. One of the main disadvantages of the TEM is that the method of specimen preparation kills the cells and the specimen is viewed in a vacuum. This means living cells cannot be viewed. Specimen preparation also produces artefacts and structural features that do not exist in living cells.

Table 4.1 Features of the electron microscope.

Feature	Electron microscope
Magnification	Up to 300 000×.
Resolution	Approximately 0.0005 μm.
Stains	Heavy metal stains identify substances, structures and provide contrast for easier viewing. No colour stains.
Living specimen	The electron microscope does not allow viewing of living cells.
Mounting	Metal background in a vacuum chamber.
Focusing	By electromagnetic lenses.
Energy source for viewing	A beam of electrons is passed through the specimen.

Scanning electron microscopes

The scanning electron microscope (SEM) emits an electron beam which is rapidly passed back and forth over the surface of the specimen. Surface variations alter the pattern of the scattering of the electrons and the pattern is recorded, amplified and transmitted to a TV monitor. This gives a three-dimensional detailed view of the surface of the specimen. The image has great depth of field.

QUESTIONS

1. Outline why the electron microscope has better resolution than the light microscope.
2. Outline the basic principle behind the operation of an electron microscope.
3. Construct a table to compare the advantages and disadvantages of a light microscope.
4. Discuss the importance of the transmission electron microscope.
5. Discuss the importance of the scanning electron microscope.
6. Identify the type of microscope that was used to view each of the following.

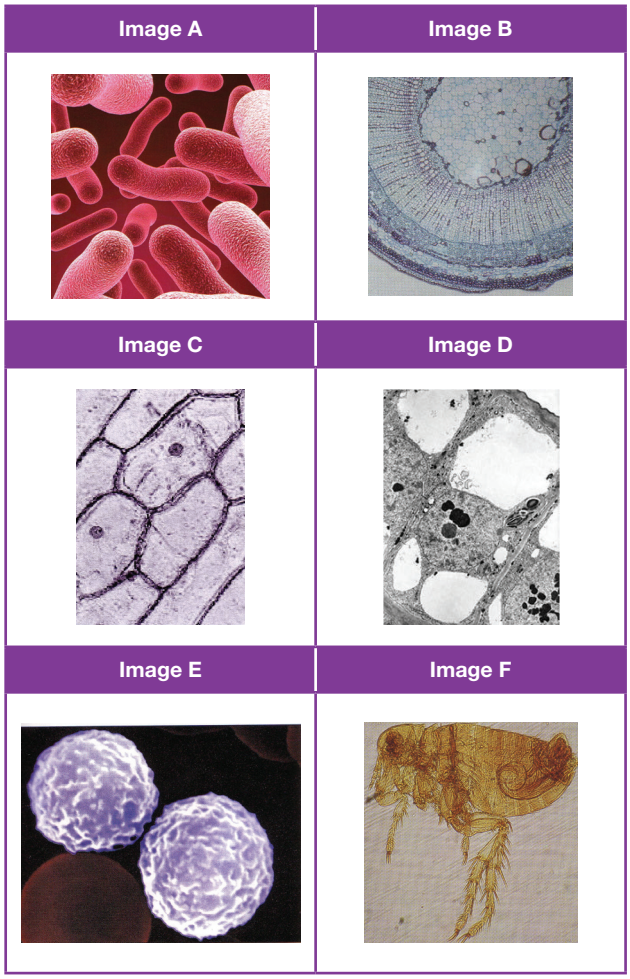

Figure 4.1 Images from different types of microscopes.

7. What is the limit of resolution of a transmission electron microscope?
   (A) 0.5 centimetres.
   (B) 0.5 millimetres.
   (C) 0.5 micrometres.
   (D) 0.5 nanometres.

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8 Experiment – Making a Wet Mount

Many specimens are mounted in water, 50% glycerine or some other medium before they are studied under a light microscope. The refractive index of the mounting medium allows a better examination of detail than studying a dry sample. The cover slip reduces the reflecting surfaces and keeps the specimen from quickly drying out under the heat of the light.

Steps in preparing a wet mount

1. Clean a glass microscope slide and cover slip by holding the sides and making sure you do not leave fingerprints on either object.
2. Place the thin section specimen to be studied in the centre of the slide.
3. Place a drop of water (or whichever medium you are using) on the specimen.
4. Place the edge of the cover slip on the slide so that it is just touching the edge of the medium. This causes the medium to spread along the edge of the cover slip.
5. Use a needle to lower the cover slip over the specimen (see Figure 8.1).

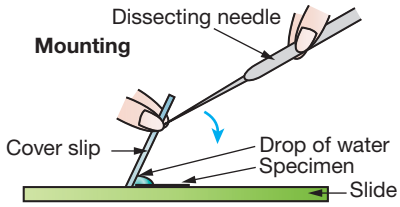

Figure 8.1 Making a wet mount.

6. Dry the slide if any medium has overflowed from beneath the cover slip. A specimen should never be 'floating' beneath the cover slip in too much medium. Too little medium can lead to many air bubbles which means a new slide will have to be made.

Staining

Specimens are stained to provide contrast and to identify specific chemicals or structures. The stain may be applied directly to the specimen, e.g. a drop of iodine solution is placed on the specimen instead of a drop of water, or the stain may be applied by irrigation. The irrigation technique is used if you wish to observe the specimen before and after staining. To irrigate a slide you place a piece of paper towelling or tissue on one side of the cover slip and using a dropper place one drop of the dye on the other side of the cover slip. You can observe the movement of the dye across the slide while looking down the eyepiece. Table 8.1 summarises the uses of some common dyes used in school microscopy.

Table 8.1 Common dyes.

Stain	Its Use
Iodine solution	A weak solution of potassium iodide is the distinguishing test for starch (solution turns from yellow to blue/black). In plant cells lignified cell walls stain various colours of golden brown while cellulose walls remain unstained. It makes the nucleus more visible.
Toluidine blue	Is a 'double stain'. It is a blue solution that reacts with cations in plant materials to give several different staining reactions. Polyphenolic compounds, e.g. lignin and tannins stain green, greenish-blue or bright blue, e.g. xylem stain green. Pectic acids stain pinkish-purple, e.g. carbohydrate walls of parenchyma. Nuclei become visible and it does not stain cellulose or starch.
Phloroglucinol and HCl	Is a specific test for lignin staining lignified walls bright red.
Neutral red	Stains primary cell walls and is often used as a counterstain in combination with other dyes.
Methylene blue	Is used to stain animal cells and shows the nucleus and cytoplasmic granules, e.g. staining cheek cells and blood films.

QUESTIONS

1. Explain why it is important to use a needle to lower the cover slip onto the specimen.
2. If care is not taken when preparing the wet mount, there may be numerous air bubbles present. Describe the appearance of an air bubble.
3. For each of the following situations, identify the cause of the problem with the slide.
   (a) The specimen keeps 'floating' and moving out of focus.
   (b) Individual cells are not distinct and the image remains blurry when the fine adjustment knob is used to focus up and down.
   (c) Thick black lines rim around the specimen and the image is unclear beyond these lines.
4. Figure 8.2 shows a section of onion epithelium stained with iodine.

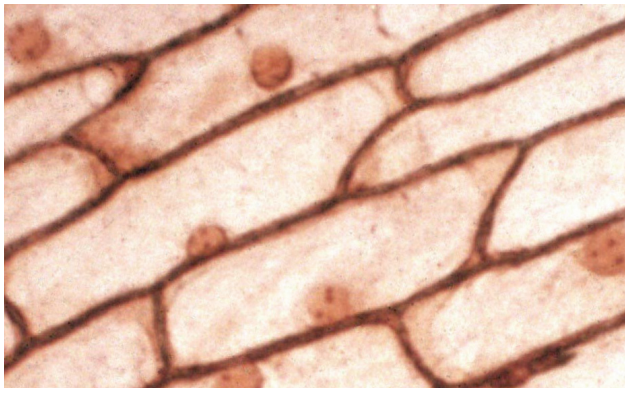

Figure 8.2 Onion epithelium.

Identify the structures that are visible in this section.

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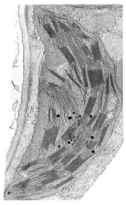
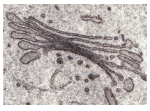
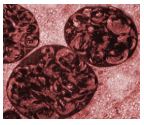
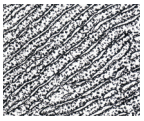
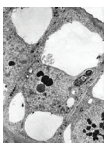
24 Cell Organelles Summary

All cells have a **cell membrane**. The **cytoplasm** is the entire contents of the cell inside the cell excluding the nucleus. The semifluid part of the cytoplasm is the **cytosol**. Cell organelles are specialised structures found in the cell.

Table 24.1 Summary of cell organelles.

Organelle	Its structure	Its function
Mitochondria 	Mitochondria are oval shaped with a double membrane. The inner membrane is highly folded (folds called cristae) to increase surface area for site of chemical reactions.	It is the site of aerobic respiration and where most ATP (adenosine triphosphate) is generated.
Chloroplast 	Chloroplasts have a double membrane with stacks or grana containing chlorophyll to trap sunlight. The grana are in a proteinaceous matrix (stroma).	It is the site for photosynthesis in plant cells converting sunlight energy to chemical energy stored in sugar.
Golgi body 	Is a single membrane structure with sacs stacked like pancakes. Vesicles contain macromolecules, e.g. enzymes, hormones and pinch off from the stack.	Modification of lipids and proteins and storage and packaging of materials for export from the cell.
Lysosome 	A membrane bound organelle containing enzymes and are produced in Golgi bodies.	Pick up and break down unwanted materials or foreign invaders, e.g. old organelles, bacteria, food.
Endoplasmic reticulum 	Network of internal membranes, tubules and vesicles which increase in number as the cell becomes more active in protein synthesis.	It is involved in the transport of materials in the cell, the site of synthesis of many proteins and lipids and connects the cell membrane with the nuclear membrane.
Ribosome  Black dot on ER	Very small, spherical granules made of RNA and protein often attached to endoplasmic reticulum.	It is the site of polypeptide and protein synthesis.
Vacuole 	A fluid-filled membrane bound sac. In animals they are usually small, but in plants can be large.	Variety of functions, e.g. storage, digestion or water removal. Involved in turgor pressure in plant cells.

QUESTIONS

1. Define cytosol.
2. List the parts of the cell that are involved in the membrane system of the cell.
3. Identify the organelles involved in collecting or releasing energy.
4. Explain why cells that have a high rate of protein synthesis have a very large number of ribosomes present in the cytosol.
5. In plant and animal cells, the endoplasmic reticulum (ER) makes up more than half the total membrane of the cell. The tubules (cisternae) of ER have an internal space called the ER lumen (cisternal space). The ER membrane connects with the nuclear membrane so that the ER lumen is continuous with the space between the two membranes of the nuclear membrane.
   Suggest why there is a need to connect the nuclear membrane to the membrane system in the cytosol.
6. Name the form of energy produced by cellular respiration.
7. (a) What is the function of vacuoles?
   (b) Compare the vacuoles found in plant cells and in animal cells.
8. Which of the following organelles is involved in the breakdown of unwanted materials?
   (A) Golgi bodies. (B) Mitochondria.
   (C) Ribosomes. (D) Lysosomes.
9. The diagram shows a section of a cell.

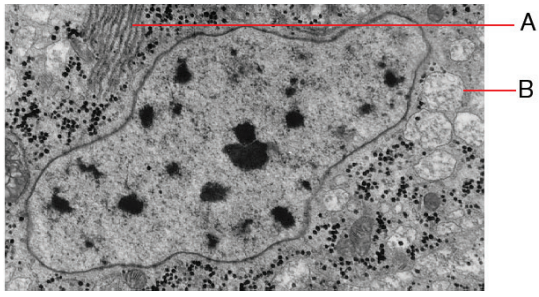


Figure 24.1 Section of a cell.

What are structures A and B?

	Structure A	Structure B
(A)	Endoplasmic reticulum	Nucleus
(B)	Golgi body	Lysosome
(C)	Endoplasmic reticulum	Lysosome
(D)	Golgi body	Mitochondria

10. Which of the following organelles is involved in the packaging and export of materials from a cell?
    (A) Golgi bodies. (B) Mitochondria.
    (C) Ribosomes. (D) Lysosomes.

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Frye and Edidin

In 1970 Frye and Edidin used fluorescent dye-labelling techniques to conclusively demonstrate the notion of fluidity of the cell membrane. In their experiments they fused human and mouse cells in culture to produce human-mouse cell hybrids and used antibodies labelled with fluorescent dyes to identify the proteins of mouse or human origin. They found that immediately after fusion the human and mouse proteins were to be found in separate halves of the hybrid cells. Then after a short time and incubation at 37°C the human and mouse proteins were intermixed over the cell surface. They thus showed that the proteins in the cell membrane could move from place to place on the cell membrane.

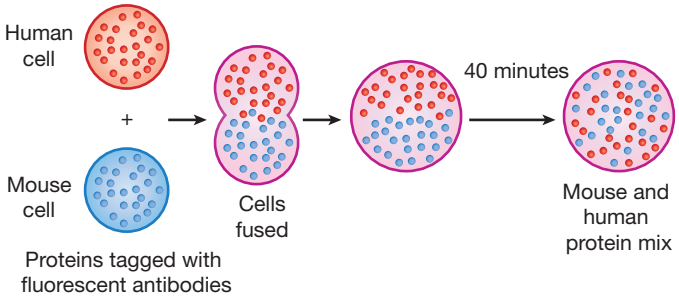

Figure 25.2 Frye and Edidin experiment.

Jonathan Singer and Garth Nicolson

In 1972 Singer and Nicolson proposed the **fluid mosaic model** of the cell membrane. This model kept the lipid bilayer and suggested that the proteins were macromolecules embedded in the bilayer going partway or completely across the membrane. They distinguished between **peripheral proteins** which dissociate from the membrane when the membrane is treated with polar reagents, e.g. extreme pH or high salt and **integral membrane proteins** which are inserted in the membrane and can only be dissociated with reagents that are detergents which displace the membrane lipids.

More recent research

More recent research has shown the presence of a carbohydrate layer on the outer surface of the cell membrane known as the **glycocalyx**. The glycocalyx consists of specific carbohydrates that form complexes with membrane proteins (**glycoproteins**) and membrane lipids (**glycolipids**). The glycocalyx is involved in the protection of the cell surface and different complexes act as markers for cell-cell interactions, e.g. interactions between leucocytes (white blood cells) with endothelial cells of blood vessels which can lead to the inflammatory response if the endothelial cells are injured. There is also ongoing research into the structure of channel proteins in the membrane. There is also research into the structure of other membranes relating structure to function.

A study of different membranes has shown that all membranes are not identical with membrane thickness varying from 5 to 10 nm depending on the location of the membrane. Different membranes have different proteins and carbohydrates or similar proteins and carbohydrates but in different proportions, e.g. the cell membrane has more cholesterol than other membranes and the mitochondrial membrane has more proteins than other membranes.

QUESTIONS

1. Explain why 19th century scientists knew that the cell membrane existed but did not clearly describe its structure.
2. Explain why 19th century scientists knew that plant cells had a barrier around the cell contents besides the cell wall.
3. Construct a table to summarise the work of Traube, Quincke, Overton, Fricke, Gorter and Grendel, Danielli, Robertson, Mueller and Rudin, Frye and Edidin and Singer and Nicolson.
4. In the Singer and Nicolson proposal, what is the difference between peripheral and integral membrane proteins?
5. What is the glycocalyx?
6. The diagram shows a model of the cell membrane that was proposed in 1935.

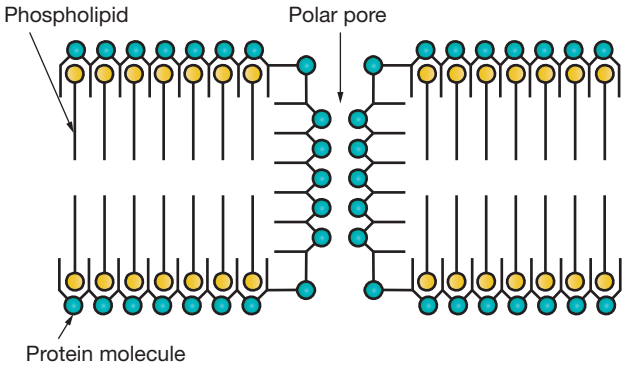

Figure 25.3 Model of cell membrane proposed in 1935.

Who proposed this model?
(A) Traube.
(B) Danielli.
(C) Mueller and Rudin.
(D) Singer and Nicolson.

7. What is the name of the current model of the cell membrane?
(A) Lipid monolayer model.
(B) Glycocalyx model.
(C) Unit membrane model.
(D) Fluid mosaic model.

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- **Membrane receptor proteins** – communicate with the environment, e.g. they can receive a signal from a hormone, neurotransmitter, cytokine or growth factor which triggers the cell to carry out a specific internal response, e.g. signals the nucleus to begin gene expression to start the synthesis of a particular protein.
- **Membrane enzymes** – some enzymes that modify molecules needed near the cell surface are found on either side of the cell membrane.

Signal transduction

Signal transduction occurs when an extracellular molecule activates an IMP receptor in the cell membrane. The receptor sends the message into the cell. The message may signal the activation of a particular gene to start gene expression to make a particular protein or the message may alter specific chemical reactions in the cell and alter cell metabolism.

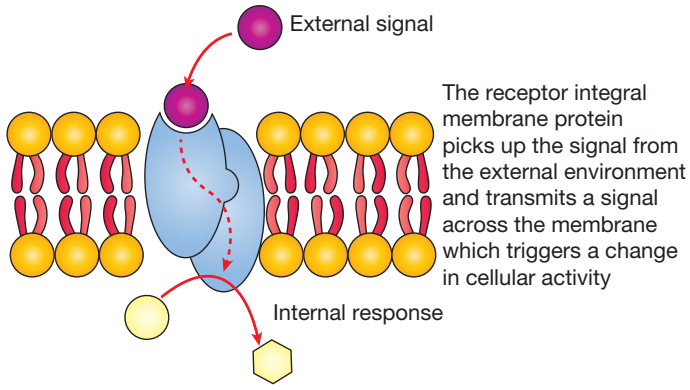

Figure 26.5 Fluid mosaic model.

Diffusion across the cell membrane

Molecules soluble in lipids, e.g. oxygen and carbon dioxide, dissolve in the phospholipid bilayer and diffuse across the membrane. Molecules not soluble in lipids, e.g. water, also diffuse across the cell membrane through small transitory openings made by the movement of the fluid lipids. **Aquaporins** are integral membrane proteins that form pores in the membrane that act as water channels allowing the fast movement of water in or out of the cell.

Facilitated diffusion across the cell membrane

Many compounds need to combine with a particular 'carrier' molecule to cross the membrane. As the carrier molecule moves across the membrane, it transports the molecule with it, e.g. large water-soluble molecules such as amino acids and simple sugars combine with transport integral proteins.

If energy is used to move a chemical against a concentration gradient, it becomes active transport across the membrane.

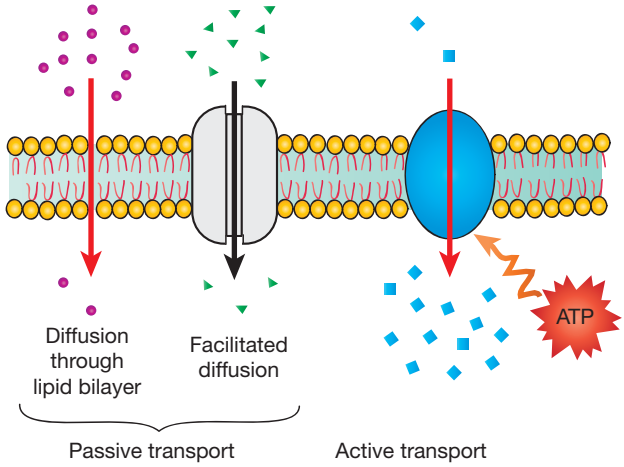

Figure 26.6 Transport across the cell membrane.

QUESTIONS

1. What is meant by semipermeable?
2. Who proposed the fluid mosaic model of the cell membrane?
3. Describe the structure of the cell membrane.
4. What is the function of carbohydrates on the surface of the cell membrane?
5. Why is the model called the 'fluid' model?
6. What is the importance of the 'kinks in the unsaturated hydrocarbon tails of phospholipids?
7. Outline what happens to lipids at low and high temperatures.
8. Outline the benefits of lipids having high amounts of unsaturated hydrocarbons.
9. What are integral membrane proteins?
10. Construct a table to summarise the action of three types of proteins associated with the cell membrane.
11. Describe how water crosses the cell membrane.
12. Describe how water soluble amino acids cross the cell membrane.
13. When is active transport involved in the movement of substances across the cell membrane?
14. Explain why some substances cannot cross the cell membrane.
15. What is the name of the current model of the cell membrane?
    (A) Fluid mosaic. (B) Biprotein layer.
    (C) Trilipid layer. (D) Drifting protein.
16. How does most water cross the cell membrane?
    (A) Active transport.
    (B) Attached to a large carrier protein.
    (C) Dissolving in the phospholipid layer.
    (D) Diffusion through aquaporins.

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Osmosis

Osmosis is a type of diffusion. It is the movement of water from an area of high concentration of water to an area of low concentration of water across a semipermeable membrane. (*Note*: In chemistry osmosis refers to the net movement of any solvent, not just water.)

The process of osmosis is highly important in osmoregulation. **Osmoregulation** is the active regulation of the osmotic pressure of body fluids so they do not become too dilute or concentrated in particular areas. **Osmotic pressure** is the pressure needed to stop the flow of water across a semipermeable membrane. The **water potential** is the physical property that predicts the direction in which water will flow and is determined by the solute concentration and the applied pressure.

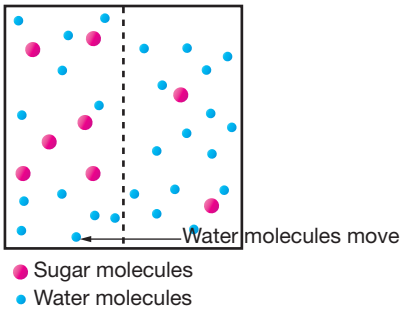

Figure 29.4 Osmosis.

QUESTIONS

1. Define diffusion.
2. Why does diffusion occur?
3. What is meant by a concentration gradient?
4. During diffusion, how do the particles move with respect to the concentration gradient?
5. How does the size of the particle affect the rate of diffusion?
6. How does temperature affect the rate of diffusion?
7. What is the relationship between the rate of diffusion and how far the particle has to travel?
8. Define permeability.
9. Define solubility.
10. If two molecules, one water soluble and one lipid soluble had equal size, which one would more easily pass through a cell membrane?
11. For two lipid soluble molecules, would a small molecule or a large molecule have the fastest rate of diffusion?
12. Identify two substances that enter the human body by diffusion.
13. Define osmoregulation.
14. What is meant by the water potential?
15. Define osmotic pressure.
16. In an aqueous solution of glucose, what is the solvent and what is the solute?
17. Glucose has the formula $C_6H_{12}O_6$ while sucrose has the formula $C_{12}H_{22}O_{11}$. Explain why when carrying out experiments using dialysis tubing to show that some substances can cross a membrane while other substances cannot cross the membrane you need to use an aqueous sucrose solution and not an aqueous glucose solution.
18. The diagram shows an animal cell in a container filled with distilled water

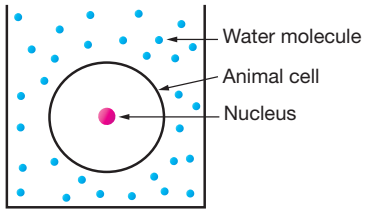

Figure 29.5 Animal cell in a container of water.

(a) What would you expect to happen to the animal cell? Explain your answer.
(b) If it was a plant cell in the container, would the result be the same? Explain your answer.

19. The kidney can change the permeability of the collecting duct. How does this assist excretion for the body?
20. In plants sugar (sucrose) is loaded into the phloem against a concentration gradient. Explain why water follows the sugar into the phloem.
21. Which of the following does *not* cross the cell membrane by simple diffusion?
(A) Carbon dioxide. (B) Glucose.
(C) Ethanol. (D) Oxygen.
22. The diagram shows the results of an experiment using dialysis tubing.

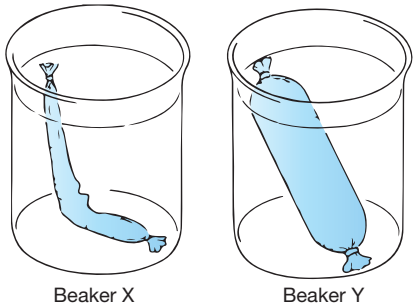

Figure 29.6 Experiment using dialysis tubing.

Pure distilled water and sucrose solution were used in setting up the equipment. Which of the following best accounts for the results of this experiment?
(A) Sucrose solution was in bag Y with distilled water outside and water moved out of the bag by osmosis.
(B) Sucrose solution was in bag X with distilled water outside and water moved out of the bag by osmosis.
(C) Water was in bag Y with sucrose solution outside and water moved into the bag by osmosis.
(D) Water was in bag X with sucrose solution outside and water moved out of the bag by osmosis.

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33 Experiment – Plasmolysis

Plasmolysis occurs in cells with cell walls when the cytoplasm shrivels and the plasma membrane pulls away from the cell wall. This occurs when the cell is in a hypertonic environment and is due to osmosis. At the moment the protoplast begins to pull away from the cell wall and the cell is beginning to plasmolyse, there is zero internal pressure. The osmotic pressure in a plant is highly important in providing support if there is non-woody tissue and in the transport of substances throughout the plant. The walled cells of bacteria and fungi can also plasmolyse in hypertonic solutions.

Experimental method

To observe plasmolyis using a light microscope you need to make a wet mount of red onion skin. You must make sure you peel the red layer as the pigmented cells dramatically show the change when the cells are irrigated with a hypertonic solution.

The onion skin needs to be mounted with a drop of water (see Figure 33.1).

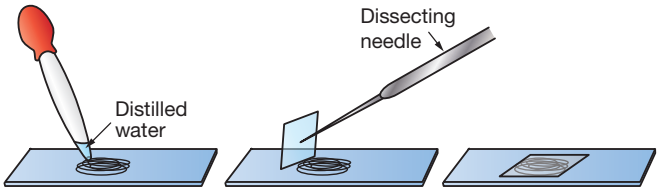

Figure 33.1 Making a wet mount.

Once you have observed the wet mount under low power and high power and drawn your observations you need to irrigate the cell with a concentrated salt solution.

To irrigate the slide you need to place paper towelling or tissue on one side of the cover slip and place a drop of the concentrated salt solution on the other side of the cover slip. (see Figure 33.2). Look down the eyepiece and watch happens as the salt solution is drawn across the slide.

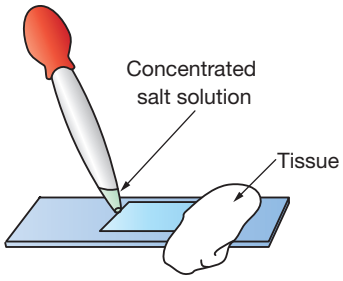

Figure 33.2 Irrigating a slide.

It is important to observe the change and watch the cell membrane move away from the cell wall in plasmolysis.

Experimental results

Figure 33.3 shows plasmolysed cells viewed under a light microscope, high power (400×).

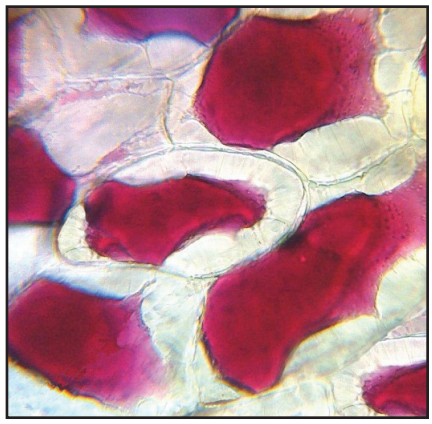

Figure 33.3 Plasmolysed cells under a light microscope HP.

QUESTIONS

1. Define plasmolysis.
2. When does plasmolysis occur?
3. Discuss the difference between a turgid plant cell and a plasmolysed plant cell.
4. Which groups of organisms, besides plants, experience plasmolysis?
5. What happens when cells become ‘flaccid’?
6. Explain why it was important to use a red onion rather than a ‘normal’ onion.
7. Why is it important to view the slide as it is being irrigated?
8. Figure 33.4 shows three cells. The cells are from the same plant and each was placed in a solution with a different salt concentration.

Figure 33.4 Plant cells.

Correctly match the cell to the solution in which it was placed.

	Cell X	Cell Y	Cell Z
(A)	Hypertonic solution	Hypotonic solution	Isotonic solution
(B)	Hypotonic solution	Isotonic solution	Hypertonic solution
(C)	Isotonic solution	Hypotonic solution	Hypertonic solution
(D)	Hypertonic solution	Isotonic solution	Hypotonic solution

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35 Active Transport

Active transport involves the movement of substances across a membrane against a concentration gradient. This process requires energy usually in the form of ATP which is supplied by respiration.

Active transport and the cell membrane

Transporter proteins (pump proteins) in cell membranes carry out active transport. The transporter proteins are all carrier proteins. Figure 35.1 shows active transport across a membrane.

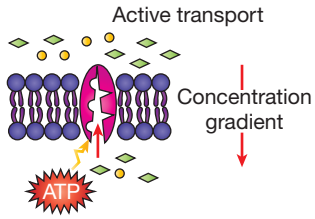

Figure 35.1 Active transport across a membrane.

There are many different transporter proteins, e.g. plant roots absorb potassium and other ions by active transport and neurons have a sodium/potassium pump which pumps potassium ions in and sodium ions out by active transport as part of a nerve impulse. Active transport is also involved in moving ions against an electrochemical gradient. An electrogenic pump is a transporter protein that generates voltage across a membrane, e.g. the sodium/potassium pump in neurons.

Endocytosis

Cytosis is the passage of large 'packages' of material across a membrane. The materials are large and cannot move across by diffusion or with the assistance of carrier or channel proteins. Endocytosis is a process where a cell takes in macromolecules by forming vesicles from the plasma membrane. If the substance is liquid, it is called **pinocytosis** while if the substance is solid it is called **phagocytosis**. Endocytosis requires an energy input and is a form of active transport. Figure 35.2 shows the two types of endocytosis.

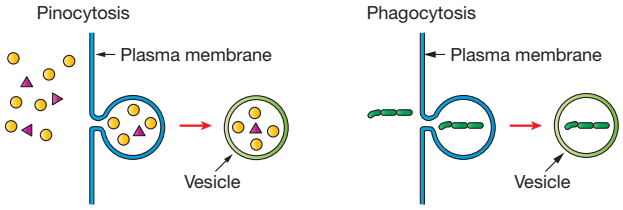

Figure 35.2 Endocytosis.

Exocytosis

Exocytosis is the process when vesicles inside the cell fuse with the cell membrane and the contents of the vesicle are secreted from the cell. Exocytosis requires an energy input and is a form of active transport. Figure 35.3 shows exocytosis.

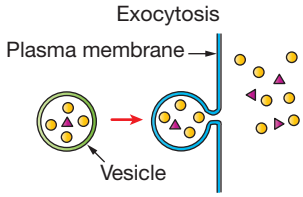

Figure 35.3 Exocytosis.

QUESTIONS

1. Define active transport.
2. What is an electrogenic pump?
3. Define cytosis.
4. Distinguish between endocytosis and exocytosis.
5. Distinguish between pinocytosis and phagocytosis.
6. Construct a table, with a column for a diagram, to compare the different types of transport across a membrane.
7. Figure 35.4 shows a biological process that occurs in cells.

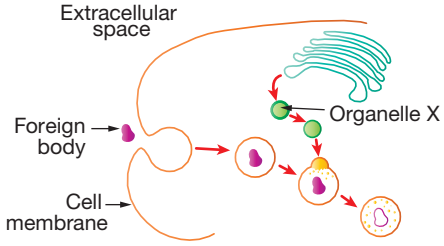

Figure 35.4 A biological process.

   (a) Identify the process that is happening to the foreign body.
   (b) Describe this process.
   (c) Identify organelle X and describe what it is doing.

8. Figure 35.5 shows a sodium-potassium pump.

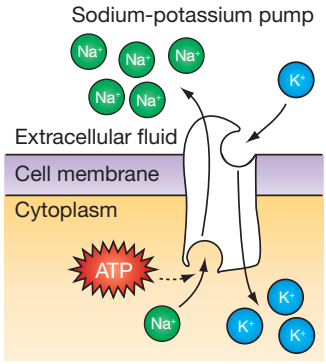

Figure 35.5 Sodium-potassium pump.

   Describe what is happening in this process.

9. Which cells produce ATP?
   (A) Only cells with a nucleus.
   (B) Only plant cells and animal cells.
   (C) Only animal cells.
   (D) All living cells.

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Surfing VCE Biology Unit 1

37 Rates Of Binary Fission

There can be a rapid procession of prokaryotic cells through their cell cycle by binary fission. Some species under favourable conditions can produce a new generation within 15 to 20 minutes, while other species can take much longer to produce a new generation, e.g. 24 hours. The spirochete bacteria *Treponema pallidum* when grown in ideal conditions reproduces in 33 hours.

Since one prokaryote divides into two, the growth rate is exponential, i.e. 2 cells become 4, then 8, 16, 32 etc.

However, in cultures and real situations a colony does not always grow at an exponential rate. When first exposed to new conditions there is often an inoculation period or lag time when the cells are adapting to the new conditions. The cells may be growing in size, increasing metabolic activity and/or synthesising new components, e.g. proteins, RNA. The cells will then reproduce by binary fission with an exponential growth rate. There is then a stationary stage as the cells use up their food supply, the release of metabolic wastes introduces toxins and poisons, the prokaryote has to compete with other micro-organisms for resources or they are consumed by other organisms. The graph shows the growth of the bacteria *Escherichia coli* in culture with explanations of why the number of cells in the culture changes over time. *E. coli* is a gram negative, facultative anaerobic, rod shaped bacterium found in the lower intestine of many endotherms. It is often used in laboratory experiments and is used as an indication of sewage pollution in water resources. Under favourable conditions it can reproduce in 20 minutes.

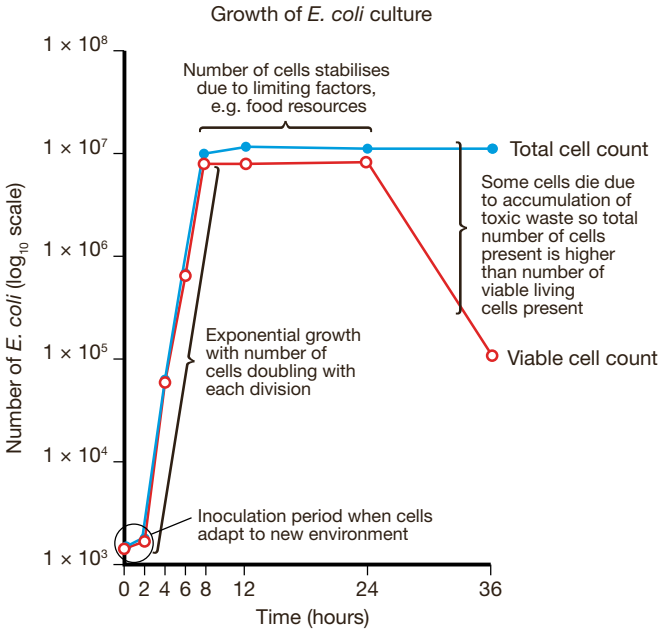

Figure 37.1 Growth rate of *E. coli* in culture.

Genetic diversity

Reproduction by binary fission means that offspring cells are genetically identical to the parent cell. However, the fast procession through the cell cycle by the prokaryotes means that errors in DNA replication, e.g. by spontaneous mutations such as point substitutions, deletions, insertions occur and can lead to increased genetic diversity of the prokaryote within a short time. In a study at Michigan State University 20 000 generations were followed over 3000 days. The results showed that the bacteria populations accumulated beneficial mutations and rapidly evolved when confronted by environmental selective pressures.

Formation of endospores

Many prokaryotes form endospores when conditions become less favourable, e.g. their environment lacks particular essential nutrients. In this process a copy is made of the original chromosome and it is surrounded by a tough, multilayered structure that forms the endospore. Water is removed from the endospore stopping its metabolism. The original cell then lyses and the endospore is released to survive the harsh conditions, e.g. many endospores can survive exposure to boiling water. The endospore stays dormant until the return of favourable conditions, e.g. suitable temperature and water availability.

QUESTIONS

1. How quickly can prokaryotes reproduce?
2. What is exponential growth?
3. Describe *Escherichia coli*.
4. Explain why *E. coli* is often used in laboratory experiments.
5. The probability of a spontaneous mutation occurring in a given *E. coli* gene averages around one in 10 million (1×10^7) per cell division.
   (a) If *E. coli* in a human intestine produce 2×10^{10} new cells each day, how many bacteria in the intestine will have a mutation in that gene?
   (b) If there are 4300 genes on the *E. coli* chromosome, how many mutations occur per human host per day?
   (c) Explain why populations of *E. coli* can rapidly evolve when confronted by new environmental selective pressures.
6. What is an endospore?
7. What is the evolutionary significance of endospores?
8. If the gram positive bacteria *Staphylococcus aureus* has a generation time of 30 minutes, how long would it take for one bacterium to divide by binary fission to become a colony of over one million cells?
   (A) 10 hours (B) 20 hours
   (C) 10 days (D) 20 days

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Cytokinesis in plant and animal cells

Cytokinesis is the division of the cell's cytoplasm following the division of the nucleus. Cytokinesis is important because it stabilises the internal concentration of materials in the two new cells.

The cell organelles are evenly divided and distributed between the two daughter cells. Each new cell needs sufficient organelles such as mitochondria, ribosomes and endoplasmic reticulum so that it can grow and carry out the processes of living.

In **animal cells** a cleavage furrow begins at the centre of the cell. The cell membrane constricts with the help of a contractile ring of microtubules and microfilaments which appear near the cell surface and contract. Cleavage continues as the cell membrane continues to be pinched in until they are separated into two segments. Plants cannot do this as they have rigid cell walls.

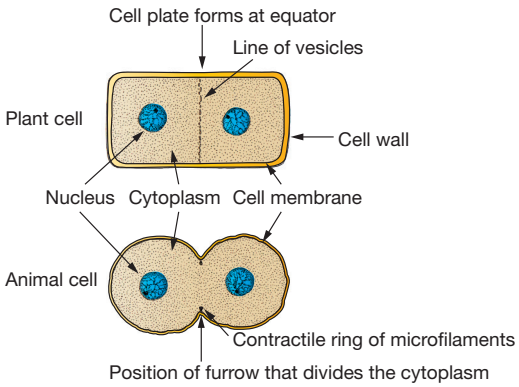

Figure 39.2 Cytokinesis.

In **plant cells**, a cell plate forms during telophase across the mid-line of the parent cell. The cell plates forms by the coalescence of tiny vesicles. These vesicles were made by Golgi bodies and contain the components of the cell wall and the cell membrane. The vesicles fuse and the plate grows outward from the centre of the cell, forming two membranes that become the two new cell membranes. The new cell walls form between these membranes.

QUESTIONS

1. (a) Define mitosis.
   (b) Explain why mitosis is vital for multicellular organisms.
2. (a) Define cytokinesis.
   (b) Explain why cytokinesis is important.
3. Outline the role of mitosis.
4. Which organelles contain DNA?
5. During the 'resting' phase of the cell cycle, is the cell really 'resting'?
6. Describe how cytokinesis is different in plants and animals.
7. How are the cell organelles divided between the two new daughter cells?
8. Describe the appearance of a cell at the beginning of mitosis.
9. Briefly outline the process of mitosis.
10. Describe spindle fibres and their function.
11. When will cells divide?
    (A) The surface area to volume ratio becomes too large.
    (B) Nutrients cannot efficiently reach all parts of the cell by diffusion.
    (C) Membrane surface area is too large to efficiently support cellular metabolism.
    (D) Wastes leave the cell too quickly.
12. A scientist was observing a cell undergoing mitosis. Which event would show it was a plant cell rather than an animal cell?
    (A) Formation of cell plate.
    (B) Cleavage of the cytoplasm.
    (C) Spindle fibres attach to centrioles.
    (D) Formation of chromatids.
13. A cell with 14 chromosomes undergoes mitosis. How many chromosomes will be in each daughter cell?
    (A) 7 (B) 14 (C) 21 (D) 28
14. The diagram shows mitosis and interphase.

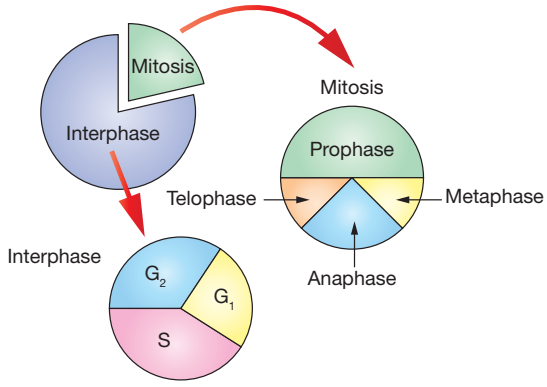

Figure 39.3 Interphase and mitosis.

From this diagram what is the longest phase of mitosis?
(A) S phase.
(B) Interphase.
(C) Prophase.
(D) Anaphase.

15. Which organelle produces the vesicles that contain the components of the cell wall and cell membrane for cytokinesis in plant cells?
    (A) Mitochondria.
    (B) Chloroplasts.
    (C) Nucleus.
    (D) Golgi bodies.

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In mammals **adult stem cells** are found in several locations. These cells generate specific cell types and can self-renew. During mitosis in **asymmetric division** a stem cell will produce one identical daughter cell and a more specialised daughter cell that will become further specialised.

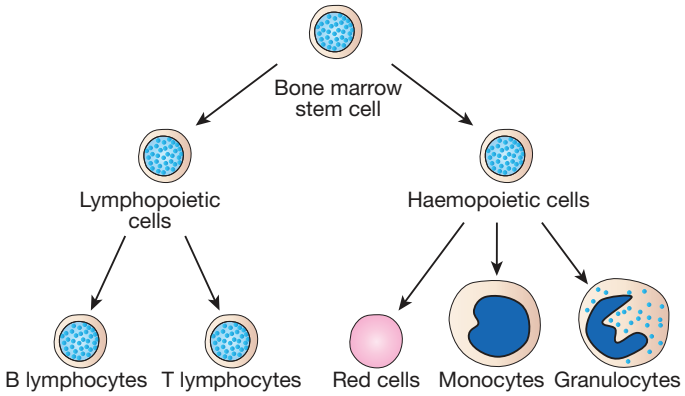

Figure 41.3 Cell types from bone marrow.

Summary of mitosis

Mitosis involves a series of stages. At the beginning of mitosis the nucleus is surrounded by the nuclear membrane. The genetic material has already duplicated, during the S phase, but cannot be seen as the chromosomes have not condensed. During mitosis the chromosomes become visible as two sister chromatids, the chromatids line up at the equator of the cell, the two sister chromatids separate to become chromosomes. The spindle fibres are microtubules with associated proteins which attach to the centromere of the chromatids. During anaphase the microtubules shorten and the chromosome attached to the centromere moves to the pole. Daughter nuclei form at the poles.

Control of mitosis and the cell cycle

The cell cycle involves mitosis and interphase. Interphase consists of three stages – G_1, S and G_2. A group of molecules act in a coordinated manner forming a cell cycle control system. Near the end of the G_1 stage of the cell cycle there is an important checkpoint for mammalian cells. If this checkpoint receives a go-ahead signal the rest of the cycle will continue and the cell will divide. If the checkpoint does not receive the signal the cell switches to a non-dividing state, G_0 phase. Most body cells are in G_0 phase.

QUESTIONS

1. Define mitosis.
2. Define cytokinesis.
3. Explain the importance of mitosis.
4. What is the relationship between specialised cells, unspecialised cells and the ability to divide?
5. Identify some types of cells that lose the ability to divide.
6. List some factors that influence the rate of cell division in cells that retain the ability to divide.
7. (a) What is a stem cell?
   (b) What is the relationship between stem cells and sites of mitosis?
8. Identify the sites of mitosis in plants.
9. (a) What is metamorphosis?
   (b) Draw a flow chart to show the steps in metamorphosis.
10. Outline how mitosis is linked to metamorphosis.
11. Identify some areas in mammals where mitosis is constantly occurring.
12. Where are adult stem cells found in mammals?
13. What happens in asymmetric division of stem cells?
14. Explain why stem cells need to be self-renewing.
15. Name some cell types that come from stem cells in bone marrow.
16. Briefly outline the main steps of mitosis.
17. What are the two main parts of the cell cycle?
18. What is the believed origin of mitosis?
19. Mitosis is part of the cell cycle. How is the cell cycle controlled?
20. What happens if the checkpoint near the end of the G_1 stage receives a go-ahead signal and if it does not receive a signal?
21. Which tissues in a plant would you expect to be undergoing mitosis?
    (A) Xylem. (B) Phloem.
    (C) Cambium. (D) Cortex.
22. Why is mitosis important?
    (A) It provides genetic stability for an organism.
    (B) It allows growth.
    (C) It provides a means to repair damaged tissues.
    (D) All of the above.
23. The diagram shows a section of grass. The shoot tip has an apical meristem and there are intercalary meristems at the nodes.

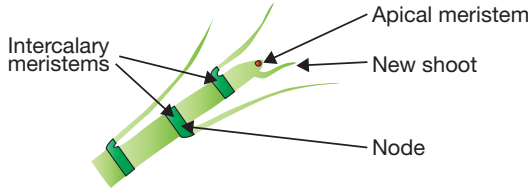

Figure 41.4 Section of grass shoot.

What is the benefit for grass of having intercalary meristems?
(A) The grass will continue to grow after cutting or grazing at the shoot tip.
(B) Woody growth can occur along the whole stem.
(C) Flowers can form between each node.
(D) Specialised cells which produce nectar can form at the nodes to attract pollinators.

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SURFING

VCE BIOLOGY UNIT 1

STUDY DESIGN 2022

Area Of Study 2

How Do Plant and Animal Systems Function?

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61 Water Balance In Vascular Plants

Vascular plants have conducting tissues which are **xylem** for conducting water and mineral ions from the roots to the leaves and phloem which moves the products of photosynthesis around the plant.

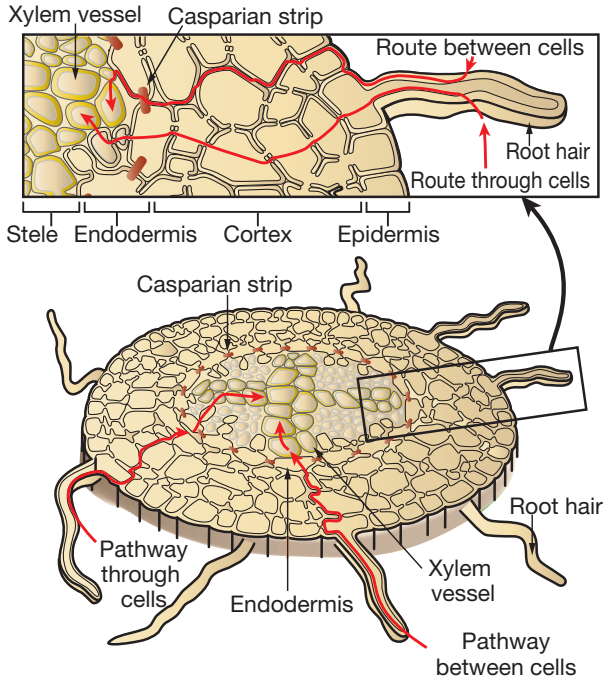

Figure 61.1 Movement of water into a root. Water enters the root hairs and can move through either the cells or the cell walls and intercellular spaces. The Casparian strip blocks movement through these cell walls. In this way, the plant controls the movement of materials into the root, as it has to pass at some stage across the cell membranes.

Absorption of water in root hair cells

Each root hair is an extension of an epidermal cell in the root. The structure of the root hair greatly increases the surface area available for the absorption of water and mineral ions. The root epidermis is not covered in a waxy cuticle like the leaf epidermis, as the root needs to be able to allow water to be easily absorbed across its surface. The inside of a root hair is mainly vacuole with a thin layer of cytoplasm lining the sides. Water usually enters the root hair by osmosis which is passive transport, however under certain conditions the plant may use energy to actively secrete water inwards causing water to be absorbed faster than by simple osmosis. Once the water has entered the root hair it can either move through the cells or between the cell walls and through the intercellular spaces. In the root the Casparian strip is a layer of wax around the endodermis and it blocks movement through these cell walls.

In this way, the plant controls the movement of materials into the centre of the root where the xylem is situated as the water has to pass, at some stage, across a cell membrane. Thus the endodermis, with the Casparian strip, prevents the backflow of water and maintains root pressure.

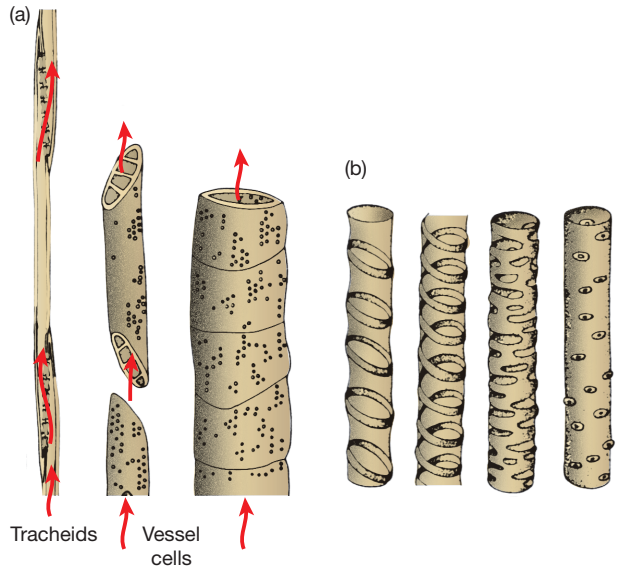

Figure 61.2 Xylem. (a) Xylem consists of the narrower tracheids and the shorter but wider vessels. (b) Secondary thickening of the xylem vessels.

Xylem

Xylem transports water and inorganic ions up the plant from the roots to the leaves. Xylem tissue consists of several types of cells, e.g. **tracheids**, which are long thin cells with tapered, interconnected walls, and **xylem vessel cells**, which do not have end walls and form long tubes. The inner cambium cells differentiate to form xylem. The walls of tracheids and xylem vessel cells have pits to allow the sideways movement of water in or out of the xylem. Lignin thickening on the walls of xylem vessels provides structural support. Movement of water in the xylem is due to a number of factors. Root pressure from the inward movement of water into the xylem forces water up the stem. However, the main force against the pull of gravity, especially in tall trees, is due to **CAT** – short for cohesion, adhesion and transpiration pull. **Cohesion** is the force that holds molecules of the same type together. Water molecules resist being separated from one another so when water at the top is pulled up, the molecules next to them tend to be drawn up, in turn. **Adhesion** refers to the ability of water molecules to stick to other materials, e.g. the very thin walls of the xylem vessels cause capillarity and the water sticks to the sides of the walls. **Transpiration pull** refers to the force caused by the evaporation of water out of a stomate so that the change in concentration in the mesophyll, combined with cohesion, pulls water up and out of the xylem.

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63 Experiment – Movement Of Water In Xylem

Some biology students wished to investigate the movement of materials in xylem. They placed one stick of celery with leaves in a beaker of eosin solution and another stick of celery in a beaker of water and left both to stand overnight. Eosin is a red-orange coloured stain.

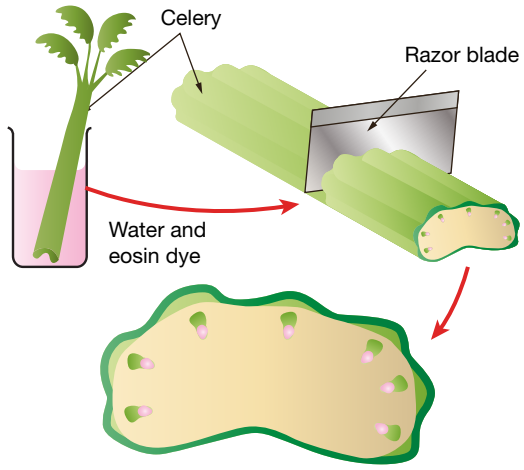

Figure 63.1 Celery experiment.

The next day they cut thin sections from each stick of celery, made a wet mount of each and studied the structures that were visible under a light microscope. They compared the two slides, noting the sections that had become stained red-orange in the slide from the celery that had been in the eosin solution.

The students drew a block diagram to show the location of the different tissues seen under the microscope. They labelled the tissue that had been stained with eosin.

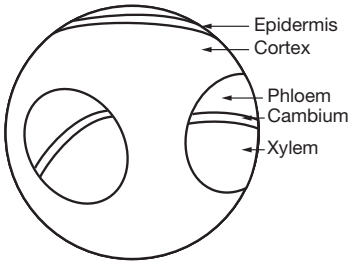

Figure 63.2 Block diagram of tissues in the stick of celery as seen under low power with a light microscope.

QUESTIONS

1. What is eosin solution?
2. Which tissue had been stained with eosin?
3. Identify the material that travels in the xylem.
4. What is the direction of movement of materials in the xylem?
5. What is a vascular bundle in a plant?
6. Identify the tissues that are found in a vascular bundle in a plant.
7. Xylem cells are aligned end to end, forming long tubes. In many cases, the end walls whither away, causing the formation of a continuous tube. The xylem cells die once they reach maturity and lack cytoplasm. Their walls can be thickened with lignin to give strength. Discuss how these features would aid the transport of materials in xylem.

Figure 63.3 is to be used for the next TWO questions. It shows a cross-section of a stick of celery that had been placed in eosin solution and left to stand for several hours.

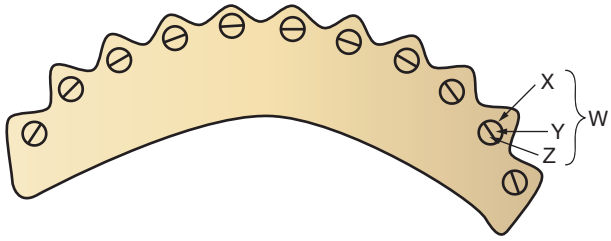

Figure 63.3 Cross-section of celery.

8. Which tissue will be stained red-orange?
   (A) Tissue X. (B) Tissue Y.
   (C) Tissue Z. (D) Tissues X and Y.
9. Which correctly identifies each tissue?

	X	Y	Z
(A)	Xylem	Phloem	Cambium
(B)	Xylem	Cambium	Phloem
(C)	Phloem	Cambium	Xylem
(D)	Cambium	Xylem	Phloem

10. Identify the substance that is often found in the walls of xylem to give strength to the xylem cells.
    (A) Lignin. (B) Glucose.
    (C) Starch. (D) Chitin.
11. Which of the following correctly describes the movement of materials in xylem?
    (A) Water moves up and down the plant.
    (B) Sugars move up and down the plant.
    (C) Sugars move up the plant.
    (D) Water moves up the plant.
12. The walls of many xylem cells have areas called pits, where the wall is thinner. What is the purpose of these pits?
    (A) Increase structural strength of xylem.
    (B) Allow sideways movement of water from one xylem cell to another.
    (C) Allow the entry of sugars from adjacent cells.
    (D) Provide an opening for transpiration.

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66 Feedback Mechanisms

Homeostasis usually involves a feedback mechanism. In a feedback mechanism the response is monitored.

Situation monitored	→	changes made	→	situation reassessed	→	changes made

The response becomes the new stimulus.

Figure 66.1 Feedback mechanism.

In a **negative feedback system** a specific change results in a response opposite to the initial situation. For example, in humans if the body temperature becomes too low (stimulus), the person may start shivering (response). The shivering generates heat and the body becomes warmer (new stimulus). The feedback mechanism monitors the rise in temperature and will cause the **opposite** to the initial response – it will **stop** the shivering.

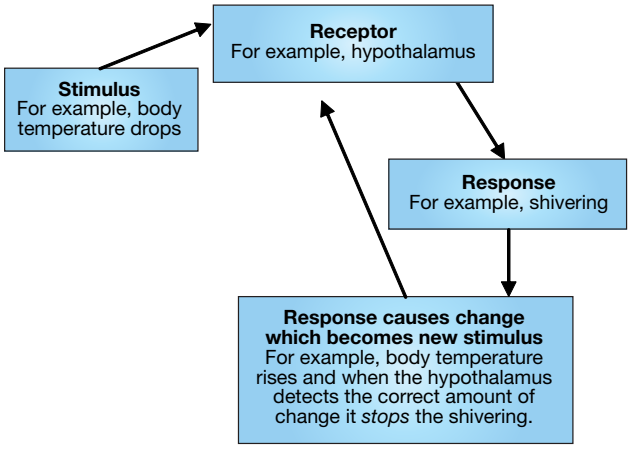

Figure 66.2 Negative feedback mechanism.

In a **positive feedback system** the monitoring will reinforce and amplify the situation, causing more of the same situation to take place. For example, during childbirth oxytocin is released to cause contractions of the uterine muscles and the pressure of the baby's head against the opening of the uterus causes more oxytocin and more contractions. As the baby's head continues to push against the uterus, sensors near the cervix stimulate even more contractions so that the pressure to keep dilating the opening to the uterus increases until the baby is born. Positive feedback is not as common as negative feedback.

QUESTIONS

1. Define feedback mechanism.
2. Compare negative and positive feedback, explaining an example for each.
3. The diagram shows how an air conditioner controls the temperature of a room.

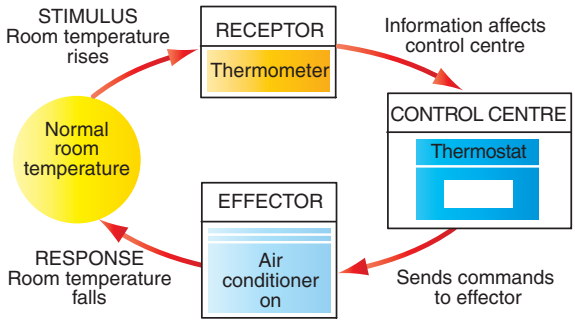

Figure 66.3 How an air conditioner works.

Compare the functioning of the air conditioner with thermoregulation in humans.

4. The diagram shows thermoregulation in humans.

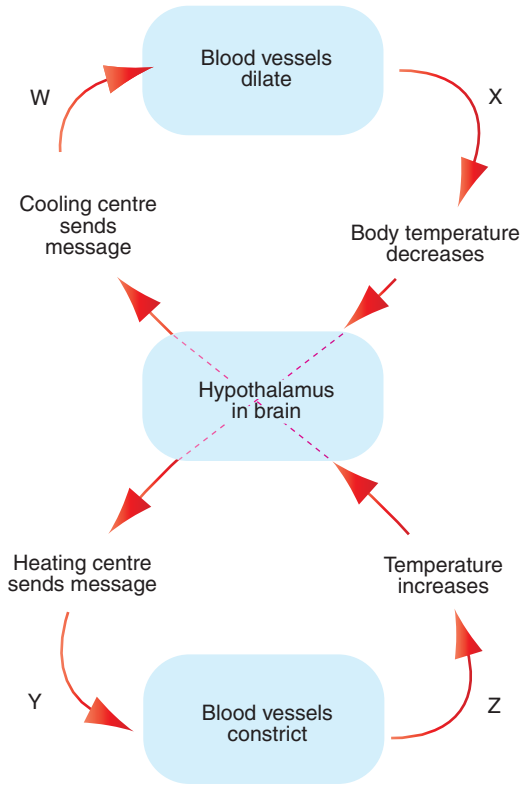

Figure 66.4 Thermoregulation in humans.

Which arrow(s) show negative feedback?

(A) W only. (B) W and Y.
(C) Y and Z. (D) X and Z.

5. When the environmental temperature around a human decreases, receptors in the skin detect the changes and send messages to the hypothalamus which, in turn, initiates a message to the hair erector muscles to contract so the hair can stand up. Which of the following most correctly identifies the type of system involved in this an example?

(A) Positive feedback system.
(B) Negative feedback system.
(C) Enantiostasis.
(D) Stimulus-response system.

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69 Homeostasis and Blood Composition

Water is essential for life. Many compounds and substances dissolve in water and most of the chemical reactions in organisms involve solutes dissolved in water. Water has a high specific heat and helps maintain the temperature of organisms. Water also has a high heat of vaporisation which takes heat from an organism in evaporative cooling.

Water is constantly lost from organisms, e.g. urine, sweat and homeostatic mechanisms are needed to maintain water balance. When the water is lost from the body fluids the dissolved solutes become more concentrated.

The blood circulating through blood vessels transports needed materials to cells and transports wastes from the cells to the excretory organs. As substances are delivered or picked up, the composition of blood changes as it travels around the body and the concentration of different solutes is different in different parts of the body. Homeostasis maintains the composition of fluids within the body within specific ranges.

The small intestine

Glucose, mineral salts, vitamins and some of the products of fat digestion pass through the walls of the villi of the small intestine into the capillaries. Most movement into the capillaries is by diffusion (passive transport) as the concentration of the food molecules is higher in the small intestine than in the capillaries. Sometimes active transport is needed if blood sugar levels are high. The capillaries join veins and the digested food molecules are transported in the blood to the liver in the hepatic portal vein.

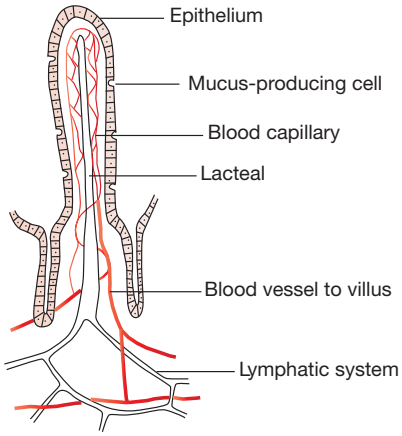

Figure 69.1 Structure of a villus.

A large proportion of the products of lipid digestion, e.g. fatty acids and glycerol move into the lacteal and are transported in the lymphatic system.

The liver

The liver has many functions. It receives the products of digestion and adjusts the blood concentration for each substance. The liver is involved in controlling sugar levels; deamination; detoxification; and storage of iron.

- **Controlling sugar levels** – The liver removes excess glucose from the blood and converts it to glycogen in a process called **glycogenesis**. Glycogen cannot be used by the cells so that when the blood is low in glucose the liver will convert the stored glycogen back to glucose or other monosaccharides in a process called **glycogenolysis**. The glucose is released into the bloodstream.

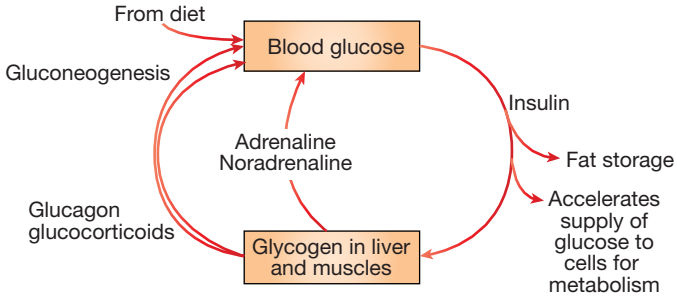

Figure 69.2 Homeostasis of sugar levels in the blood.

- **Deamination** – If there are surplus amino acids, the liver will remove the amino section (NH_2) of the amino acid. This nitrogen-containing section is changed to urea to be excreted by the kidney. The remaining section of the amino acid is converted to glycogen to be stored in the liver.
- **Detoxification** – Many toxic compounds that are ingested and absorbed into the blood are made harmless in the liver.
- **Storage of iron** – Old red blood cells are broken down in the liver and the iron from the haemoglobin is stored in the liver.

The lungs

Oxygen dissolves in the moist lining of the alveoli in the lungs and diffuses into surrounding capillaries, while carbon dioxide in the capillaries diffuses out of the blood and into the alveoli. When air enters the alveolus some of the moisture lining the sac evaporates and saturates the air with water vapour.

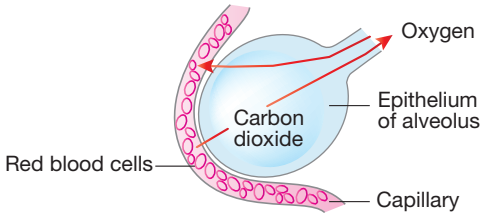

Figure 69.3 Gas exchange in an alveolus.

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71 Osmoreceptors and Water Balance

An **osmoreceptor** is a specialised sensory receptor that detects changes in osmotic pressure. Osmoreceptors are mainly found in the hypothalamus of endotherms. Osmoreceptors are very sensitive and can respond to a very small change, e.g. 1% to 2% increase in sodium ion concentration.

Water intake can vary greatly and there are **volume receptors** (low pressure **baroreceptors**), e.g. in walls of the right atria and large arteries and veins that respond to pressure changes.

The excretion of water and solutes operate in a way independently of each other when forming urine as concentrated urine has solutes in excess of water while dilute urine has water in excess of solutes.

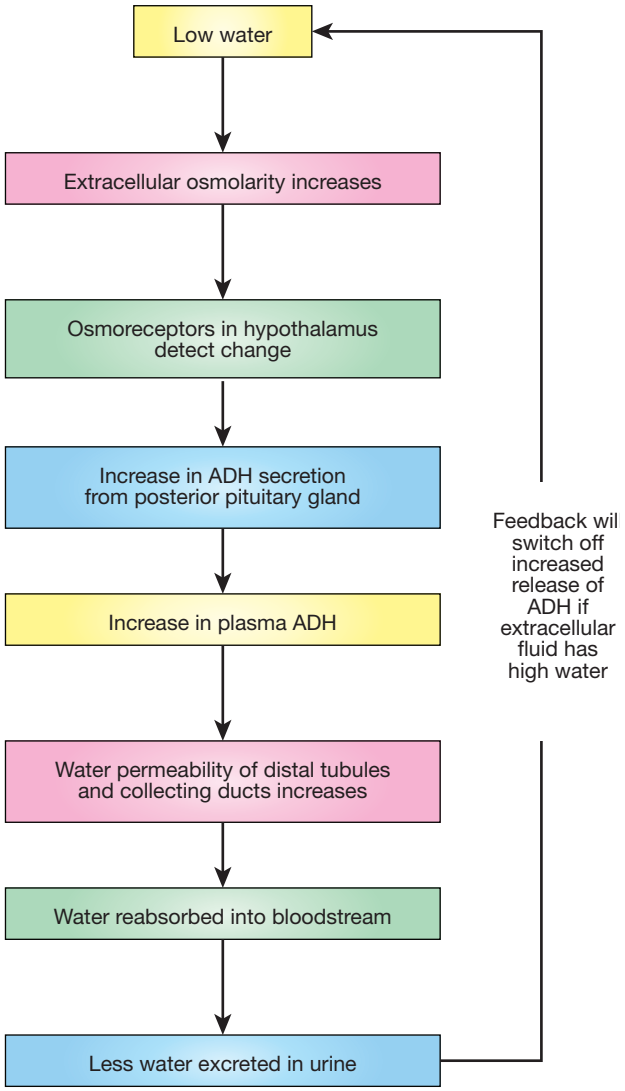

Figure 71.1 Release of ADH and feedback.

Release of ADH

When osmoreceptors in the hypothalamus detect an increase in the sodium ion concentration in the plasma (extracellular fluid osmolarity) above the normal range due to a lack of water, they send nerve signals to the posterior pituitary gland to release the hormone ADH (antidiuretic hormone or vasopressin). ADH is produced by the hypothalamus and stored by the posterior pituitary gland.

ADH enters the bloodstream and travels to the kidney where it changes the water permeability of the convoluted tubules and collecting duct walls so that more water is reabsorbed into the bloodstream from the ducts. Its also increases the permeability of the collecting duct walls to urea which diffuses in from the bloodstream. These two effects cause the urine concentration to increase. Thus ADH causes water to be conserved while sodium and other solutes continue to be excreted in the urine.

The release of ADH is also controlled by a decrease in blood pressure and/or blood volume. When arterial baroreceptors detect a drop in blood pressure and blood volume, e.g. due to haemorrhage then ADH is secreted and water is reabsorbed by the kidneys to help restore blood volume and pressure to normal.

If there is abnormal secretion of ADH, e.g. either too much or too little ADH then the kidneys will have difficulty concentrating or diluting urine correctly. The release of large volumes of dilute urine can lead to dehydration.

The thirst mechanism

The thirst mechanism is regulated by fluid intake and the osmoreceptor-ADH mechanism. As water is lost from the body, e.g. in sweat, urine, faeces and exhaled breath the extracellular fluid becomes more concentrated and the reduction in plasma volume causes a feeling of thirst. There is a thirst centre in the hypothalamus with osmoreceptors that activate the thirst mechanism.

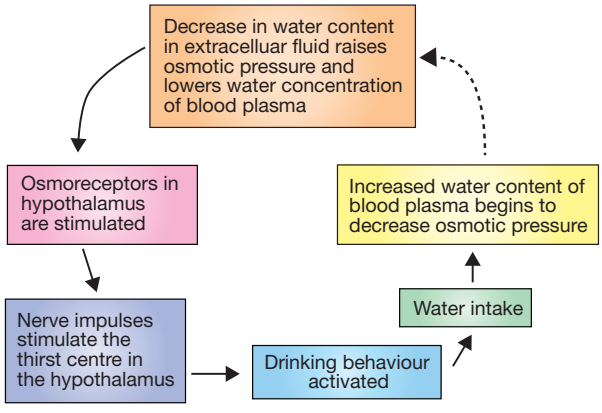

Figure 71.2 Thirst mechanism.

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72 Feedback Regulation and the Endocrine System

There are two main types of feedback regulation for the control of hormone secretion: simple endocrine pathway and simple neuroendocrine pathway.

Simple endocrine pathways

Many hormones are part of a **simple endocrine pathway** where a stimulus, either internal or external leads to the secretion of the hormone. The hormone travels in the bloodstream to the target cell where specific receptors interact with the hormone to cause the cell to produce and release the hormone. For example, when low blood glucose level is detected by alpha cells in the pancreas, glucagon, a peptide hormone produced in the alpha cells in the pancreas is secreted into the bloodstream. Glucagon causes liver cells to convert glycogen into glucose molecules which will lead to a rise in blood glucose levels. Similarly when a low pH is detected in the duodenum the S cells of the intestinal glands in the duodenum secrete the hormone secretin. Secretin regulates water balance and will inhibit secretion of gastric acid by the parietal cells of the stomach and stimulates cells in the pancreas to produce hydrogen carbonate.

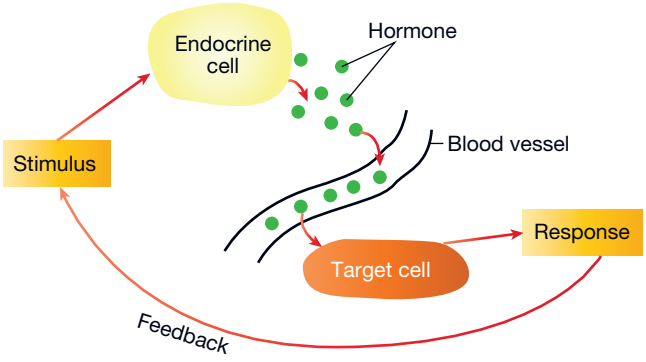

Figure 72.1 Simple endocrine pathway.

Simple neuroendocrine pathways

In a **simple neuroendocrine pathway** the stimulus is detected by a sensory neuron which stimulates a neurosecretory cell to produce a neurohormone. For example, the neurosecretory cells of the hypothalamus make antidiuretic hormone (ADH) which is stored in the posterior pituitary gland. ADH is released from the posterior pituitary gland when there is a reduction in plasma volume and increases water retention in the kidneys causing less urine to be released. Oxytocin is another neurohormone produced by the hypothalamus and stored in the posterior pituitary gland. Oxytocin is involved in birth causing dilation of the cervix, labour contractions and is also involved in lactation.

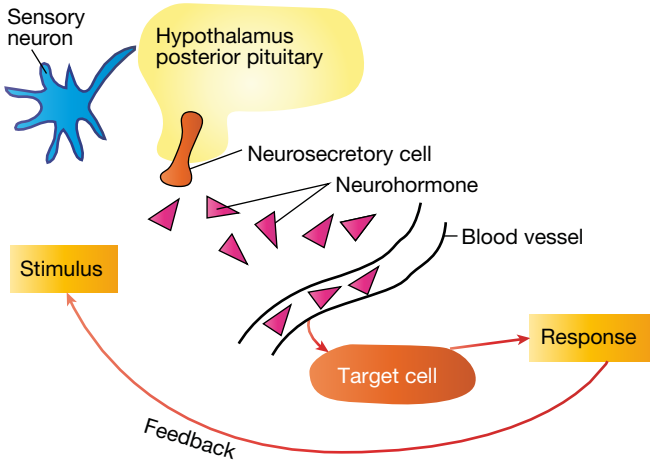

Figure 72.2 Simple neuroendocrine pathway.

In **negative feedback** the effector response reduces the initial stimulus and the response stops thus preventing overreaction by the system to the initial stimulus.

In **positive feedback** the stimulus is reinforced and leads to a greater response, e.g. suckling stimulates sensory nerves in the nipple that sends messages to the hypothalamus which releases oxytocin from the posterior pituitary gland to cause the mammary glands to secrete more milk.

QUESTIONS

1. Identify the two types of feedback regulation for the control of hormone secretion.
2. Draw a flow chart to show the sequence of events when low blood glucose levels are detected.
3. Distinguish between positive and negative feedback.
4. Explain why the release of oxytocin is an example of positive feedback.
5. Describe how the release of the hormone secretin is an example of negative feedback.
6. In humans the release of the hormone cortisol from the adrenal gland occurs when the body is under stress and produces the following effects.
   - Breakdown of proteins separating amino acids.
   - Conversion of amino acids to glucose in the liver.
   - Reduced glucose uptake by many body cells except those in the brain.

   (a) How does cortisol reach its target cells?
   (b) What would happen in negative feedback in this situation?
   (c) Suggest why the body benefits from the release of cortisol when under stress.
7. Which of the following is a neurohormone?
   (A) Oxytocin. (B) Secretin.
   (C) Insulin. (D) Glucagon.

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74 Glucose Feedback Loops

Glucose is a simple **monosaccharide** carbohydrate with the formula $C_6H_{12}O_6$ and is the main form of sugar used by cells, e.g. in respiration to release energy. Glucose is a **polar molecule** as its structure has an uneven distribution of charges and this increases its solubility in water.

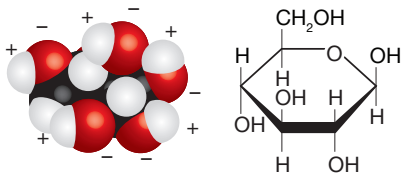


Figure 74.1 Structure of glucose.

Glucose units are joined together to produce a polysaccharide as a way of storing energy. In animal cells the polysaccharide is **glycogen** which is found in all tissues of the body with particularly high concentrations found in the liver and skeletal muscles.

Many invertebrates make the structural polysaccharide **chitin**, e.g. in the exoskeletons of all arthropods while plants make the structural polysaccharide **cellulose** and the storage polysaccharide **starch**.

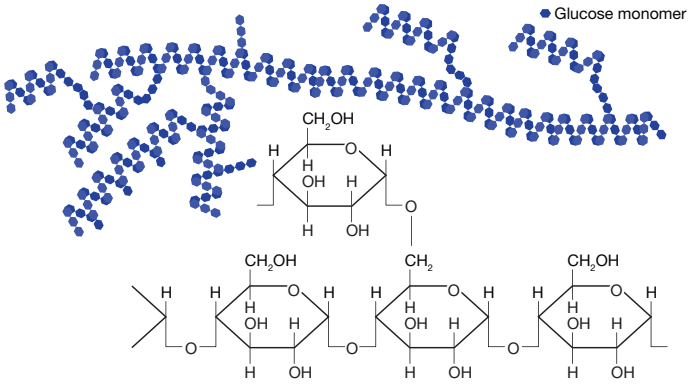


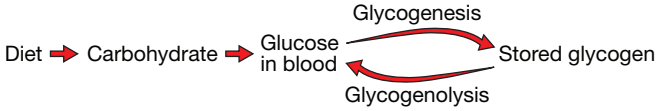
Figure 74.2 Glycogen is made up of many glucose monomers and is highly branched.

Glucose blood sugar levels

Normal blood glucose levels for fasting should be 3.0 to 5.5 mmol/litre (54 to 100 mg/dL) and if there is no fasting the normal range can be 3.0 to 7.8 mmol/litre (54 to 140 mg/dL). People with diabetes need to monitor their blood glucose levels, e.g. with a blood glucose meter which involves testing a drop of blood on a testing strip and putting the strip into the meter.

After eating a meal the carbohydrates are broken down in the digestive system and most are absorbed into the bloodstream as glucose. If blood glucose levels rise too high then **glycogenesis** occurs – glycogen is synthesised from glucose.

If plasma glucose levels decrease **glycogenolysis** occurs and the body converts the glycogen back to glucose.



Insulin and glucagon

The two hormones, insulin and glucagon, both made in endocrine cells of the islets of Langerhans in the pancreas, control blood glucose levels. **Alpha (α) cells** secrete glucagon and **beta (β) cells** secrete insulin.

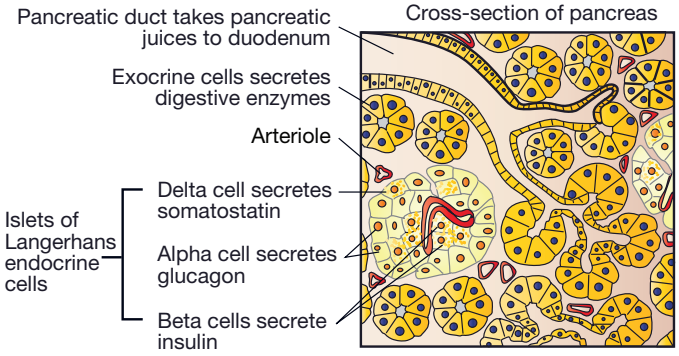


Figure 74.3 Structure of glucose.

Insulin lowers blood glucose levels by acting on cell membranes and stimulating the uptake of glucose especially by muscle cells and connective tissue cells and stimulates glycogenesis with the conversion of glucose into glycogen, especially in liver and skeletal muscle cells. Insulin also causes amino acids to be taken up by cells and converted into proteins, the synthesis of fatty acids and storage of fat in adipose tissue. It prevents the breakdown of protein and fat and decreases glycogenolysis.

Glucagon increases blood glucose levels by stimulating glycogenolysis and the conversion of glycogen to glucose in the liver and skeletal muscles.

After a meal as the blood glucose level drops the change is detected and the pancreas decreases insulin production. Less insulin reduces all its effects and with low glucose levels activating the secretion of glucagon the body releases glucose from the liver between meals.

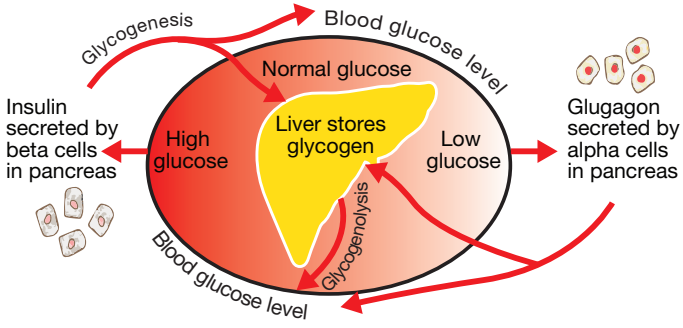


Figure 74.4 Actions of insulin and glucagon.

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77 Disorders Of the Thyroid Gland

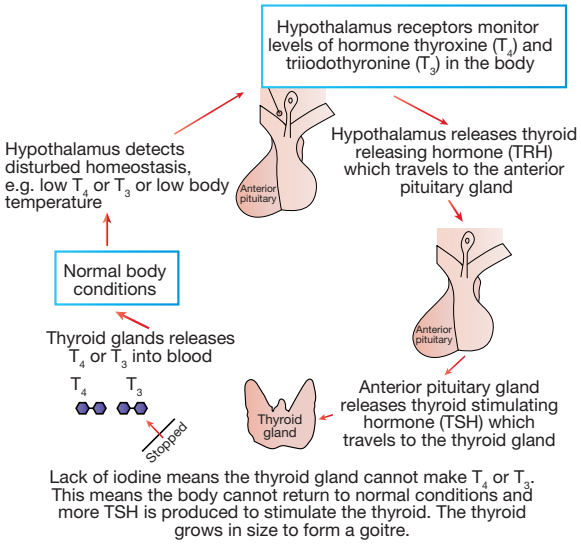
Malfunctions of the thyroid gland can range from life-threatening cancers to small, harmless goitres in the neck.

Hyperthyroidism is the overproduction of thyroxine and causes nervousness, insomnia and excessive excitability; heat intolerance and excessive sweating; increased heart rate and blood pressure; and weight loss. Most effects of hyperthyroidism are observable with the thyroid gland increasing in size to two or three times its normal size. Many patients have extreme fatigue with an inability to sleep.

Hyperthryoidism causes an increase in metabolism and the most common cause is associated with **Graves' disease** which is an autoimmune disorder. In Graves' disease the immune system makes an antibody – the **thyroid stimulating immunoglobulin** (TSI) which causes the thyroid gland to make surplus thyroxine.

Hypothyroidism is the underproduction of thyroxine. If it occurs during infancy it affects the development of brain cells and can lead to permanent mental deficiency and dwarfism. In adults it causes dry skin, intolerance to cold and lack of energy. If there is insufficient iodine in the diet, thyroxine cannot be produced causing the pituitary to make large amounts of TSH which stimulate the thyroid gland which grows in size to form a goitre.

(a)



(b)

Figure 77.1 (a) Lack of thyroid hormones forms a goitre. (b) Goitre.

Cretinism is caused by extreme hypothyroidism during foetal development, infancy or childhood. The low levels of thyroid hormones cause failure of body growth and mental retardation and can be due to lack of iodine in the diet or a genetic defect of the gland. As skeletal growth is more affected by low thyroid hormones than soft tissue growth a child with cretinism will be stocky, short and obese.

QUESTIONS

1. Draw a flow chart to show what happens if there is a low concentration of thyroid hormones in the blood.
2. (a) What is hyperthyroidism?
   (b) Describe some symptoms of hyperthyroidism.
3. (a) What is hypothyroidism?
   (b) Describe some symptoms of hypothyroidism.
4. Explain why common salt is iodised.
5. Describe cretinism.
6. Which element deficiency causes hypothyroidism?
   (A) Iodine. (B) Fluorine.
   (C) Potassium. (D) Bromine.
7. The diagram shows the glands of the endocrine system for males and females.

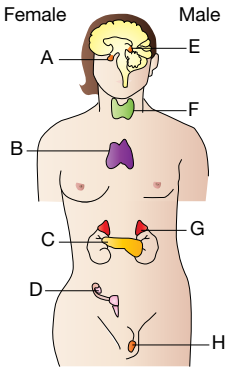


Figure 77.2 Endocrine system for males and females.

Which part is the thyroid gland?
(A) Part A (B) Part E (C) Part F (D) Part B

8. The graph shows the effect of a large dose of thyroxine on the basal metabolic rate.

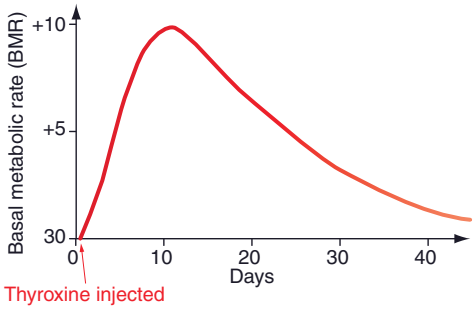


Figure 77.3 Effect of thyroxine on BMR.

From the graph, when is the BMR most affected by the injection of a large dose of thyroxine?
(A) Day 0 (B) Day 10 (C) Day 20 (D) Day 40

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SURFING

VCE BIOLOGY UNIT 1

STUDY DESIGN 2022

Topic Test

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Topic Test

Section A – Multiple Choice (40 marks)

1. The diagram shows a type of cell of an organism.

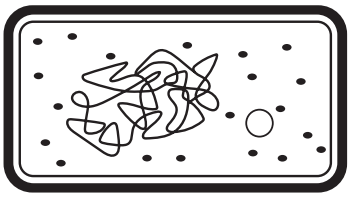

Figure TT.1 Type of cell.

What is this type of cell?
(A) Prokaryote as it has a nucleus.
(B) Prokaryote as it does not have a nucleus.
(C) Eukaryote as it has a nucleus.
(D) Eukaryote as it does not have a nucleus.

2. The diagram shows a plant cell and an animal cell.

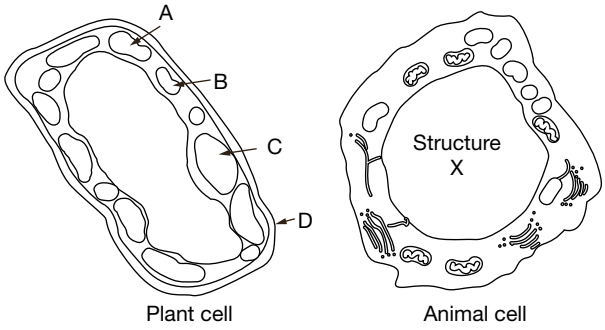

Figure TT.2 Plant cell and animal cell.

Which structure in the plant cell performs the same function as structure X in the animal cell?
(A) Structure A.
(B) Structure B.
(C) Structure C.
(D) Structure D.

3. Which of the following structures increase the surface area for the absorption of water into plants?
(A) Roots hairs.
(B) Stomates in sunken crypts.
(C) Withering of the end walls in xylem.
(D) Lack of a cuticle on roots.

4. Which organelles are mainly involved with the transformation of energy?
(A) Chloroplasts, mitochondria.
(B) Lysosomes, nuclei.
(C) Nuclei and mitochondria.
(D) Lack of a cuticle on roots.

5. Which organisms do *not* have cells with membrane bound organelles?
(A) Fungi. (B) Protists.
(C) Eukaryotes. (D) Prokaryotes.

6. A thin section of an unknown tissue was stained with several different dyes to determine if the tissue came from a plant or from an animal. Which of the following is *least* likely to show that the tissue is from a plant?
(A) Iodine showed starch granules.
(B) Toluidine blue showed lignified cell walls.
(C) Phloroglucin stained lignin in xylem vessels.
(D) Sudan IV stained lipid droplets.

7. While investigating the difference between plant and animal cells, students needed to make wet mount slides of different tissues. Which of the following methods is the preferable method to use when placing a cover slip on a prepared specimen on a microscope slide?

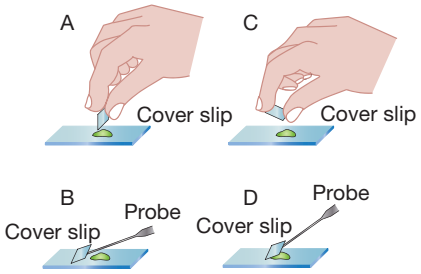

Figure TT.3 Experimental method.

8. The graph shows cell surface versus cell volume for different shaped cells.

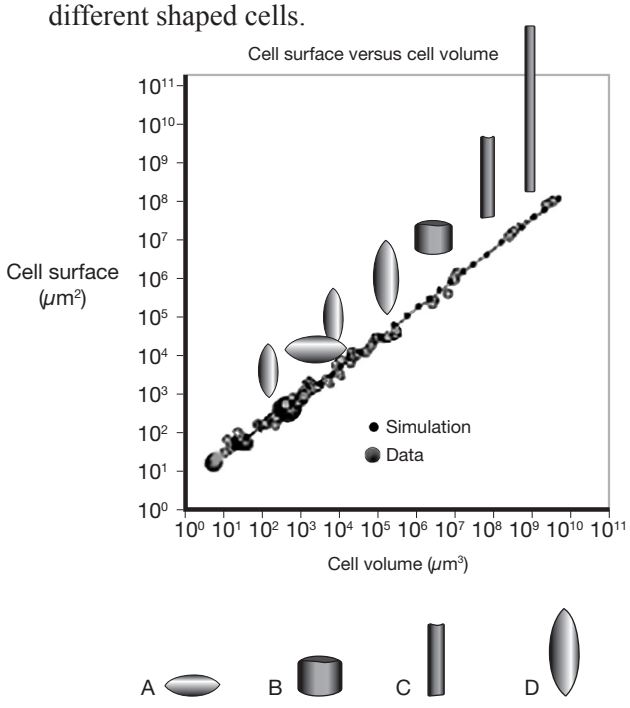

Figure TT.4 Cell surface versus cell volume.

According to this graph which cell would have the most efficient diffusion of substances into and out of the cell?

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Use the following diagram for the next TWO questions.

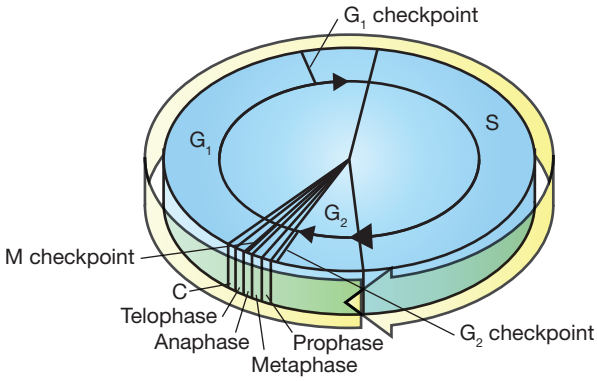

Figure TT.13 Cell cycle.

31. At which checkpoint is DNA damage checked to see if sister chromatids are correctly attached?
(A) S checkpoint.
(B) M checkpoint.
(C) G_1 checkpoint.
(D) G_2 checkpoint.

32. In which phase is DNA replicated and the amount of DNA in the nucleus doubles?
(A) G_1 phase.
(B) G_2 phase.
(C) Mitosis.
(D) S phase.

33. Apoptosis can cause atrophy. What happens during atrophy?
(A) Body tissues and organs waste away.
(B) Large substances are taken up and digested.
(C) Programmed and controlled cell death.
(D) Water balance is maintained across a membrane.

Use the diagram of a section of the gastrointestinal tract for the next TWO questions.

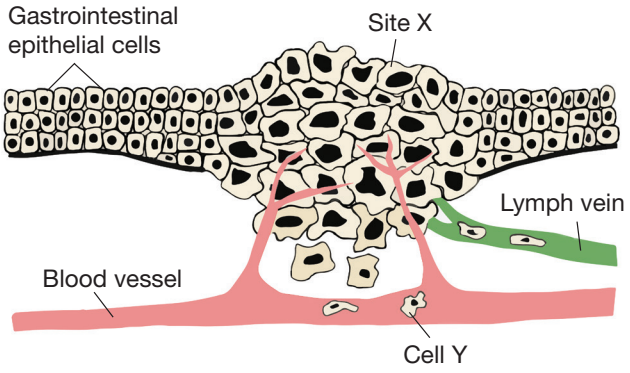

Figure TT.14 Section of gastrointestinal tract.

34. What is most likely happening at site X?
(A) Abnormal cells are proliferating to form a primary tumour.
(B) Cells are differentiating to form an exocrine gland.
(C) Cells are enlarging to improve ability to absorb digested nutrients.
(D) Cells are secreting hormones.

35. Cell Y had been part of site X. What is the significance of cell Y?
(A) It is an epithelial cell travelling to the liver to be destroyed.
(B) It is an epithelial cell moving to the vascular system to initiate an immune response.
(C) It is a cancer cell programmed for apoptosis.
(D) It is a cancer cell migrating to another area spreading the cancer.

36. What is the correct order of the stimulus-response pathway?
(A) Stimulus → central nervous system → sensory → neuron → effector → response.
(B) Stimulus → motor neuron → central nervous system → effector → response.
(C) Stimulus → receptor → central nervous system → effector → response.
(D) Stimulus → receptor → central nervous system → sensory neuron → response.

37. Why would a diabetic inject glucagon?
(A) Lower blood glucose levels by promoting gluconeogenesis.
(B) Raise blood glucose levels by promoting gluconeogenesis.
(C) Lower blood glucose levels by inhibiting gluconeogenesis.
(D) Raise blood glucose levels by inhibiting gluconeogenesis.

38. Alcohol consumption can produce a diuretic effect and in excessive amounts can compromise body functioning leading to disease. What happens when alcohol acts as a diuretic?
(A) It acts as a stimulant increasing fluid retention.
(B) It acts as a depressant increasing fluid retention.
(C) It decreases haemoglobin levels improving hydration.
(D) It changes fluid balance increasing the risk of dehydration.

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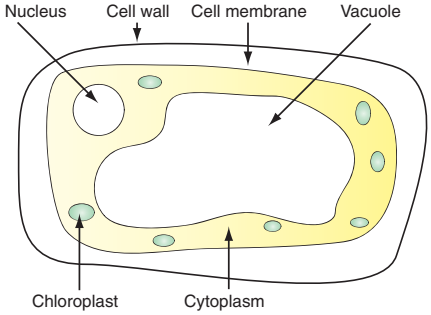
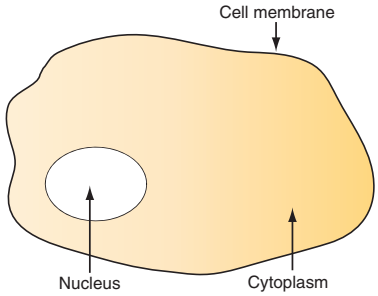
Answers

1 Assumed Knowledge

1. Living organisms can – 1. Respire. 2. Assimilate food and synthesise organic molecules. 3. Grow. 4. Reproduce. 5. Respond to stimuli from their environment. 6. Excrete. 7. Move around.
2. The cells of living things have a cell membrane, cytoplasm and DNA.
3. Plant cell.



4. Animal cell.



5. A = eye of person using the light microscope, B = ocular lens, C = objective lens, D = specimen, E = condenser lens, F = light source
6. When using a light microscope, you should always wear shoes with covered toes, as the microscope is heavy and if you drop it you could damage exposed skin on your feet.
7. The nucleus stores information needed to control all cell activities.
8. The cell membrane surrounds the cell contents from the external environment and controls the substances that can leave or enter the cell.
9. Cytoplasm is a general term for the contents of a cell outside the nucleus and within the cell membrane.
10. Protoplasm is the semifluid transparent substance that makes up the living matter of plant and animal cells including the nucleus and cytoplasm.
11. A chloroplast is a green organelle found in green tissues of plants that captures sunlight in photosynthesis to manufacture sugars from carbon dioxide and water.
12. Photosynthesis is a process where the energy of sunlight is used to convert carbon dioxide and water into sugars and oxygen.
13. Groups of organisms that can photosynthesise include plants, algae and photosynthetic bacteria.
14. Carbon dioxide and water are needed for photosynthesis using light energy and in the presence of chlorophyll.
15. The function of the digestive system is to break down ingested food into smaller particles so that nutrients can be absorbed into the body.
16. A = salivary glands, B = oesophagus, C = stomach, D = liver, E = gall bladder, F = pancreas, G = large intestine, H = small intestine, I = appendix, J = anus
17.

Part	Structure	Function
Mouth	Has teeth and openings from salivary glands	Teeth break food into small pieces and salivary enzymes begin chemical digestion
Oesophagus	Long tube	Moves food to stomach by peristalsis
Stomach	Muscles and glands in wall	Churns food and produces digestive enzyme to digest protein
Small intestine	Long thin tube with villi and glands	Digestion is completed and nutrients absorbed through walls
Large intestine	Long tube	Water, salts and vitamins absorbed
Anus	Muscular ring	Eliminates faeces

18. (a) Xylem transports water up the plant from roots to leaves.
    (b) Phloem transports sugars up and down the plant.
    (c) Leaves are the site of photosynthesis where light energy is changed into chemical energy to be used by the plant.
    (d) Roots support the plant, anchor it in the soil and are the site of water absorption.
19. (a) (i) Carbohydrates are broken down into glucose.
    (ii) Proteins are broken down into amino acids.
    (iii) Fats are broken down into fatty acids.
    (b) Scientists make simple models to make it easier to understand complex systems providing, as in this case of the model of the digestive system, a basic idea of the structure and functioning of a multifaceted body system. The diagram shows the digestive system as a long tube through the body that acts as a a functional unit of life.
20. Cellular differentiation is the process in which a cell becomes specialised in structure so it can perform a specific function, e.g. red blood cell, liver cell, cardiac muscle cell.
21. Osmosis is the movement of water across a semipermeable membrane from a region of high water to a region of low water.
22. ATP (adenosine triphosphate) is the main source of energy to drive cellular reactions and active transport. It is hydrolysed when a phosphate bond is broken and free energy is released.

2 Characteristics Of Living Things

1.

Characteristic	Description of characteristic
Growth and development	Involves an increase in mass due to an increase in the size of individual cells and/or and increase in the number of cells.
Reproduction	Is the ability to produce offspring and can be either sexual or asexual.
Respiration	Is a series of chemical reactions in which cells obtain energy from food.
Respond to stimuli	Stimuli from either the internal or external environvment cause a response in or by the organism.
Movement and locomotion	Part or the whole organism can move.
Nutrition or feeding	Organisms obtain matter and energy to build their physical structure and continue the functions of life.
Assimilation	Is the process of converting food into the living material of life.
Metabolism	Is the sum of all chemical reactions within the organism.
Excretion	Is the removal of unwanted waste products of metabolic reactions.

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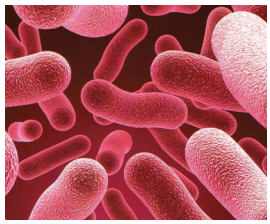
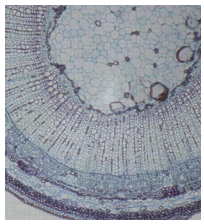
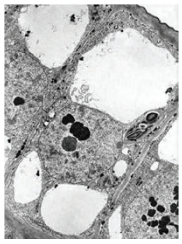
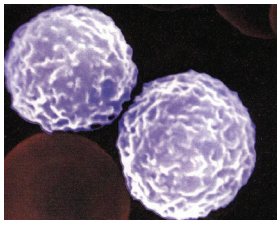
6.

Image A	Image B
 Scanning electron microscope	 Light microscope
Image C	**Image D**
 Light microscope	 Transmission electron microscope
Image E	**Image F**
 Scanning electron microscope	 Light microscope

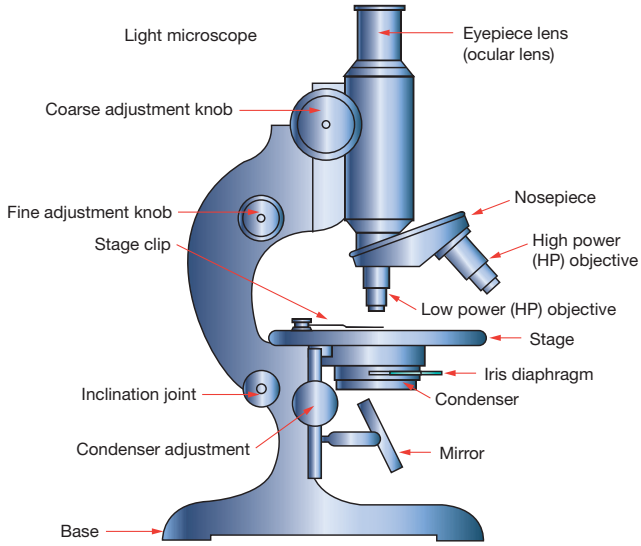
7. D

5 The Stereo Microscope

1. The stereo microscope is easily identified as it has two ocular eyepieces that each view the object from different angles. There are two separate optical paths for viewing.
2. You are likely to use a stereo microscope when dissecting small organisms or when you need to observe the external features of a specimen.
3. The parts of the stereo microscope are:
   A = ocular lens
   B = objective lens
   C = stage clip
   D = stage
   E = focus knob
   F = arm
4. If a compound microscope has two eyepieces which give the same image then the image will not be three-dimensional and give a 'stereo' image. To provide a three-dimensional image there must be two images each from slight different viewing angles.
5. In a stereo microscope the lens is a distance away from the object and this gives poor resolution.
6. A typical school stereo microscope has a magnification ranging from 10× to 40× while a typical school monocular microscope has a magnification from 40× to 400×.
7. Salt crystals are light coloured and usually translucent. The dark colour beneath the crystal is needed to provide contrast so that the crystal can be properly viewed.
8. When using a stereo microscope some parts of an organism may not be in focus as the specimen is three-dimensional with several levels. The microscope is focusing on one level making other levels appear out of focus.
9. A

6 Experiment – The Light Microscope

1.



2. It is important to always use two hands when carrying a light microscope as they are heavy and if dropped could damage skin and feet. If dropped the fall will likely irreparably damage sections of the microscope and the school may not be able to replace the equipment. You should *never* swing a microscope and hold it with one hand.
3. It is very important to always view the stage from the side when lowering the low power objective as many microscopes allow the lens to be lowered as far as the slide and even lower, which can break the slide. Cut glass can pierce skin and potentially cause infection if it is not clean. By always raising the lens away from the slide you reduce the possibility of breaking the glass slide.
4. (a) Using the low power objective (10×) gives an overall magnification of $10 \times 10 = 100\times$.
   (b) Using the high power objective (40×) gives an overall magnification of $10 \times 40 = 400\times$.
5. The iris diaphragm controls the amount of light reaching the stage and passing through the specimen.
6. When changing objective lenses it is usually necessary to adjust the amount of light as higher magnification lenses require more light and you need the correct amount of light to see details in the specimen. When changing from high power to low power a decrease in the amount of light is usually needed.
7. A stereo microscope is usually a low powered microscope that has two eyepieces and provides a stereoscopic view of the specimen. It is usually used for looking at organisms or parts of organisms, e.g. in dissections and does not use thin sections on a microscope slide as used by light compound microscopes.
8. If you touch the lens with your finger you will leave a print that has body oil which smudges the glass. If the oil is on the glass for a lengthy time period, it can etch the glass. Lens paper must be used to clean the lens. Other types of paper, e.g. paper towel, tissues, toilet paper scratch the lens.

7 Experiment – Using a Light Microscope

1. Magnification refers to the ratio between the size of the image (the apparent size of the object under the microscope) and the actual size of the object. Resolution is the ability to distinguish between two points as separate.
2. (a) The diameter of the field of view under low power is 1.4 mm which is 1400 μm.
   (b) If the high objective lens (40×) is used then the change is from an overall magnification of 100× to 400×.

   $$\text{New diameter field of view} = 1400 \times \frac{100}{400}$$
   $$= 350\ \mu\text{m}$$

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3. Pluripotent stem cells are able to give rise to any of the embryonic germ layers that form all cell types of the body but not the placenta or umbilical cord.
4. In mammals multipotent stem cells are adult stem cells that are found in various tissues, e.g. bone marrow stem cells give rise to the different types of blood cells and brain stem cells give rise to nerve cells.
5. The blastocyst is an embryonic stage in mammals that is a hollow ball of cells produced about one week after fertilisation in humans.
6. In humans the blastocyst implants in the endometrium around day 7 and implantation is usually completed by day 14.
7. The trophoblast is the outer layer of cells of the blastocyst.
8. Some of the trophoblast develops into the chorion which is an extraembryonic membrane that encloses the entire embryo and forms the placenta.
9. The inner cell mass of the blastocyst become the embryo.
10. In humans the embryo becomes a foetus in week eight.
11. Organogenesis is the development of body organs from the three germ layers.
12. Humans and other vertebrates are triploblastic with 3 germ layers while the jellyfish and corals are diploblastic with only 2 germ layers. The third layer in humans and other vertebrates is the mesoderm which is between the endoderm and ectoderm and gives rise to muscles and most other organs between the digestive tract and the outer covering of the animal.
13. Cell differentiation means the cell becomes specialised with specific structures and functions, e.g. nerve cells have a particular shape and are used to carry nervous impulses.
14. Adult stem cells or tissue specific stem cells are unspecialised cells and found in particular locations in the body.
15. Adult stem cells are needed for growth, repair and maintenance of different tissues and organs of the body.
16. (a) The ectoderm develops into the skin epidermis, sensory receptors in the skin, epithelial lining of the mouth and rectum and the nervous system.
    (b) The mesoderm develops into the notochord, skeletal and muscular system, excretory system, circulatory and lymphatic systems and dermis of the skin.
    (c) The endoderm develops into the epithelial lining of the digestive tract and respiratory system, liver and pancreas, thyroid and parathyroid glands, lining of the urethra, urinary bladder and reproductive systems.
17.

Part of body	Cell types produced at that site
Brain	Oligodendrocyte Astrocyte Neuron
Skin	Epidermis Hair follicle
Gut	Secretory cells
Bone marrow Blood stem cell	Red blood cells White blood cells Platelets
Bone marrow Blood vessel stem cell	Arteries Veins Capillaries
Bone marrow Mesenchymal stem cell	Muscle cell Bone cell Cartilage cell Fat cell

18. Induced pluripotent stem (iPS) cells are cells that have been treated, e.g. with a retrovirus so that they behave like embryonic stem cells.
19. D
20. A

45 Differentiation and Specialised Cells

1. Differentiation is a process when a young, relatively unspecialised cell develops into a more mature state to become a more specialised cell.
2. In a multicellular organism each cell must be supplied with oxygen and nutrients and wastes need to be removed. The process of diffusion is too slow and inefficient to meet the requirements of each cell. Thus a multicellular organism needs specialised cells with division of labour so particular tasks can be carried out more efficiently and each cell is supplied with oxygen and nutrients and wastes removed.
3. Differential gene expression means that a particular gene is 'switched on' to produce a particular polypeptide. The production of this polypeptide and protein leads to the cell taking a particular shape and having a particular function.
4. Muscle cells produce the proteins myosin and actin. These proteins form filaments that interact to cause cell contraction. The contraction is needed to provide locomotion for the multicellular organism.
5. A tissue may have only one kind of cell or several kinds of cells. For example, connective tissue contains red blood cells, white blood cells, lymph, cartilage and bone.
6. The main types of mammalian tissue are: 1. Epithelial tissue. 2. Connective tissue. 3. Muscle tissue. 4. Nervous tissue.
7. Epithelial tissue is found over many surfaces and linings of body cavities, e.g. it is the outer part of skin and forms the linings of the digestive tract, the lungs, the blood vessels and various ducts.
8. Epithelial cells are either flat (squamous), cubical or columnar in shape.
9. Microvilli increase the surface area for diffusion and active transport into and out of the cell.
10. The basement membrane is the floor of an epithelial membrane on which the basal cells rest. The basement membrane is usually made of a network of white, wavy, non-elastic fibres that form a fibrous network.
11. An endocrine gland is a ductless gland that secretes hormones directly into interstitial fluid. An exocrine gland has ducts.
12. Connective tissue is found in many areas of the body, e.g. bone, cartilage, blood, tendons and ligaments.
13. Muscle cells are specialised to convert chemical energy in ATP into mechanical energy for movement.
14. Smooth muscle is involved in most involuntary movement of internal organs. Striated muscle is involved in voluntary movement. Cardiac muscle is responsible for the beating of the heart.
15. Nervous tissue consists of neurons and glial cells.
16. There are several types of neurons (nerve cells), e.g. sensory neurons take messages from a sensory receptor to the CNS, motor neurons take messages from the CNS to an effector, e.g. muscle or gland and bipolar cells take messages from the retina.
17. A
18. C
19. B

46 Cells, Tissues, Organs and Systems

1. (a) A cell is the basic unit of life.
   (b) Tissue is a group of cells with similar structure and function.
   (c) Organ is a group of tissues grouped together to make a structure with a special function.
   (d) System is usually a group of organs whose function is closely related.
2. (a) A leaf is an organ.
   (b) Xylem tissue is present in the leaf.
   (c) Epidermal cell in the epidermis.
3. There are 3 types of muscle tissue – smooth muscle, skeletal muscle and cardiac muscle. These tissues are in different systems, e.g. cardiac muscle is in the cardiovascular system, skeletal muscle is in the muscular system and smooth muscle is in a variety of systems, e.g. digestive system along the alimentary canal and cardiovascular system in the walls of arteries. Although these muscles in these systems have their own specific functions, they all have the general purpose being used to generate force that leads to motion of some kind.
4. C
5. B

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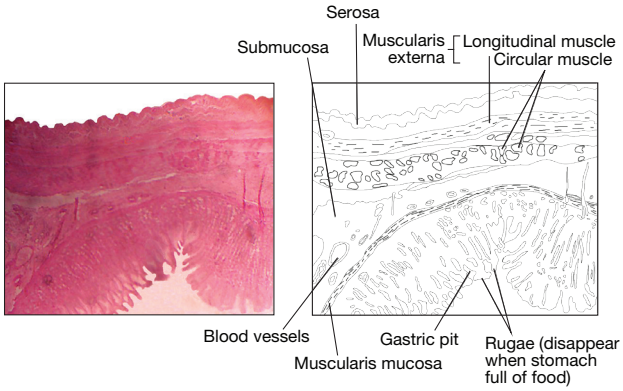
6. Features that aid the absorption of digested food include: 1. The long length of small intestine. 2. Villi, covered with microvilli increase the surface area for absorption. 3. The thinness of the epithelial lining. 4. A rich blood supply in each villus.
7. In the bloodstream, glucose is carried to the liver by the hepatic portal vein where it may be stored or altered as needed by the body. If there is excess glucose it is stored as glycogen and when blood sugar levels fall, the glycogen is turned back into glucose and released so that blood sugar levels remain fairly constant.
8. Once in the lacteal, the fatty acids are recombined to form fats once again. The fats are often coated with special proteins, becoming lipoproteins for transportation. The lymphatic system transports the lipids from the digestive system to the circulatory system, draining into veins at two locations near the shoulders.
9. A
10. B
11. C
12. D
13. A
14. C
15. C
16. D
17. C
18. D
19. A

54 Microscopic Digestive Surfaces

1. The four layers of the wall of the digestive tract are the serosa, muscularis externa, submucosa, and mucosa.
2. The innermost layer is the mucosa which has epithelial tissue, a basement membrane, connective tissue and in some places a thin outer coating of smooth muscle.
3. Peritoneum is a serous membrane that lines the cavity of the abdomen and covers the abdominal organs. The mesentery is a peritoneal fold that connects the stomach and intestines to the abdominal wall.
4. Microvilli increase the surface area for absorption in the intestine.
5. 

55 Experiment – Rat Dissection

1. Differences between the human and rat digestive systems include: 1. Humans have a physically larger digestive system than rats though both are similar proportionally to their respective body size. 2. Rats have a larger caecum than humans used as a fermentation chamber which is specialised to digest plant materials, e.g. seeds. 3. Rats do not have a gall bladder (do not need to digest fats).
2. Precautionary measures include instruction on how to correctly use the equipment and take care not to cut yourself when using sharps both when setting up, dissecting, cleaning up and packing away. Before starting the dissection all students need to be made aware of what will be happening and if some students feel faint at either the idea or the sight they need to be given care and an alternate way of learning about the structure and positioning of internal organs, e.g. digestive system and respiratory systems.
3. It is important to keep the scissors pointing upwards when first cutting open the abdominal cavity to make sure you do not pierce and open any internal organs, e.g. cutting into the intestines which would lead to the release of faeces into the abdominal cavity.
4. Mesentery holds the small intestines in place attached to the abdominal wall.
5. The mesenteric arteries that are attached to the mesentery supply the intestine with nutrients for respiration. The mesenteric veins take digested food materials and waste materials from intestine capillaries to the hepatic portal vein.
6. A

56 The Endocrine System

1. The endocrine system is a body system composed of different endocrine glands that are ductless glands which secrete hormones directly into the bloodstream or body fluids.
2. Hormones are chemical signals that travel in the blood and body fluids and act on specific target cells to cause a specific response for internal communication and regulation and maintaining homeostasis.
3.

Feature	Nervous system	Endocrine system
Speed of transmission	Rapid	Slower
Mode of transmission	Electrochemical impulse along nerve fibres	Hormones travelling in bloodstream and tissue fluids
Response time	Immediate	Slower acting
Response duration	Short time	Long time – up to years
Specificity	One effector	Several organs or target cells

4. A = pituitary gland
   B = thyroid gland
   C = ovaries
   D = pineal gland
   E = parathyroid glands
   F = thymus gland
   G = adrenal glands
   H = pancreas – islets of Langerhans
5. (a) The diagram shows how the hypothalamus (releasing TRH) and anterior pituitary gland (releasing TSH) control the secretion of the thyroid hormones. The release of hormones from several glands is controlled by the release of other hormones. The thyroid hormones are important in controlling many body functions, e.g. maintaining normal blood pressure, heart rate, muscle tone and digestion. The diagram also shows how hormone control is a feedback mechanism.
   (b) To reach their target organ, e.g. travelling from the anterior pituitary gland to the thyroid gland, the hormone travels in the blood.
6. Insulin and glucagon are antagonistic hormones as they both regulate the concentration of glucose in the blood but have opposite effects. Low blood glucose levels will cause the alpha cells of the pancreas to release glucagon into the blood which will cause liver cells to break down glycogen and release glucose into the blood. High blood glucose levels will cause the beta cells of the pancreas to release insulin into the blood which will cause the liver to take up glucose and store it as glycogen as well as body cells to take up more glucose.
7. Adrenaline and noradrenaline are the flight or fight hormones.
8. There are three main types of hormones – the peptide hormones, the steroid hormones and the amine hormones.
9. A

57 The Thyroid Gland

1. The thyroid gland lies below the larynx on each side and anterior to the trachea.
2. The thyroid gland produces thyroxine (T_4), tiiodothyronine (T_3) and calcitonin.
3. Thyroxine is an amino acid with four iodine atoms.

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