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Study Guide

Via Afrika Life Sciences

Grade 10

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Our Teachers. Our Future.

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Introduction to Life Sciences

Life Sciences is all about how life on Earth occurs: the principles of life, their interconnected systems, and maintaining a stable balance of life in the biosphere. It links with other fields, such as physiology, agriculture, Earth science, physical science, mathematics, technology, community health, medicine, population and environmental studies, archaeology, anthropology and palaeontology.

The Life Sciences have a number of theories that try to explain phenomena and events that occur on Earth. Models are used to explain how processes work and solve problems using the accepted basic rules (laws) of cause and effect that have been tried and tested over time.

Certain scientific methods, tools and techniques are important in investigating Life Sciences phenomena and are used often in investigations and observations. This is what makes studying Life Sciences so exciting. You are able to conduct Life Sciences investigations yourself – at school and at home – to answer your own questions.

This study guide works with the activities, hands-on practical tasks, and exercises that are found in the Learner's Book.

The study guide helps you to check your understanding of the principles of the Life Sciences, to practise your scientific skills and to solve modern Life Sciences problems and issues with what you know. In doing so, it prepares you for your class tests and examinations.

Attempting the questions in this study guide helps you recognise the kinds of questions you can be asked. It also challenges you to practise difficult questions, solve problems and recognise the issues – how they affect not only you but also life around you on the ever-changing planet Earth.

1 Purpose of studying Life Sciences

To best understand the Life Sciences, you will need to practise questions associated with:

1 Scientific knowledge and understanding
2 Science process skills (scientific investigations)
3 Understanding of the roles of science in society.

1.1 Knowing and understanding scientific knowledge

This aim is achieved through:

1.1.1 Acquiring knowledge

In the process of acquiring knowledge you must:

- access information from a variety of sources
- select key ideas
- recall facts
- describe concepts, processes, phenomena, mechanisms, principles, theories, laws and models in the Life Sciences.

1.1.2 Understanding, comprehending, making connections between ideas and concepts to make meaning of Life Sciences

In the process of making meaning and achieving understanding you must:

- build a conceptual framework of science ideas
- organise or reorganise knowledge to derive new meaning
- write summaries
- develop flow charts, diagrams and mind maps
- recognise patterns and trends.

1.1.3 Applying knowledge of Life Sciences in new and unfamiliar contexts

You must be able to:

- apply knowledge to new and unfamiliar contexts
- use information in a new way.

1.1.4 Analysing, evaluating and synthesising scientific knowledge, concepts and ideas

In the process of learning science you must be able to:

- analyse information/data
- recognise relationships between existing knowledge and new ideas
- critically evaluate scientific information
- identify assumptions
- categorise information.

1.2 Investigating phenomena in the Life Sciences

This aim is achieved through a range of skills that relate to doing practical work in Life Sciences. You must be able to:

1.2.1 Follow instructions – during investigations

1.2.2 Handle equipment or apparatus – use laboratory or improvised equipment appropriately and safely

1.2.3 Make observations – make and record different kinds of observations in different ways: drawings; descriptions; grouping according to similarities and differences; measurements; comparisons of materials before and after treatment; observing results; counting and recording information in an appropriate way

1.2.4 Record information or data – make drawings; descriptions; simple tables; single graphs

1.2.5 Measure – know what to measure, how to measure it, have a sense of the degree of accuracy that is required for: volume; temperature; mass/weight; counting of numbers and making estimates

1.2.6 Interpret – know how to convert information from one form into another – tabulated data into an appropriate graph; perform appropriate simple calculations; analyse and extract information from tables and graphs; apply knowledge of theory to practical situations; recognise patterns and/or trends; appreciate the limitations of experimental procedures; make deductions based on evidence

1.2.7 Design or plan investigations or experiments – plan or design a simple investigation or experiment: identify a problem, formulate an hypothesis; select apparatus or equipment and/or materials; identify variables; suggest ways of controlling variables; plan an experiment; suggest ways of recording results; understand the need for replication or verification.

1.3 Appreciating and understanding the history, importance and applications of Life Sciences in society

This aim is achieved through:

1.3.1 Understanding the history and relevance of some scientific discoveries – knowing particular discoveries or scientists associated with the topics and content

1.3.2 Understanding the relationship of indigenous knowledge to Life Sciences – knowing, understanding and appreciating the different cultural contexts in which indigenous knowledge systems were developed, shaped by different world views, compared to modern science and technology

1.3.3 Understanding the value and application of Life Sciences knowledge in industry, in respect of career opportunities and in everyday life – knowing, understanding and appreciating the applications and relevance that knowledge of Life Sciences has found in various aspects of society associated with the topics and content.

2 Concept maps (graphic organisers)

A graphic organiser or concept map is a useful tool in summaries and for understanding how topics learnt are related to each other. It also allows you to relate the information learnt to new information being obtained through creating the necessary links and associations.

While working through the associated topics, create and/or complete the concept maps provided to produce a study summary of the topic and strand.

Concept maps and graphic organisers are also useful in structuring responses to paragraph and essay type questions.

3 Formal assessment tasks for the year

You will be required to perform the following assessment tasks during the year:

- Hands-on practical investigations
- Research assignments
- Class tests
- June examination
- November examination
- November Practical examination.

4 Understanding assessment tasks and questions

You should not be scared of class tests, practical tests and examinations, and practical examinations. Preparing for assessment tasks involves:

- understanding what the tasks need you to do
- recognising what kind of thinking each question is testing
- recognising the question words and what they require.

All of this can be achieved through regular practice in being able to recognise what a question asks of you. The following information is provided to help you understand what each question in any assessment task needs you to do.

4.1 Understanding what kind of thinking assessment tasks measure

Each assessment task wants to know if you:

- know and can remember information that you have learnt
- understand and can explain the information that you have learnt
- can analyse and solve everyday problems using what you have learnt
- can analyse, can integrate information to understand the cause and effect of changes and can evaluate information for limitations, accuracy and bias.

Your examination paper will cover these areas as shown below.

Weighting of thinking levels for assessment and associated verbs used in questions				
Thinking levels	Knowing science	Understanding science	Applying scientific knowledge	Analysing, synthesising, evaluating scientific knowledge
% of examination paper	40%	25%	20%	15%
Verbs used in questions	• state • name • label • list • define • describe • identify • measure and others...	• explain • compare • rearrange • give an example of • illustrate • calculate • make a generalisation • outline • contrast • tabulate and others...	• predict • apply • use knowledge • demonstrate • determine / solve • implement • judge • estimate and others...	• select • differentiate • analyse • infer/deduce • suggest • discuss • categorise/ classify • evaluate and others...

It is important for you to practise questions across all of the thinking levels. Many questions go beyond simply remembering facts to see if you can solve problems that you will encounter during your life.

4.2 Common verbs used in Life Sciences assessment questions or instructions

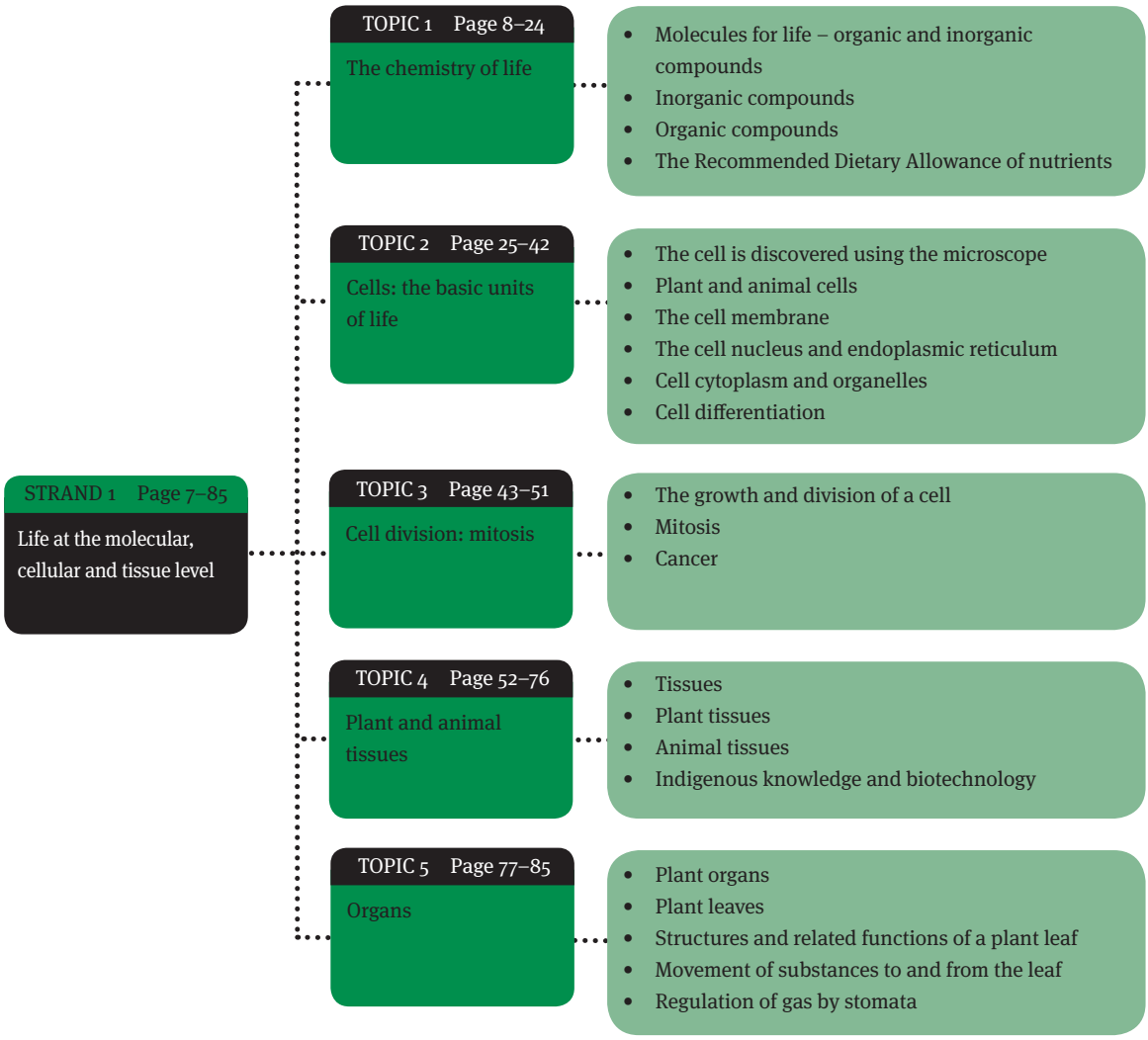
Here are words and expressions that you may come across in formal assessment tasks are listed below – make sure that you know their meaning too so that you know what is expected of you:

- **categorise** – group or organise according to similarities or differences; use criteria
- **differentiate** – use differences to qualify categories
- **give an example of** – requires a concise answer with little or no supporting argument
- **implement** – use
- **label** – identify on a diagram or drawing
- **make a generalisation** – provide an overview statement that explains a trend or represents an overall comment
- **name** – identify
- **rearrange** – reorganise according to certain criteria in a logical way
- **select** – choose
- **solve** – determine or find
- **use knowledge** – make use of given information to work out a result, predict an outcome, or explain an observation

Strand 1

Life at the molecular, cellular and tissue level

Overview



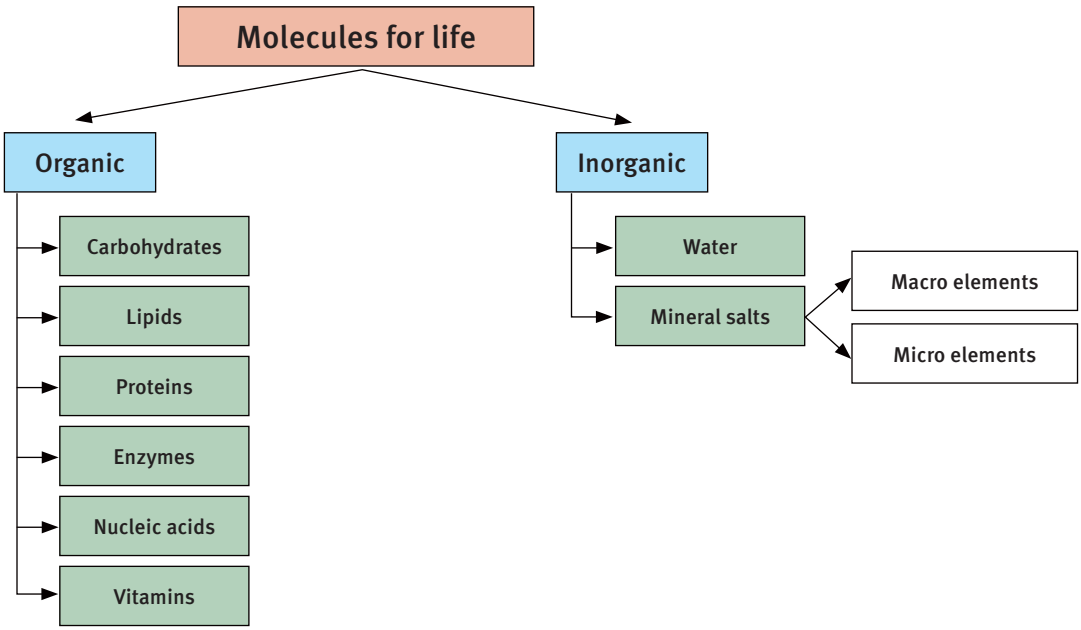
All living organisms are made of atoms that combine to form molecules, and these make up the basic units of life: cells. Cells are grouped together and organised to form tissues, organs and systems that make up large organisms. Each part performs a specific function for the living organism in order to keep it alive. This strand introduces you to life at the molecular, cellular and tissue level.

Topic 1

The chemistry of life

Overview

Living organisms depend on inorganic and organic compounds from the natural environment as life-giving resource materials to build and maintain their cells, tissues, organs and body forms.



1 Molecules for life – inorganic and organic compounds

- Matter is made up of atoms of the elements.
- Atoms are joined to form molecules through chemical bonds.
- A molecule is any chemical structure made of atoms, held together by bonds.
- A compound is a chemical substance made up of atoms of two or more elements.

1.1 Matter is made of organic and non-organic substances

- All living and non-living matter is made up of organic and inorganic substances.
- Inorganic and organic compounds are found as mineral elements (salts) and molecules; table salt is NaCl, a combination of sodium (Na) and chloride (Cl).

2 Inorganic compounds

- Inorganic compounds are made by natural geo-physical processes in the environment.
- They form in living organisms as part of metabolism, in metabolic reactions.
- Examples are water, carbon dioxide, oxygen, sulphur dioxide gas and sodium chloride (table salt).

2.1 Water

Water (H_2O) is used:

- to dissolve substances (solvent)
- to transport substances in the external and internal environments
- as a substance (medium) for chemical reactions to occur in
- to control temperature
- for support and structure
- in reproduction.

2.2 Mineral elements for animals and humans

- Mineral elements (minerals) are inorganic, and naturally found as salts in the external environment.
- Macro mineral elements – those needed in large quantities
- Micro mineral elements – those needed in small quantities (trace elements); taken up as salts (ions)
- Macro mineral elements needed by humans: sodium (Na), potassium (K), calcium (Ca) and phosphorus (P)
- Micro mineral elements needed by humans: iron (Fe), iodine (I)
- Lack of macro and micro minerals can cause deficiency diseases.

2.3 Mineral elements needed by plants

- Plants need mineral elements for their metabolic processes.
- They are taken up as salts (ions) from the soil.

2.3.1 Macro mineral elements needed by plants

- Macro mineral elements needed by plants: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S) and iron (Fe)
- Nitrogen and phosphorus are taken up as nitrates and phosphates.
- Nitrogen enters roots as nitrate in soil – from humus decomposition, animal faeces and urine, nitrogen-fixation, adding fertiliser (nitrate or ammonia).
- Phosphorus enters roots as phosphates – from humus decomposition, animal faeces and urine, mineralisation processes of rock, adding phosphate fertiliser (phosphates).

2.3.2 Micro mineral elements needed by plants

Micro mineral elements needed by plants: boron (B), copper (Cu), iron (Fe), chlorine (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn)

2.4 Fertilisers

- Fertilisers supply plant nutrients or they correct soil fertility, where years of farming or over-using has removed nutrients.
- They are the most effective way to improve crop yields, quality of food and fodder.
- The major nutrients in fertilisers are nitrogen, phosphorus and potassium.
- Nitrates – supply nitrogen
  - Organic forms: plant matter, manure, sewage, food wastes, or any nitrogenous organic compound
  - Inorganic forms: nitrate or ammonia
- Phosphates – supply phosphorus
  - Organic forms: plant matter, manure, sewage, food wastes
  - Inorganic forms: phosphate or superphosphate
- Too much inorganic fertiliser can harm a humus-depleted soil. The soil becomes overloaded with urea, nitrates and phosphates – these leach into surface water.
- Organic fertiliser can bring back natural fertility.

2.4.1 Leaching of agricultural fertilisers into groundwater, rivers and dams

- Water movement leaches phosphate out of soil, often leaving too little for healthy plant growth.
- Huge amounts of fertiliser are lost through surface run-off and leaching into ground water.
- Excess fertilisers/nutrients in water bodies removes oxygen, and animals and plants in the water die.

2.4.2 Eutrophication

- Eutrophication occurs when nitrogen-rich compounds in fertiliser run off and cause lack of oxygen in water bodies, especially coastal zones.
- Without dissolved oxygen they cannot support plant and animal life.
- The water also becomes cloudy and discoloured causing decreased photosynthesis and cold temperatures.

3 Organic compounds

- Organic compounds are made through chemical reactions in living organisms; they are nutrient and energy sources.
- They are made of molecules and contain carbon, hydrogen and oxygen; some may contain nitrogen, sulphur and phosphorus.
- Examples are: carbohydrates, lipids, proteins (including enzymes), hormones, nucleic acids and vitamins

3.1 Carbohydrates

- Carbohydrates are made from the elements carbon, oxygen and hydrogen.
- They are used to:
  - store energy – starch in plant cells; glycogen in animal muscle cells
  - provide energy – during cellular respiration in the mitochondrion
  - provide structure and protection – cell wall in plant cells.

Table 1.1 Carbohydrates grouped according to size

Type	Monosaccharides	Disaccharides	Polysaccharides
Structure	single (mono) sugar molecules	two (di) sugar molecules joined	many (poly) sugar molecules joined
Examples	glucose and fructose	maltose and sucrose	starch, cellulose, glycogen

3.1.1 Starch (polysaccharide) test

The starch test uses iodine solution to show the presence of starch:
Positive ⇢ blue-black colour; Negative ⇢ yellow-orange colour.

3.1.2 Glucose tests

- Fehling's A and B test for glucose: positive ⇢ green, yellow, orange, red colour; negative ⇢ blue colour.
- Benedict's test for glucose: positive ⇢ brick-red colour; negative ⇢ blue colour.

3.2 Lipids

- Lipids are fats and oils.
- They are organic molecules made of carbon, oxygen and hydrogen.
- Made of: one glycerol molecule joined to three fatty acid molecules.
- Saturated lipids (fats) – are from animals, are solids, have single bonds between atoms; examples: lard and butter
- Unsaturated lipids (oils) – are from plants, are liquids, have double bonds between some of the atoms (mono-unsaturated and poly-unsaturated lipids); examples: olive oil, cod liver oil, sunflower oil and margarine

- Uses of lipids:
  - provide structure – as phospholipids in cell membranes
  - absorb nutrients – vitamins A and D
  - store energy – oils in plant seeds
  - provide insulation – fat layers under the skin prevent heat loss
  - protect organs from shock and movement – layers around internal organs
  - provide water – e.g. a camel hump is broken down to water in drought
  - provide waterproofing – wax layers (cuticles) on plant surfaces

3.2.1 Lipid tests

- Lipid tests for fats and oils use their ability to dissolve in solvents; lipids dissolve in ether and do not mix in water (immiscible).
- Ether test: positive ⇢ translucent oil mark on paper; negative ⇢ no oil mark
- Water test: positive ⇢ immiscible (oil floats on water); negative ⇢ miscible

3.3 Cholesterol

- Cholesterol is a lipid (sterol); it is made and used by bodies to keep healthy.
- Cholesterol digests fats and makes vitamin D and hormones.
- Cholesterol comes from both your body and the animal products you eat.
- There are three types of cholesterol:
  - low-density lipoprotein (LDL) – known as 'bad' cholesterol
  - high-density lipoprotein (HDL) – known as 'good' cholesterol
  - triglycerides.
- Lipoproteins carry cholesterol through the body as it cannot dissolve in blood.
- When you eat fat, the liver converts it to a lipoprotein, which is carried through the body as low-density lipoprotein (LDL).

3.3.1 LDL cholesterol and genetic LDL cholesterol

- Too much LDL in the blood slowly builds up plaque in the arteries that go to the heart and brain.
- Plaque is a thick deposit that makes arteries narrow and hard – a condition called atherosclerosis.
- The arteries can block up, causing a heart attack or stroke.
- A high level of genetic LDL cholesterol means a person is more likely to get fat deposits at a younger age.

3.3.2 HDL cholesterol

- HDL in blood prevents a heart attack.
- It carries cholesterol away from arteries to the liver for excretion.
- It removes cholesterol from plaque. This slows plaque build-up.

3.4 Triglycerides

- Triglyceride is a fat made in the body.
- High levels in the blood are caused by being overweight, a high-carbohydrate diet, no exercise, smoking, and drinking too much alcohol.
- People with high triglycerides often have a high LDL level and a low HDL level.
- Many develop heart disease and/or diabetes.

3.4.1 Total cholesterol count

- The two types of lipids, HDL and LDL, along with triglycerides and genetic LDL, make up your total cholesterol count.
- It can be determined through a blood test.

3.5 Proteins

- Proteins are organic compounds made from carbon, oxygen, hydrogen and nitrogen; some may contain phosphorus, sulphur and iron.
- They are made of 20 different kinds of amino acids, which are sequenced in a specific order.
- Proteins are fibrous, globular and membrane-bound.
- Proteins are classified by size and the number of amino acids they contain:
  - amino acids: 1 molecule – tryptophan, glycine, alanine
  - dipeptides: 2 joined amino acids – aspartame (artificial sweetener)
  - tripeptides: 3 joined amino acids – glutathione (anti-oxidant)
  - peptones: 4–10 joined amino acids – peptone, tryptone
  - polypeptides: 10–50 joined amino acids – digested parts of proteins
  - proteins: 50 or more joined amino acids – albumen, gelatine.
- Proteins have four kinds of unique structure:
  - primary structure – the sequence of amino acids joined together
  - secondary structure – the way the chain is folded (pleated) or coiled (spiral)
  - tertiary structure – the fibrous or globular shape of the protein polymer
  - quaternary structure – two or more proteins joined together.
- Proteins are denatured when the amino acid chains or structure of the protein changes under heat, pH and salt.
- Uses of proteins:
  - store potential energy
  - source of amino acids
  - provide structure
  - provide support
  - transport
  - co-ordinate chemicals as hormones
  - provide protection as antibodies
  - speed up metabolic reactions as enzymes
  - allow movement through membranes
- A continual lack of protein in a daily diet causes the diseases kwashiorkor or marasmus.

3.5.1 Protein tests

- Millon's reagent test: positive ⇢ wine red colour; negative ⇢ white/cream colour
- Biuret test: positive ⇢ violet to purple colour; negative ⇢ blue colour
- The Biuret test uses sodium hydroxide and copper sulphate solution – these are added to the test tube directly and heated.

3.5.2 Factors that affect protein structure

Factors that denature proteins and affect how they function are:

- high temperature (not low)
- extreme acidity or alkalinity (pH concentration)
- high salt concentration.

3.6 Enzymes

- Enzymes are organic compounds with a specific structure, and are made from carbon, oxygen, hydrogen and nitrogen; some of them contain sulphur.
- They are modified proteins.
- Enzymes:
  - may change shape during a reaction but this is not permanent
  - are not used up or destroyed during metabolic chemical reactions
  - function best in certain specific optimum conditions
  - act on a specific substrate (substance)
  - break down or build (synthesise) molecules.
- The functions of enzymes are to:
  - perform building-up (anabolic) and breaking-down (catabolic) reactions
  - control specific reactions due to their shape and chemical structure
  - act as catalysts that control the rate of metabolic reactions in organisms by lowering the energy needed for the reaction.
- An example of an important enzyme in cells is catalase (peroxidase). Hydrogen peroxide endangers metabolic reactions in a cell, but catalase breaks down hydrogen peroxide to form oxygen gas and water (bubbles):

hydrogen peroxide	⇢	water	and	oxygen gas
$2H_2O_2$	⇢	$2H_2O$	+	O_2

3.6.1 Factors that affect enzyme action

- The rate of an enzyme reaction and its efficiency is influenced by:
  - temperature
  - pH concentration
  - nature and amount of the substrate
  - amount of enzyme.

- Temperature affects enzyme action in the following ways:
  - low – molecules have low kinetic energy; enzymes become inactive
  - optimum – maximum enzyme activity
  - high – protein structure of enzymes is denatured; activity stops.

  Enzymes are denatured when their amino acid chains begin to come undone or refold and the shape of the active site changes.

- Concentration of pH affects enzyme action in the following ways:
  - low – protein structure of enzymes becomes denatured; activity stops
  - optimum – maximum enzyme activity
  - high – protein structure of enzymes becomes denatured; activity stops.

  Enzymes are denatured when acidity causes the active site to change shape.

3.6.2 Enzymes in everyday life

- Enzymes are added to washing powders to break down stain molecules.
- Different enzymes are used:
  - proteases – break down proteins (blood, egg, gravy)
  - amylases – break down starches
  - lipases – break down fats and grease.
- Most washing powders contain one type of enzyme, but some have two or all three.

3.7 Nucleic acids

- Nucleic acids are large, organic molecules made of carbon, hydrogen, oxygen, nitrogen and phosphorus.
- Two types exist in cells:
  - DNA (deoxyribonucleic acid): in the nucleus; stores information to make protein
  - RNA (ribonucleic acid): in the nucleus and on ribosomes in the cytoplasm; helps to make proteins from amino acids.

3.8 Vitamins

- Vitamins are organic compounds.
- They help control metabolic reactions and are part of a healthy diet.

Table 1.2 Deficiency diseases caused by lack of vitamins

Vitamin	Main source	Deficiency disease
Vitamin A	fish oil, dairy products, yellow vegetables	night blindness
Vitamin B (complex)	legumes, nuts, cereals, grains, egg yolk, liver	beriberi, pellagra
Vitamin C	citrus fruit, tomatoes, vegetables	scurvy
Vitamin D	dairy, egg yolk, liver, made in skin using sunlight	rickets
Vitamin E	cereals, seeds, oils, green leafy vegetables	nerve problems, immune disorders

4 The Recommended Dietary Allowance of nutrients

- The Recommended Dietary Allowance or RDA (also called the Recommended Daily Allowance) is a chart that nutritionists have made to show the normal nutrients healthy people need.
- A diet is food eaten regularly by a person.

4.1 Nutrient content of foods

- By law the nutrient content, additives and preservatives used in a food must be printed on its package.
- The package must show quantities of fat and oils, energy, carbohydrate, protein, fibre, vitamins, minerals, preservatives, colourants and additives.
- This is to help people to choose foods they need every day for a healthy diet.

4.1.1 Calculating the energy value of foods in a meal

- Food energy is measured in two types of units: calories and joules.
- A calorie is the amount of heat energy needed to raise the temperature of 1 ml of water at 15 °C by 1 degree.
- The amounts involved in measuring food energy are so large that kilocalories (kilo = 1 000) and kilojoules are mostly used. The scientific term 'kilocalorie' is simply called a 'calorie' in diet language.
- To convert kilocalories to kilojoules you multiply the kilocalories by a common multiplier of 4,2.
- All calories are the same. A fat calorie is exactly the same as a carbohydrate calorie.

4.1.2 Energy supplied by the major food groups

- The number of calories in a food shows the potential of the energy in the food.
- The diet calorie energy value of the major organic food groups is calculated like this:
  - 1 g protein provides 4 calories
  - 1 g carbohydrate provides 4 calories (dietary fibre excluded)
  - 1 g fat provides 9 calories.
- Example: A hard-boiled egg weighing 50 g consists of 6 g of protein, 1 g of carbohydrate and 6 g of fat. Its kilojoule energy value is calculated as follows:
  (6 g protein × 4 calories) + (1 g carbohydrate × 4 calories) + (6 g fat × 9 calories)
  = 82 diet energy calories
  = 82 × 4,2
  = 344,4 kilojoules

4.1.3 Balanced diets and malnutrition

- A balanced diet can be defined as a regularly-eaten combination of foods, maintaining the energy and nutrient requirement to sustain life and its activities.
- Malnourishment is bad eating habits.

- Malnutrition is caused by:
  - not eating a balanced diet
  - not eating enough food
  - eating too much food.
- Other unbalanced eating behaviours can cause nutritional diseases and conditions, e.g. kwashiorkor (not enough protein), obesity (too much energy foods), anorexia (conscious starvation by not eating) and bulimia (conscious starvation by eating and bringing up food afterwards).
- Some nutritional problems are due to genetic make-up and are called disorders.
- Many factors affect the quantity and quality of diet: how much food is available, water, soils, land, environmental conditions, pollution, poverty and disease.
- To balance a diet in order to maintain a healthy body:
  - Balance food eaten with physical activity – balance energy input with energy output.
  - Eat a variety of food.
  - Eat plenty of grain products, vegetables and fruit.
  - Consume sugar, salt and alcohol in moderate amounts.
  - Limit your intake of fat, especially saturated fat and cholesterol.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 A protein molecule which is denatured, has:

A split into smaller molecules
B changed its shape
C combined with another molecule
D been diluted. (2)

1.2 A protein-digesting enzyme when mixed with starch solution would:

A have no action
B produce amino acids
C produce glucose
D digest the starch. (2)

1.3 Which ONE of the following is **not** a carbohydrate?

A glycogen
B cellulose
C glycerol
D sucrose (2)

1.4 Which of the following food tests is used to test for glucose?

A ether
B Benedict's solution
C iodine solution
D Millon's reagent (2)

1.5 Which comparison between glucose and a protein is INACCURATE?

	Glucose	**Proteins**
A	Millon's test is wine red	Millon's test is colourless
B	Fehling's A and B is orange	Fehling's A and B is blue
C	C, H and O	C, H, O and N
D	Single molecule	Many amino acid molecules

(2)

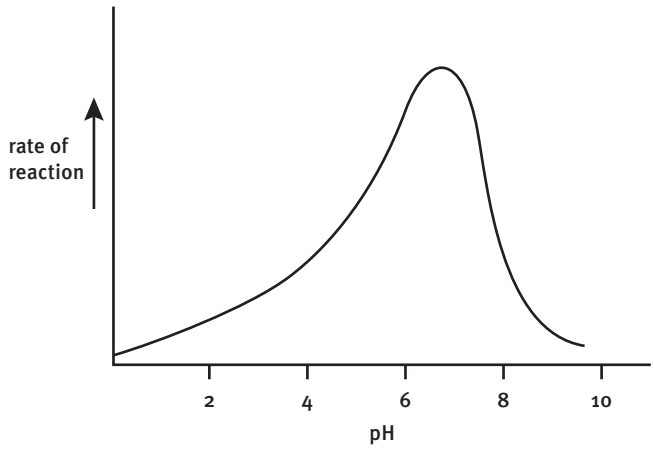
1.6 Which of the following correctly describes enzymes?

Enzymes:

(i) may permanently change shape during a reaction
(ii) are neither used up nor destroyed during metabolic reactions
(iii) function best in specific optimum conditions
(iv) act on any substrate.

A (i) and (iii)
B (ii) and (iii)
C (ii) and (iv)
D (iii) and (iv) (2)

1.7 The graph shows the rate of an enzyme reaction at different levels of acidity or alkalinity (pH).



From the graph, what is the optimum pH for this enzyme?

A pH 2
B pH 7
C pH 10
D none of these (2) [14]

Question 2: Scientific terminology

Use the correct scientific terms when answering these questions.

2.1 Name the chemical elements present in a protein. (5)
2.2 What name is given to the subunits which make up all proteins? (1)
2.3 What are the two types of chemical compound which combine to form a lipid? (2)
2.4 What elements are present in a lipid? (3)
2.5 Name four examples of compounds which are classed as carbohydrate. (4)

2.6 What elements are present in carbohydrates? (3)

2.7 Write the formula for glucose. (3)

2.8 Give the scientific term for:

2.8.1 the process that occurs when a water body collects farm fertiliser nutrients that increase in concentration over a period of time, reducing the oxygen levels and killing off the animal life (1)

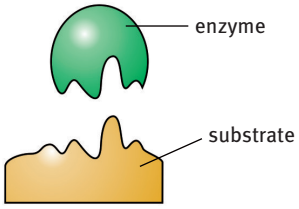
2.8.2 the movement of nutrients through the soil under the action of water until they reach the water table and are unavailable for plant growth (1)

2.8.3 mineral elements needed in small quantities for growth and metabolism. (1) [24]

Question 3: Diagrams

Identify each diagram using the clue(s) provided with the diagram.
Write your answer next to the question number.

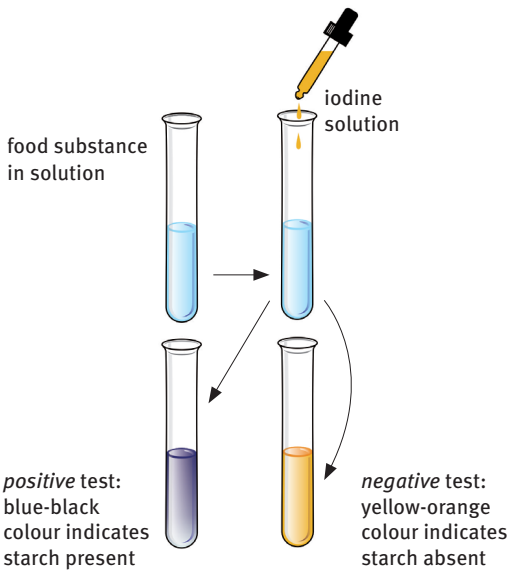
3.1 Model



3.2 Mineral lacking

3.3 Disease

3.4 Food test



[4]

Question 4: Missing words

Select the most appropriate words from the lists given in questions 4.1 and 4.2 below, to complete each of the given paragraphs.

Write the words chosen next to their corresponding numbers.

4.1 *substances, proteins, enzymes, catalysts, speed up, use up, slow down*

All cells contain __**4.1.1**__ which are __**4.1.2**__ and act as __**4.1.3**__ which __**4.1.4**__ chemical reactions. The reactions do not __**4.1.5**__ the __**4.1.6**__ which can take part in further reactions. (6)

4.2 *animals, extra-cellular, intra-cellular, cells, digestive, nuclei, catalysts*

All enzymes are produced inside __**4.2.1**__ . Enzymes which do their work outside cells are called __**4.2.2**__ . Enzymes which do their work inside cells are called __**4.2.3**__. Most of our digestive enzymes are examples of __**4.2.4**__ enzymes. (4) [10]

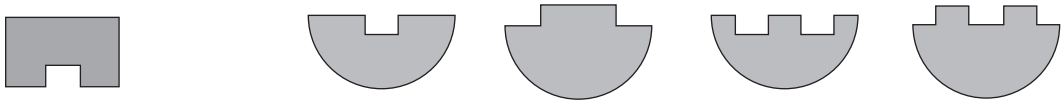
Question 5: Short response

5.1 Apart from food, what other substances do cells need to take in? (2)

5.2 What kind of substance is a lipid? (4)

5.3 In a cell, where are lipids found? (4)

5.4 Enzymes will usually react with only one substance. This can be explained by the 'lock and key' theory. If this theory is correct, which of the following substances, represented by P, Q, R and S would be acted on by enzyme A? (2)



5.5 If an enzyme-controlled reaction normally takes place at 10 °C, in general terms how will the reaction be affected by:

5.5.1 a fall in temperature to 2 °C (2)

5.5.2 a rise in temperature to 20 °C (3)

5.5.3 a rise in temperature to 65 °C? (4)

5.6 If an enzyme is denatured, why does it no longer work? (2) [23]

Question 6: Tables

6.1 The table below shows the results of an investigation into the removal of stains from clothes. Study the information and answer the questions that follow.

Type of stain	Washing temperature (°C)	Biological detergent	Non-biological detergent
Grass	40	✓	×
Mud	40	✓	×
Wine	40	✓	✓
Grass	100	×	×
Mud	100	✓	✓
Wine	100	×	×

✓ = stain removed × = stain not removed

6.1.1 What is a biological detergent and how does it work? (2)

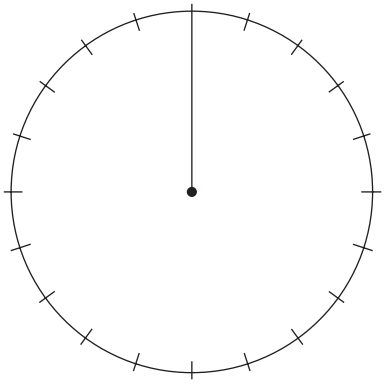
6.1.2 Which detergent removed grass stains? (1)

6.1.3 Which washing treatments did not remove wine stains? (1)

6.2 The table below shows the percentage composition of a veggie burger.

Component	Composition (%)
Protein	50
Fat	15
Fibre	25
Water	10

6.2.1 Present the information in the table in the form of a pie chart. (4)



6.2.2 The veggie burger weighs 50 grams. Calculate the mass of protein present in the veggie burger. (2)

6.2.3 A beef burger contains 35% fat. Calculate the simple whole number ratio of fat in a beef burger to fat in a veggie burger. (2)

6.2.4 Which nutrient is not present in the veggie burger data table? (1)

6.2.5 Can the veggie burger be considered as a balanced meal? Explain. (2) [15]

Question 7: Drawings

If  represents a glucose molecule, draw:

7.1 a disaccharide molecule (2)

7.2 part of a starch molecule. (2) [4]

Question 8: Comprehension

Read the passage below and answer the questions that follow.

What's in a washing powder?

Modern washing powders contain a number of chemicals which reflect the complex demands of modern living. These detergents must remove stains without damaging fabrics and washing machines. They should also be environmentally friendly.

Most detergents contain surfactants which allow the water to spread across the fabric, and builders to soften the water. In addition, lather control agents are put in to stop too much froth forming. The pleasant smell of detergents is produced by fragrances. Corrosion inhibitors protect the washing machine from rusting.

Biological washing powders also contain several types of enzyme such as proteases, amylases and lipases. These enzymes are so powerful that the powders have only 1% enzymes.

Taken from Scottish Qualifications Authority examination in public domain:

8.1 Name the chemical in washing powders which prevents too much froth forming. (1)

8.2 Why are fragrances added to washing powders? (1)

8.3 Why do biological washing powders contain a very low percentage of enzymes? (1)

8.4 Name the three enzymes found in biological washing powders and state what they act on. (6) [9]

Question 9: Data response

An experiment was conducted to investigate the effect of temperature on the activity of enzymes in yeast cells. The activity of the enzyme was measured by the volume of gas bubbles produced as froth in a measuring cylinder containing the yeast cells in a glucose solution. Study figures 1 and 2 provided by the results of the investigation and answer the questions that follow. Source: IEB examination paper November 1998

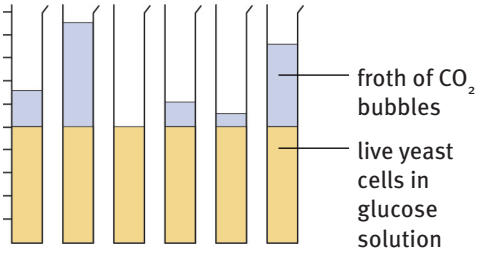


FIGURE 1 Cylinders after 1 hour

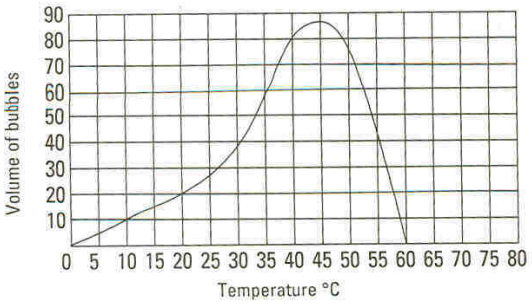


FIGURE 2 Effect of temperature on enzyme activity

9.1 To what group of nutrients does glucose belong? (2)

9.2 What volume of bubbles was produced at 45 °C? (2)

9.3 At which temperature were the enzymes totally denatured? (1)

9.4 Draw and complete the following table using the data in figure 1. Show all your calculations.

Test tube	Volume of bubbles produced (cm^3)
A	
B	
C	
D	
E	
F	

(6)

9.5 Arrange the tube results A to F in the order of increasing temperature by writing down the letters in their correct sequence. (6) [17]

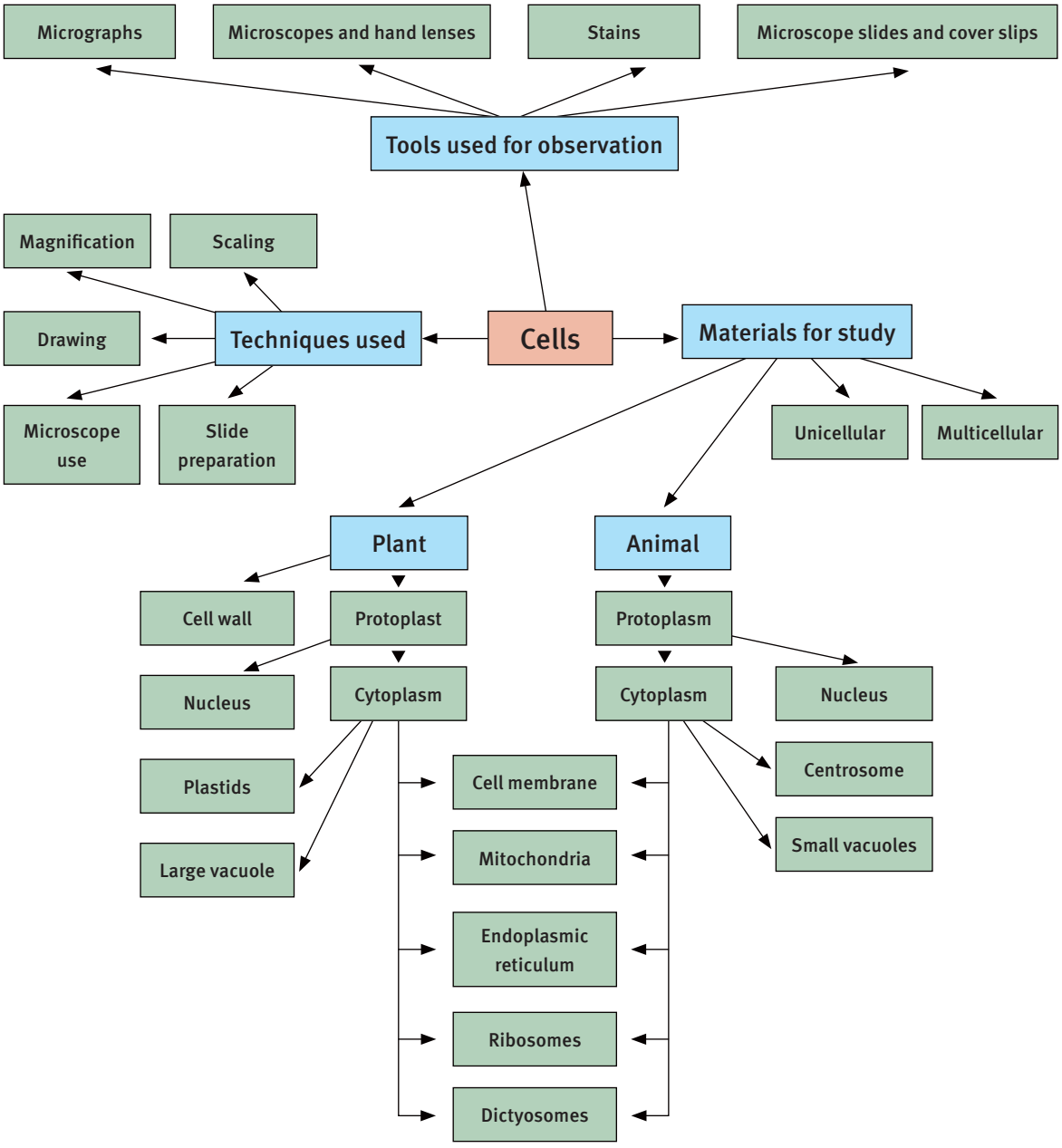
TOTAL MARKS: 120

Topic 2

Cells: the basic units of life

Overview

Cells are the building blocks of large and small organisms. Organisms may be made of a single cell or made of many cells, organised into different tissues. Each cell is specialised to perform its metabolic functions, either on its own, or together with others. Cells maintain a constant internal chemical balance called homeostasis. Internal homeostasis must be maintained for life on Earth to continue.



Topic 2

1 The cell is discovered using the microscope

- A cell is the tiny living unit or 'building block' that makes up the bodies of living organisms.
- Cells have different shapes and are microscopic.
- Robert Hooke discovered plant cells and Antonie van Leeuwenhoek discovered bacteria and single-celled animals.
- Cells were first seen with a simple lens microscope as tiny, colourless and translucent units.
- Chemical stains revealed their internal structure.
- Good light microscopes became available in the early 1900s.
- The powerful electron microscope was developed in 1940 and new techniques were needed to find out more about cells.

1.1 Tools for observation and magnification

- Hand lenses and microscopes are used for magnification.
- They use convex lenses that concentrate light, which either shines through or is reflected off specimens and objects.
- Lenses increase the size of the object by magnifying it.
- A convex lens is the type that makes images of small objects larger.
- Lenses can be combined (compounded) to increase magnification.

1.2 The cell theory

- The cell theory itself was introduced in 1838 by the scientists Schleiden and Schwann:
  - All living organisms are made of cells and are either unicellular (single-celled) or multicellular (many-celled).
  - The cell is the smallest basic unit of life that shows the characteristics and properties of life: metabolism; reproduction; movement; excretion; responding to stimuli; feeding.
  - All cells come from cells that existed before, because they divide to reproduce.
- Modern cell theory extends the original theory and includes the ideas that:
  - energy flows inside cells
  - hereditary information (DNA in genes) is passed on from cell to cell and instructs all activities in the cell
  - all cells have the same basic chemical composition.

1.3 The light microscope

- The light microscope (made of lenses) is used to study invisible, microscopic details.
- Microscopy is a combination of techniques for preparing the specimen, the use of the microscope, and human skills of observing and recording.
- A micrograph is a photograph taken through a microscope:
  - light micrographs – taken by a light microscope
  - electron micrographs – taken by an electron microscope.

1.3.1 Caring for the microscope

1 To pick up or move the microscope, hold it by the arm and under the base.
2 Never touch the lenses. Your body produces oil that sticks to the glass.
3 Use only lens paper to clean the glass. Any other paper may scratch.
4 Always start observations with the smallest or weakest objective lens and then use larger and stronger lenses. This prevents you forcing objective lenses into position and cracking them – a very expensive mistake.
5 When you have finished observing, turn the nosepiece to the low magnification objective.
6 Use the coarse focus screw to roll the nosepiece down to the platform.
7 Put on the dust cover and clean the work area and all slides and materials.
8 Be careful with glass slides and cover slips – they can cut you.

1.3.2 Using the microscope

1 Turn on at the switch or adjust the mirror to catch maximum light.
2 Put the slide on the stage.
3 Use the objective lens with the lowest magnification. Adjust the eyepieces so that you can see a well-focused image through the ocular lens.
4 Focus on the specimen slide using the 4× (low-magnification) objective lens.
5 Turn the diaphragm control until the diaphragm is closed all the way.
6 Bring the diaphragm into the sharpest focus you can, using the focusing knob on the condenser. The specimen must be in the centre of the field of view.
7 Open and adjust the condenser diaphragm slowly, until the specimen features are easy to see.
8 Move on from the 4× objective lens to more powerful objective lenses. Always start with the weakest – not the strongest – lens.
9 Adjust the fine focus to see detail at different depths before moving on to the next objective lens. Always put the specimen in the centre of the field of view.

1.3.3 Preparing a wet mount using the irrigation method

1 Put the fresh specimen into a drop of water on the microscope slide.
2 Cover it with a glass cover slip.
3 Draw stain into the specimen, under the cover slip, using paper towel.

1.3.4 Calculating total magnification and size

- Magnifying power is written on most objectives and oculars.
- The total magnification of a microscope is:

> the power of the eyepiece (ocular) × the power of the objective used

- The formula for calculating the actual size of a magnified specimen is:

$$\text{size of specimen (object)} = \frac{\text{size of image}}{\text{total magnification}}$$

1.3.5 Calculating the size of a microscope field of view

- The diameter of the field of view under low power magnification is about $3\frac{1}{2}$ mm. As the magnification increases the field of view becomes smaller.
- You can calculate the size of a microscope field of view under low power magnification by using a clear metric ruler with mm markings on top of the stage.
- Count the number of mm divisions that fit across the diameter of the field of view. Multiply the number by 1 000 to obtain the size of the field of view in µm.
  Example: A field of view of about $3\frac{1}{2}$ divisions ≈ 3,5 mm ≈ 3 500 µm.

1.3.6 Calculating magnification and size using a scale bar

- Micrographs can be used to determine the size of the original object.
- The formula to calculate original size using a scale bar provided on a micrograph is:

$$\text{actual size} = \frac{\text{size on diagram} \times \text{number on scale bar}}{\text{measured length of scale bar}}$$

2 Plant and animal cells

All cells have:

- a cell membrane – a thin boundary that encloses the cytoplasm; the cytoplasm and the cell membrane together are called protoplasm
- a nucleus – the control centre of the cell
- cytoplasm – a thick, jelly-like liquid that holds particles and structures
- organelles – structures found as single units within the cell, and making up the cell, that have particular functions for metabolism.

2.1 The plant cell

Figure 2.1 is a diagram of a general plant cell that shows all the parts found in different kinds of plants cells.

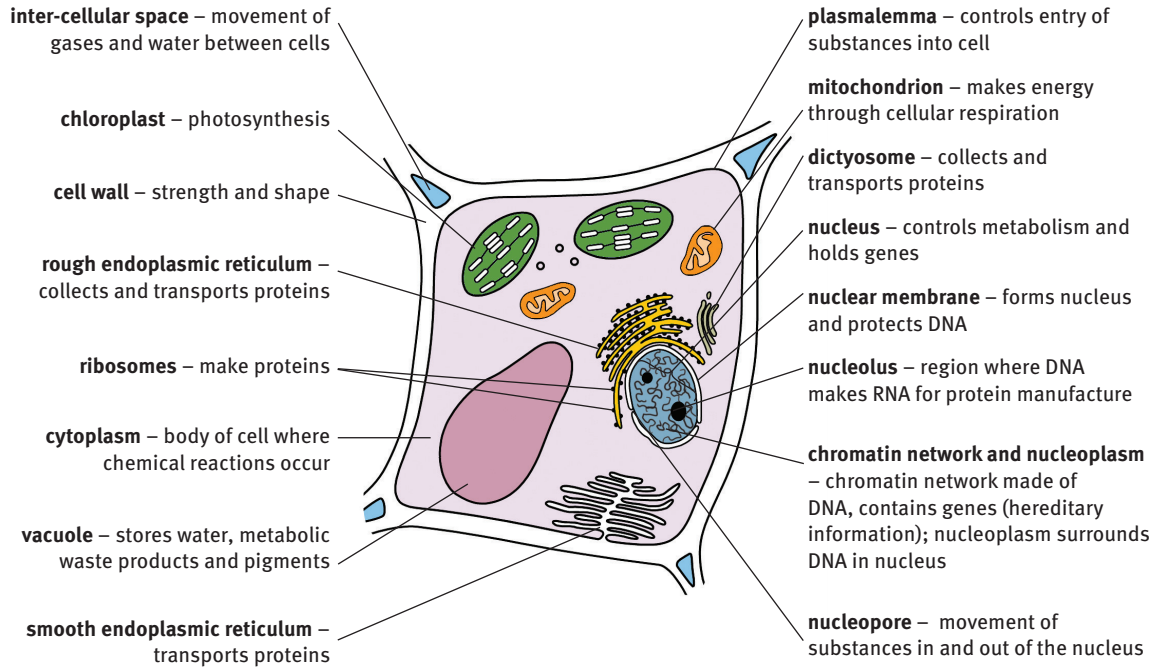


FIGURE 2.1 The structures and functions of parts making up a plant cell

2.2 The animal cell

Figure 2.2 is a diagram of a general animal cell that shows all the parts found in different kinds of animal cells.

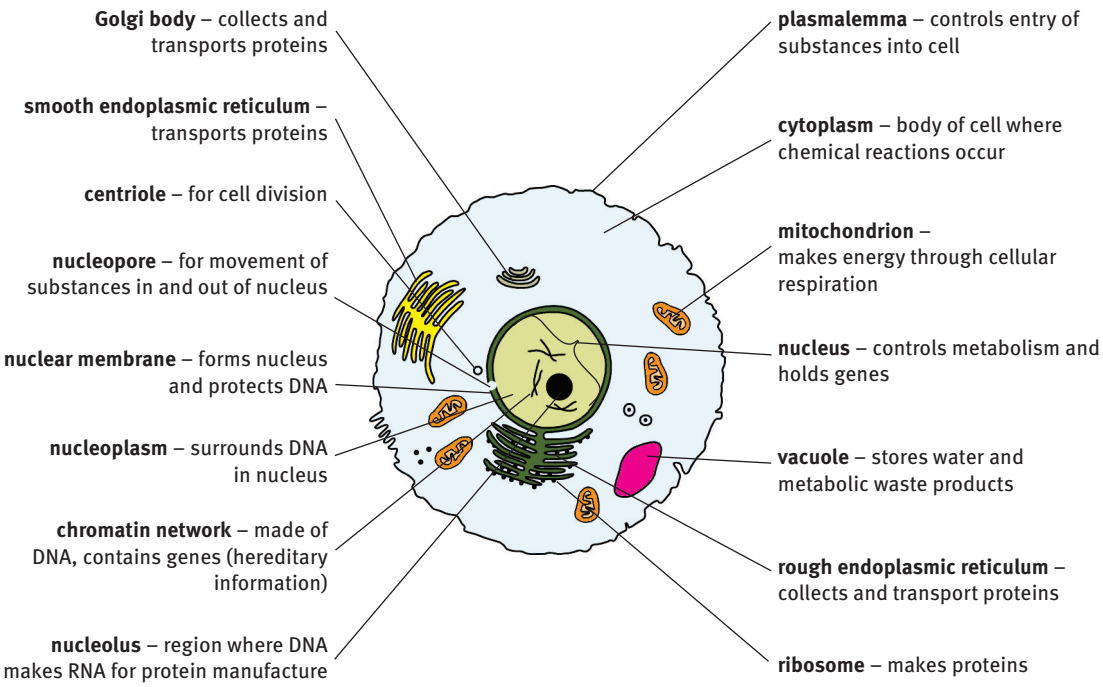
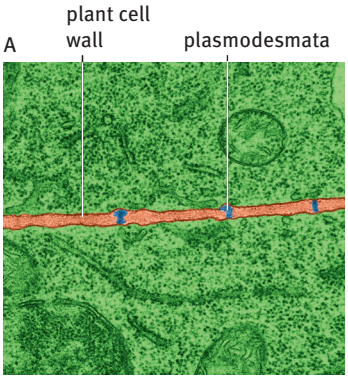


FIGURE 2.2 The structures and functions of parts making up an animal cell

2.3 The plant cell wall

The cell wall is found only in plant cells.



A Low magnification showing plasmodesmata

FIGURE 2.3 A plant cell wall

Table 2.1 Structure and function of the plant cell wall

Structure	Function
Primary cellulose cell wall	Permeable to gases and water Provides shape
Secondary lignin cell wall	Permeable to gases and water Provides strength and protection
Middle lamella	Made of pectin Joins cells together
Pits	Pores (holes) in the cell wall for communication and transport
Plasmodesmata	Threads of cytoplasm that run through pores in the cell wall and join the cytoplasm of cells – for communication and transport

3 The cell membrane

- All living cell contents are held as a unit by the cell membrane.
- The membrane is selectively permeable, meaning certain substances can move through it.

Table 2.2 Structure and function of the cell membrane

Structure	Function
Phospholipid bi-layer	Surrounds and protects cytoplasm contents of cell
Carrier proteins and channel transport proteins	Controls movement of substances in and out of cell
Form organelles	Allow specific metabolic reactions to occur together
Carbohydrates	Cell recognition
Parts modified into microvilli, pseudopodia, hollows, furrows and connections	Feeding; removing waste products Chemical communication between cells Hold cells together

3.1 Fluid mosaic model of the cell membrane

The cell membrane structure and function is explained as a model: the fluid mosaic model. The parts of the membrane are liquid and always moving.

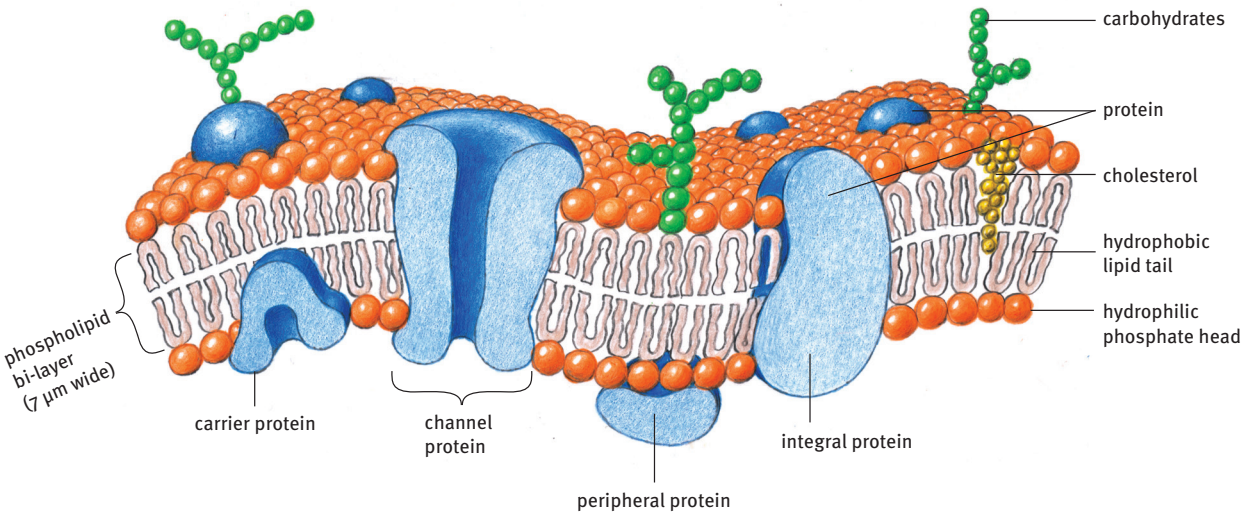


FIGURE 2.4 The fluid mosaic model

3.2 Movement of substances through the cell membrane

Cell membranes are important in helping to transport substances such as nutrients and waste products into, out of and within living cells.

Table 2.3 Movement of substances through the cell membrane

Type of movement	Simple diffusion	Osmosis (facilitated diffusion)	Carrier-facilitated transport	Active transport
Membrane needs	• Need not be alive	• Must be living • Selectively permeable • Channel proteins essential	• Must be living • Selectively permeable • Carrier proteins essential	• Must be living • Selectively permeable • Carrier protein molecules essential
Energy (ATP) use	• Passive process – cell provides no energy	• Passive process – cell provides no energy	• Passive process – cell provides no energy	• Active process – cellular respiration provides ATP energy
Description	• Non-selective • Natural random movement of substances • Liquid or gas medium or across a membrane	• Selective movement of water molecules into/out of a cell • Go through membrane • Use channel protein molecule	• Selective movement of substances into/out of cell • Use carrier protein molecule	• Selective movement using energy for substances into/out of a cell that fit the carrier protein molecule
Direction	• Substances move along a concentration gradient until evenly distributed	• Water moves along a concentration gradient using channel protein until equilibrium	• Substances move along a concentration gradient using carrier protein until equilibrium	• Substances move against a concentration gradient – low to high – using a carrier protein
Examples of substances	• Lipid-soluble molecules, oxygen, carbon dioxide, water	• Water	• Glucose	• Sodium and potassium ions

3.3 Taking up nutrients and removing waste

- In animal and plant cells the movement of water occurs through:
  - endosmosis – water moves into a cell
  - exosmosis – water moves out of a cell.
- In animal cells processes to take up nutrients and remove waste are:
  - endocytosis – taking in food particles and nutrients
  - exocytosis – removing particles and metabolic waste products.

3.4 Special structures of cell membranes

- Animal cells use structures made of folded membranes to take in substances, and to help move nutrients through the cell membrane.
- These structures are:
  - microvilli – increase surface area for absorption of nutrients
  - pinocytotic vesicles – produced in pinocytosis to take up liquids
  - phagocytic vesicles – produced in phagocytosis to take up particles using pseudopodia.

4 The cell nucleus and endoplasmic reticulum

4.1 The cell nucleus

- All living cells contain a nucleus; some animal cells, like muscle cells, may have two.
- The nucleus is the 'brain' of the cell.
- Functions of the nucleus:
  - controls how and which proteins and enzymes are made
  - when the cell will divide.

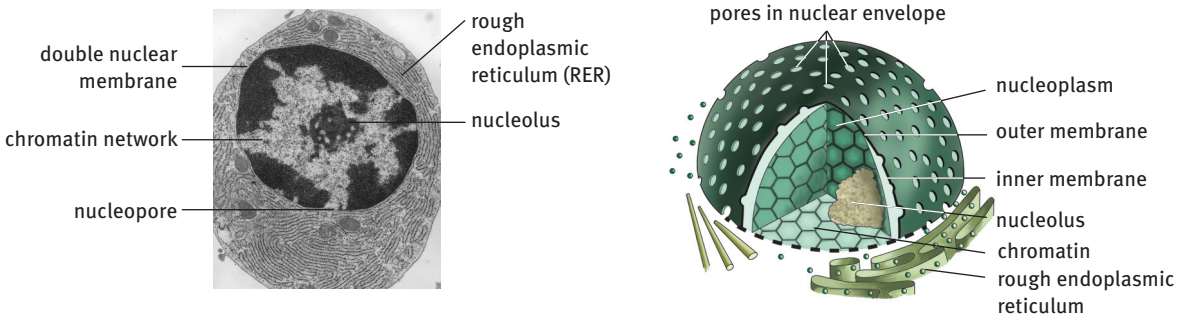


Figure 2.5 The nucleus and the rough endoplasmic reticulum

Table 2.4 Structure and function of the nucleus	
Structure	**Function**
Double nuclear membrane	Encloses and protects chromatin network
Nucleopores	Control movement of substances in and out of nucleus
Nucleoplasm	Fluid making up body of nucleus
Chromatin network	• Irregular network of long strands of DNA molecules and granules in the nucleoplasm • Has hereditary information as genes • Makes chromosomes during cell division
Nucleolus	Dense part of nucleus made up of DNA, RNA, protein

4.2 Endoplasmic reticulum

- The endoplasmic reticulum is closely linked to the nucleus:
  - smooth endoplasmic reticulum (SER) – a network of membranous tubes
  - rough endoplasmic reticulum (RER) – a network of tubes with ribosomes attached.
- Functions of the endoplasmic reticulum:
  - Connects the cell membrane and nucleus membrane.
  - SER and RER connect to the cell membrane to transport substances.
  - RER and ribosomes make proteins for transport.

5 Cell cytoplasm and organelles

- Cytoplasm – makes up the fluid body of cells; it is made of many substances and structures, and its continuous movement helps to transport them around the cell.
- Organelles – made of membranes; they perform specific metabolic functions; some are found only in animal cells and others only in plant cells.

Table 2.5 Structure and function of cytoplasm	
Structure	**Function**
90% water	Dissolves sugars and salts, holds lipids and proteins, supports chemical reactions, transports substances
Enzymes	Control the rate of chemical reactions in the cell
Cytoskeleton of proteins	Shape and support the cell
Organelles made of membranes	Control and manage metabolic reactions

5.1 Ribosome

Ribosomes are spread through the cytoplasm or attached to the endoplasmic reticulum and are the sites where the cell makes proteins.

5.2 Vacuole

- Plant cells usually have one large vacuole.
- Animal cells usually have many small vacuoles.
- Vacuoles have special functions in the cell, e.g.:
  - pinocytic vesicle – takes up fluids
  - phagocytic vesicle – takes up food particles
  - lysosome (peroxisome) – contains peroxidase; kills damaged cells
  - contractile vacuole – controls water content in the cell.
- The tonoplast is the selectively permeable membrane that surrounds a vacuole.
  - It controls the movement of water, enzymes, food, pigments, waste products and toxic substances into and out of the vacuole.
  - It provides turgidity (support) to the cell.

5.3 Mitochondrion

- Mitochondria are tiny spherical or oval-shaped organelles in the cytoplasm.
- They are responsible for cellular respiration and the manufacture of energy (ATP).

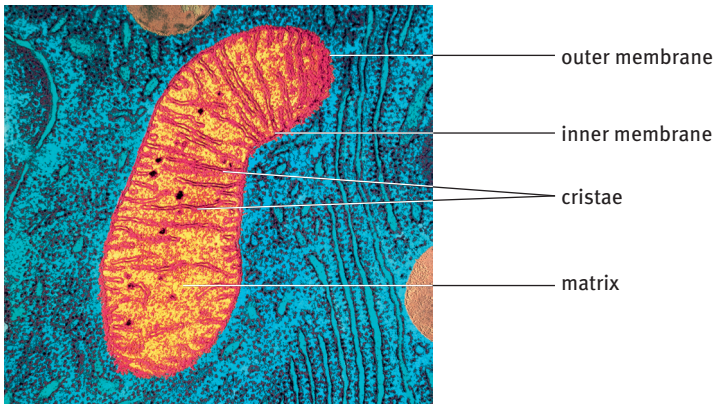


FIGURE 2.6 Structure of the mitochondrion

Table 2.6 Structure and function of the mitochondrion

Structure	Function
Double membrane	• Smooth outer membrane for easy movement through the cytoplasm; controls the movement of substances • Inner membrane folded to increase the surface area for maximum chemical reactions to occur
Crista (plural: cristae)	Site of enzyme reactions to make energy (ATP)
Matrix	Fluid with compounds for cell respiration and making energy

5.4 Golgi body and dictyosome

- These organelles are called Golgi bodies in animal cells, and dictyosomes in plant cells – they are linked to the endoplasmic reticulum.
- They sort and store cellular secretions, such as enzymes.

5.5 Plastids

Plastids are found only in plants:

- leucoplasts – store substances and are found in mature cells that are not exposed to light
- chromoplasts – have pigments that give the yellow to red colours in flowers, autumn leaves, ripening fruit and roots such as carrots

- chloroplasts – in the green-coloured cells of plants and algae; chloroplasts are responsible for photosynthesis.

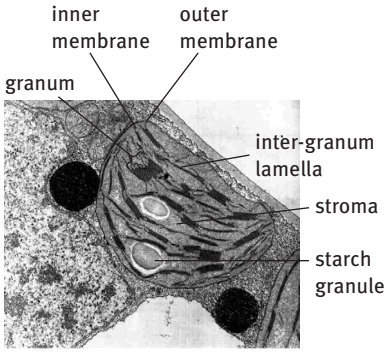


FIGURE 2.7 Structure of a chloroplast

Table 2.7 Structure and function of a chloroplast

Structure	Function
Double membrane	Smooth outer membrane allows easy movement through cytoplasm Membranes control movement of substances into and out of chloroplast
Stroma	Inner fluid of compounds, enzymes essential for photosynthesis, starch granules
Granum (plural: grana)	Stacked thylakoids for increased surface area and maximum photosynthesis
Inter-granal lamella (plural: lamellae)	Membranous bridges that connect grana with each other
Thylakoid	Membrane structures found in grana; have chlorophyll for photosynthesis
Chlorophyll	Green light-sensitive pigment needed for photosynthesis

5.6 Centrioles

All living animal cells have a centrosome made of two centrioles. The centrioles act as 'anchors' to separate chromosomes during cell division.

6 Cell differentiation

- Differentiation is a process in which a cell changes its size, shape and structure to perform a specific function.
- In animals, stem cells can differentiate to form other specialised cells.
- In plants, meristematic cells can differentiate to form other specialised cells.

Table 2.8 Differences in the structure of an animal cell and a plant cell

Animal cell	Plant cell
1 No chloroplasts present	1 Chloroplasts present
2 No cell wall present	2 Cell wall present
3 Many small vacuoles present	3 Large vacuole
4 Centrioles present	4 No centrioles present

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 Which difference between a plant and animal cell is CORRECT?

	Plant cell	Animal cell
A	Contains a chloroplast	Contains a chloroplast
B	Contains a large vacuole	Contains many small vacuoles
C	Contains no cell membrane	Contains a cell membrane
D	Contains a nucleus	Contains a cell wall

(2)

1.2 The total magnification of an animal cell was 400 ×.
What is the magnification size of the objective lens of a light microscope, if the ocular lens magnification was 5 ×?

A 80 ×
B 2 000 ×
C 0,125 ×
D 8 ×

(2)

1.3 Which of the following parts of the microscope and their functions is CORRECT?

	Part	Function
A	diaphragm	concentrates the light rays
B	lamp	warms the specimen
C	nosepiece	holds objective lenses
D	course focus adjustment	fine focus

(2)

1.4 Study the diagrams below.

Organise the diagrams in the order of preparing a wet mount.

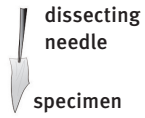
A (i), (ii), (iv), (iii)

B (i), (ii), (iii), (iv)

C (iv), (ii), (i), (iii)

D (iv), (i), (ii), (iii) (2)

(i)



(ii)

(iii)

(iv)

1.5 The part of the microscope closest to the eye is the:

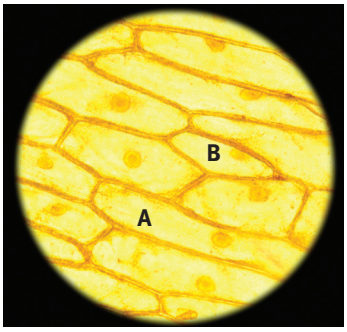
A ocular lens

B objective lens

C condenser

D body tube. (2)

1.6 The micrograph alongside was taken using a light microscope. What is the actual length of the plant cell between points A and B, if the image is magnified 40 ×?



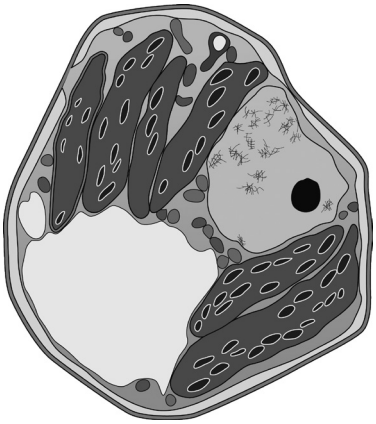
A 3,5 cm

B 0,35 mm

C 35 cm

D 3,5 mm (2)

1.7 The micrograph alongside was made using a:



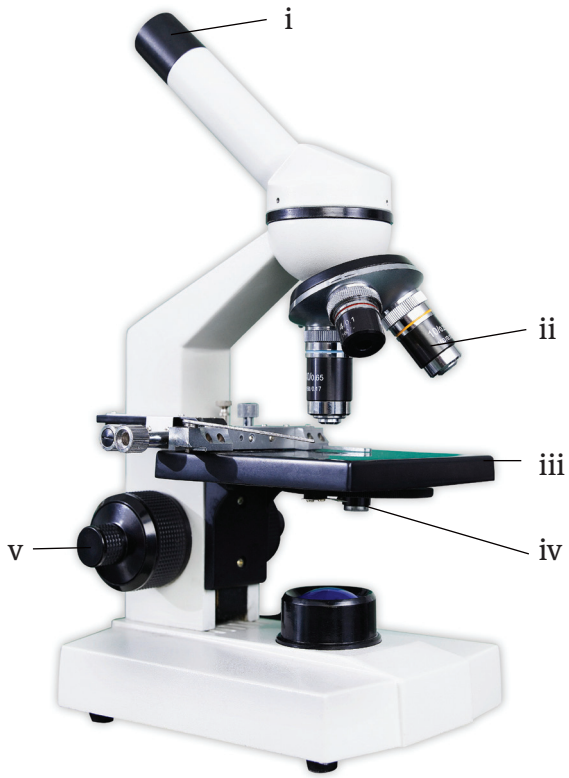
A light microscope

B scanning electron microscope

C dissection microscope

D transmission electron microscope. (2)

Use the diagram of the microscope provided below to answer questions 1.8 to 1.10.



1.8 Lenses are found in parts:

A i and iv
B i and ii
C ii and iv
D iii and v. (2)

1.9 Light rays move through parts:

A i, ii, iii and v
B i, iii, iv and v
C i, ii, iii and iv
D ii, iii, iv and v. (2)

1.10 Which of the following parts of the microscope and their functions is INCORRECT?

	Part	Function
A	i	Holds objective lenses
B	iii	Supports the specimen
C	iv	Concentrates the light rays
D	v	Fine focus

(2)

1.11 Which of the following controls the cell and its functions?
A vacuole
B ribosomes
C nucleus
D Golgi body (2)

1.12 What is the magnification of a light microscope if a specimen 10 µm long is seen as 2 mm long under the microscope?
A 20
B 200
C 0,2
D 3 (2) [24]

Question 2: True/false

Read each of the statements 2.1 to 2.5 provided below.
Decide if each statement is scientifically *correct* or *incorrect*.
If *correct*, write down the word 'true' next to the question number.
If *incorrect*, write down the word 'false' next to the question number, and *rewrite* the sentence to show the change made by *underlining* the *changed* text.

2.1 A nucleolus is part of the nucleus. (2)

2.2 The movement of water into a cell is known as exosmosis. (2)

2.3 Animal cells feed through phagocytosis. (2)

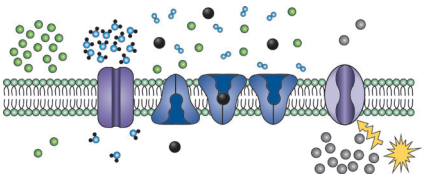
2.4 Organelles with double membranes are the nucleus, vacuole and chloroplast. (2)

2.5 Proteins that are found on the outside of the cell membrane are integral proteins. (2) [10]

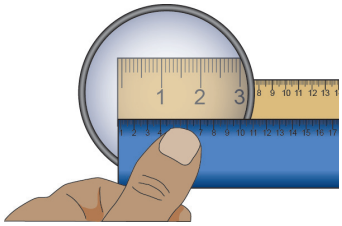
Question 3: Scientific terminology

3.1 Three diagrams (3.1.1 to 3.1.3) are provided below. Identify what each diagram is showing using the clue(s) provided with the diagram.

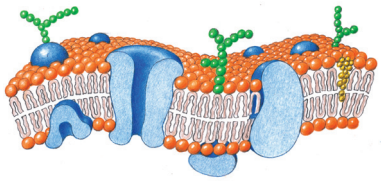
3.1.1 Process



3.1.2 Process



3.1.3 Model



(3)

3.2 Give the scientific term for each of the following descriptions. Write the term next to each question number.

3.2.1 The movement of water across a differentially permeable membrane (1)

3.2.2 The movement of a substance across a membrane using energy (1)

3.2.3 The procedure which is used to stain a wet mount (1)

3.2.4 Organelles in plant cells that contain pigments (1)

3.2.5 Organelle attached to the nuclear membrane (1)

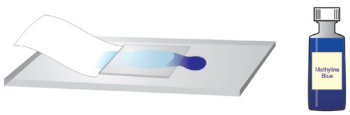
3.2.6 Organelle in which cristae are found (1)

3.2.7 Structures in animal cells used in cell division (mitosis) (1)

3.2.8 Process where cells change to perform specific functions (1) [11]

Question 4: Diagram

Use the diagram below to explain how a prepared wet mount is stained.



[5]

Question 5: Short response

5.1 What do the following scientific terms mean?

5.1.1 Selectively permeable

5.1.2 Photosynthesis (4)

5.2 Which of the following organelles are ONLY found in plant and animal cells, respectively?

mitochondrion, chloroplast, vacuole, centriole, Golgi body (2) [6]

Question 6: Tables

Tabulate the following parts of the microscope and their function:
objective lens, stage, course adjustment screw. [7]

Question 7: Drawings

Cells were studied in the laboratory after staining and using a light microscope. Photographs were taken of each of the specimens.

7.1 Calculate the actual width of the cell in diagram 1 between points A and B using the scale bar provided. (5)

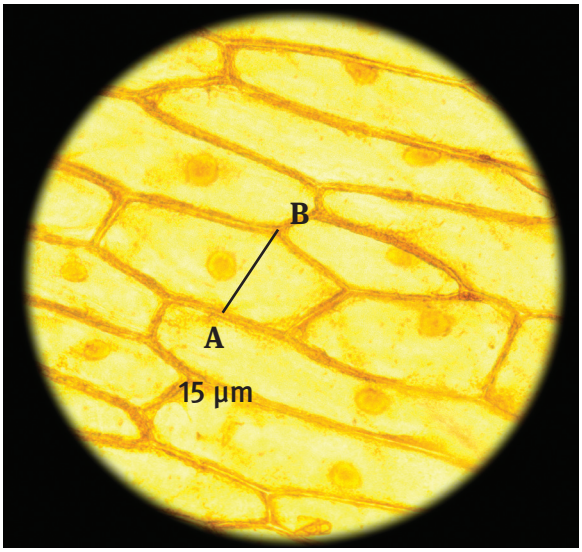


Diagram 1

7.2 Draw and label a drawing of cell C from diagram 2. Use drawing rules. (8) [13]

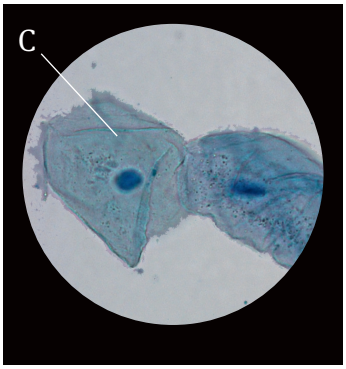
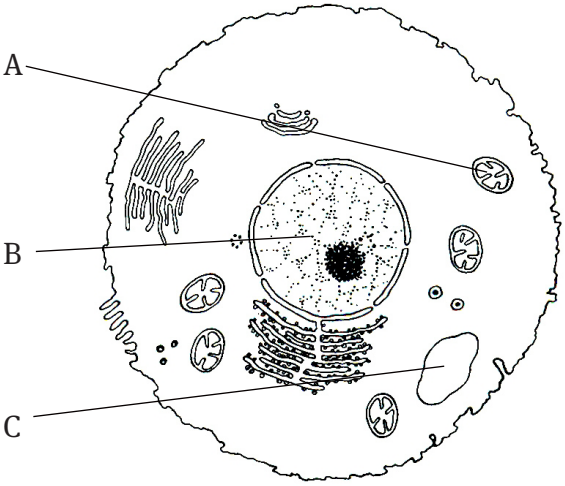
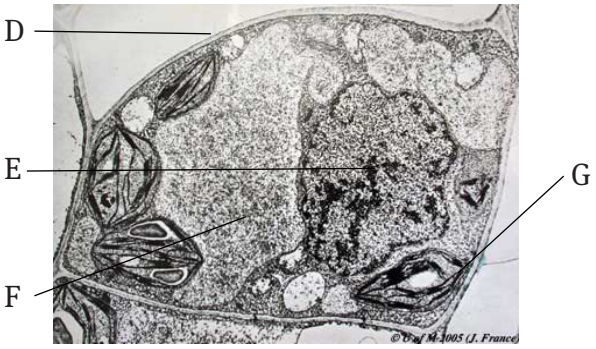


Diagram 2

8.1 Study the diagrams of cell 1 and cell 2 below and answer the questions that follow.



Cell 1



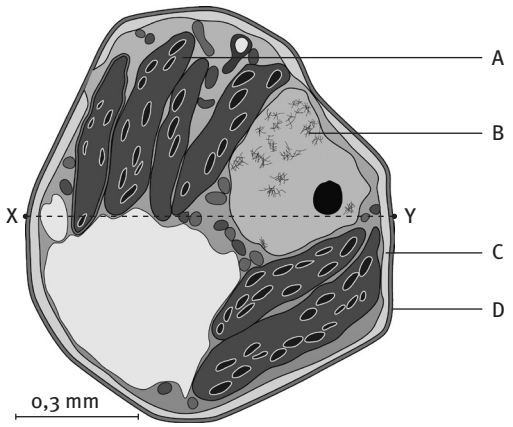
Cell 2

8.1.1 Identify parts A, B, C and F. (4)

8.1.2 Provide the function of parts D, E and G (3)

8.1.3 Name the colourful substance found in part D. (2)

8.2 Study the diagram of a cell seen under the electron microscope and answer the questions.



8.2.1 Identify the type of cell in the micrograph. (1)

8.2.2 Name parts C and D. (2)

8.2.3 State the functions associated with parts A and B. (2)

8.2.4 Provide the letters and the names for the parts in which you find:

(a) large starch granules and chlorophyll (2)

(b) DNA and a nucleolus (2)

(c) cellulose (2)

(d) a phospholipid bilayer, transport proteins and carbohydrates. (2)

8.2.5 Calculate:

(a) the magnification of the microscope using only the scale bar (4)

(b) the width of the cell in micrometres between points X and Y. (5)

8.3 Explain what will happen if the cell is put in a very salty solution. (5) [36]

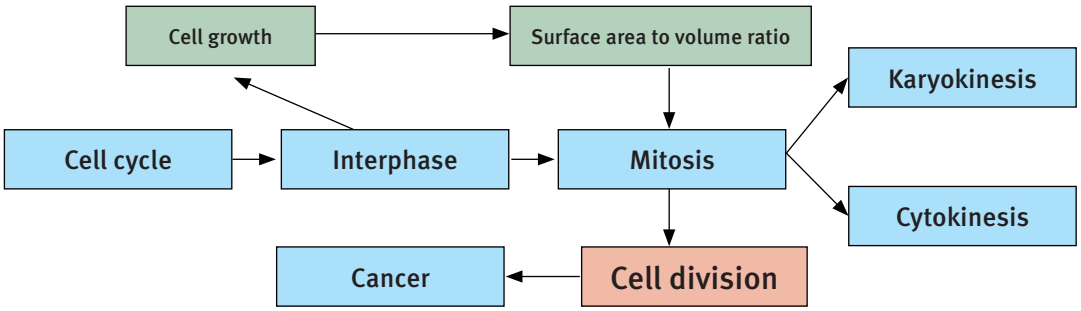
TOTAL MARKS: 112

Topic 3

Cells division: mitosis

Overview

Cells divide continuously as a way of replacing old and dying cells. Cell division ensures that living organisms grow and live.



1 The growth and division of a cell

- Growth is an increase in size and volume.
- Unicellular organisms reproduce asexually by mitotic cell division.
- Multicellular organisms use mitosis for growth, repair and replacement of dead cells.
- Cell division controls cell size and the surface area to volume ratio.

1.1 The cell cycle

The cell cycle has two parts:

- interphase which is cell growth, and
- mitosis which is cell division.

1.1.1 Interphase and chromosomes

- During interphase the cell carries out its functions and increases in size.
- In the nucleus, the DNA is duplicated to produce two sets and can be seen as chromosomes.
- Chromosomes are made of two chromatids (sets of hereditary material) joined by a centromere.

1.1.2 Surface area to volume ratio

- The relationship between a cell's volume and surface area for nutrient and waste exchange is controlled by the nucleus.
- If the ratio is too small and the cell is too large, the cell divides into two to keep the ratio correct.
- A group of small cells have a much greater surface area (of cell membrane) in relation to their volume (cytoplasm), than one large cell.

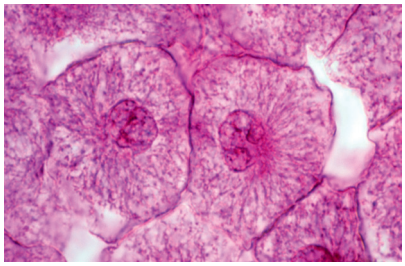
2 Mitosis

- Mitosis is the process of cell division – a mature cell divides into two identical new cells.
- Two division processes are important in mitosis:
  - karyokinesis – division of the nucleus
  - cytokinesis – division of the cytoplasm.

2.1 Purpose and location of mitosis

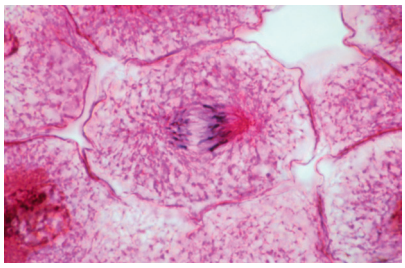
- Mitosis has three purposes:
  - Growth – multicellular organisms need cell division to grow; they all start as a single cell and soon have of a huge number of cells.
  - Repair – organisms constantly repair and renew themselves; worn out or dead cells are replaced through cell division.
  - Reproduction – single-celled organisms, such as bacteria and protists, also reproduce by cell division (binary fission and budding).
- In plants, mitosis occurs in:
  - apical meristem tissues behind the tip of the root or stem and in buds
  - lateral meristem tissues underneath bark.
- In animals, mitosis occurs in specific places in the organs, for example in:
  - bone marrow
  - skin basal layers.

2.1.1 Mitosis in animal cells

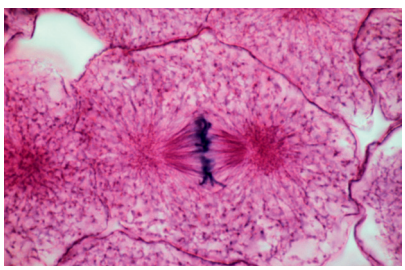


- Interphase:
  - DNA in chromatin network duplicates.
  - DNA thickens and becomes visible.

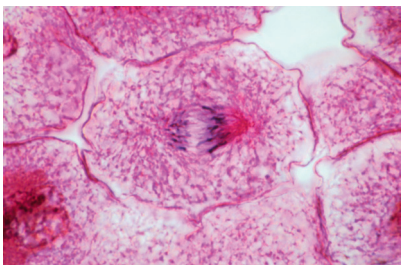
- Prophase:
  - A centrosome is made of two separate centrioles.
  - Centrosomes move to opposite sides of the cell (pole).
  - Fibres form between the centrosomes to form a spindle.
  - Each chromosome is visible as two chromatids joined by a centromere.



- Metaphase:
  - The nuclear membrane is completely disintegrated.
  - Chromosomes line up at the equator of the cell.
  - Each chromosome becomes attached by its centromere to a separate spindle fibre and starts to move towards the equator of the spindle/cell.



- Anaphase:
  - Each chromosome separates into its sister chromatids by the action of spindle fibres pulling each towards a spindle pole.
  - Each chromatid (now called a daughter chromosome) is pulled to opposite sides (poles) of the cell.



- Telophase:
  - Cytokinesis starts by the cell membrane starting to constrict at the equator of the cell.
  - A nuclear membrane and nucleolus form in each daughter cell.
  - Each daughter cell has the same number of chromosomes as the parent cell.

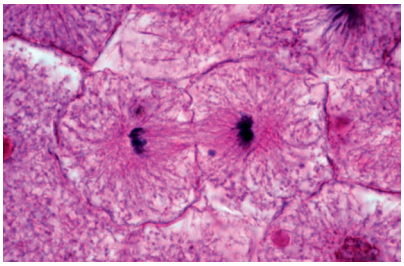


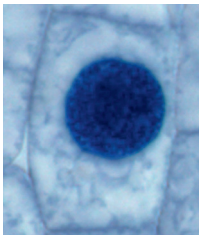
Figure 3.1 Mitosis in animal cells

2.1.2 Mitosis in plant cells

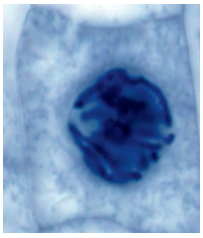
The process is the same as that in animal cells but there are two important differences.

- In animal cells the spindle forms between the pairs of centrioles. In plant cells, centrioles are absent but a spindle is still formed.
- In animal cells, the cell membrane constricts (pinches off) to form two daughter cells. In plant cells, a cell plate forms at the equator of the cell between the two sets of chromatids, and develops into a cell wall.

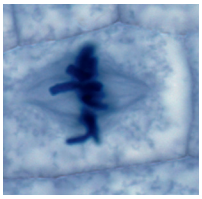
- Interphase:
  - DNA in chromatin network duplicates.
  - DNA thickens into chromosomes.



- Prophase:
  - Spindle fibres form between the poles of the cell without the use of centrosomes.



- Metaphase:
  - The nuclear membrane is completely disintegrated.
  - Chromosomes line up at the equator of the cell.
  - A centromere joins two chromatids to form a chromosome.
  - Each chromatid of a chromosome becomes attached to a spindle fibre at the centromere.



- Anaphase:
  - The centromere splits.
  - Each chromosome separates into its sister chromatids by the action of spindle fibres pulling each towards a spindle pole.
  - Each chromatid (now called a daughter chromosome) is pulled to opposite sides (poles) of the cell.

- Telophase:
  - Cytokinesis starts by a cell plate (new cell wall) forming at the equator.
  - The chromosomes unwind and lengthen to form a chromatin network.
  - A nuclear membrane and nucleolus form in each daughter cell.
  - Each daughter cell has the same number of chromosomes as the parent cell.

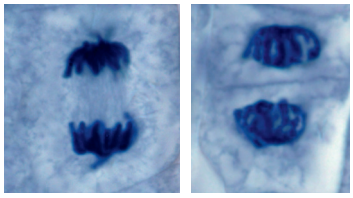


FIGURE 3.2 Mitosis in plant cells

3 Cancer

- Cancer is uncontrolled cell division and growth (mitosis), causing a tumour to develop.
- Benign tumours are cancerous cells found at the original site that do not move through the body.
- Malignant tumours leave the original site and move throughout the body invading other organs and tissues.

3.1 Causes of cancer and types of tumour

- Cancer is caused by different factors called carcinogens.
- Carcinogens are:
  - inherited susceptibility
  - radiation (sun, X-rays, radioactivity)
  - smoking
  - hormonal imbalances
  - processed foods
  - pollutants
  - pesticides
  - viruses.
- There are different kinds of cancer:
  - carcinomas – skin/epithelium cancer lining organs, glands and skin
  - sarcomas – bone, cartilage and muscle
  - leukaemia – blood, and lymphatic and immune system.

3.2 Beliefs and attitudes about cancer

- Beliefs and attitudes about cancer come from sources such as cultural stories, cancer patients and the media.
- Some beliefs and attitudes about cancer:
  - cancer is a death sentence
  - exercise or eating certain types of organic food will prevent or cure cancer
  - modern medicine can cure anything
  - patients will not die if they get the best treatment and have a positive attitude
  - cancer treatments are extremely strong, and they do more harm than good
  - treating old patients is a waste of resources
  - new treatments have not been well tested
  - there are not enough specialist cancer centres
  - treatments are too expensive
  - people fear being discriminated against by employers and society if they tell that they have cancer.

3.3 Cancer treatment

- Medical biotechnology used in cancer treatment is:
  - surgery – to cut it out with a scalpel or laser
  - chemotherapy – chemical compounds kill the cancer cells
  - radiotherapy – can use machines, radiation, injections of compounds and capsules.
- Traditional technology used in cancer treatment includes natural remedies like Cancer Bush tea and African wild potato tea.
- Complementary therapies are different treatment methods used together, if they do not affect each other. For example, a patient may have chemotherapy and use herbal teas.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 Cell division is found to occur in:

A growth
B reproduction
C cancer
D all options. (2)

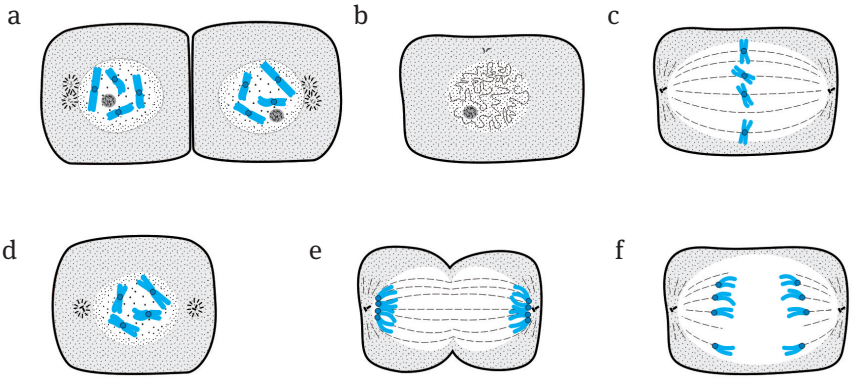
1.2 Which of the following does NOT OCCUR DURING INTERPHASE?

A spindle formation
B cytokinesis
C DNA replication
D growth (2)

1.3 Which of the following is a biotechnological treatment for cancer?

A African potato bush tea
B acupuncture
C meditation
D chemotherapy (2)

1.4 Arrange the following diagrams in the correct sequence to illustrate mitosis in an animal cell.



A (b), (d), (c), (f), (e), (a)
B (a), (b), (c), (d), (e), (f)
C (e), (a), (d), (b), (c), (f)
D (a), (d), (c), (e), (f), (b) (2) [8]

Question 2: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

2.1 The phase in which chromatids are separated (1)
2.2 The phase where chromatids are formed (1)
2.3 Plant tissue responsible for mitosis (1)
2.4 The stage of cell division in which the DNA is copied (1)
2.5 The cellulose structure that divides a plant cell into two during telophase (1)
2.6 The two structures that make up a centrosome (1) [6]

Question 3: Matching columns

3.1 Match the description in column I with the scientific term in column II. Write down only the letter of the term chosen next to the question number. For example, 3.1.1 E

Column I	Column II
3.1.1 Division of the cytoplasm	A carcinoma
3.1.2 Uncontrolled cell growth	B benign
3.1.3 Chromatids lined up at equator of cell	C cancer
3.1.4 Chromatids joined at this point	D meristematic
3.1.5 Mass of cancerous cells	E carcinogens
3.1.6 Skin cancer	F metaphase
3.1.7 Growth and mitosis	G cytokinesis
3.1.8 Cancer causing factors	H tumour
3.1.9 Cancer cells that do not spread	I centromere
3.1.10 Replicated half of a chromosome	J sarcoma
	K anaphase
	L malignant
	M chromatid
	N cell cycle

(10)

3.2 State whether each of the phrases in column I applies to A only, B only, both A and B or none in column II. Write down A only, B only, both A and B or 'none' next to the question number. For example, 3.2.1 None

Column I	Column II
3.2.1 Mitosis	A cloning B chromosomes
3.2.2 Chromosome	A chromatid B spindle fibre
3.2.3 Phases in the cell cycle	A interphase B mitosis
3.2.4 Tumour	A benign B malignant
3.2.5 Bone cancer	A carcinoma B leukaemia

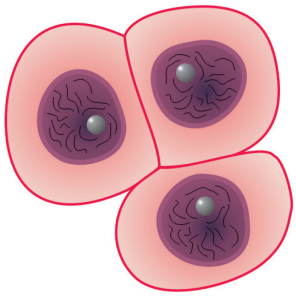
Column I	Column II
3.2.6 Centromere splits	A telophase B anaphase
3.2.7 Cytokinesis	A interphase B telophase
3.2.8 Cancer treatment	A radiotherapy B chemotherapy

(8) [18]

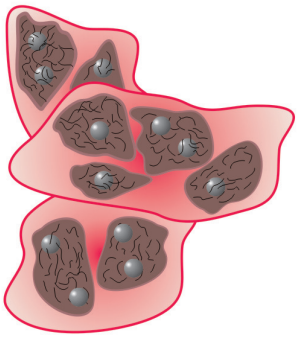
Question 4: Diagrams

Identify each diagram using the clue provided with the diagram.

4.1 Process



4.2 Uncontrolled growth



(4) [4]

Question 5: Short response

Provide the correct terms for the following:

5.1 Two parts making up a chromosome (2)

5.2 Two parts making up the cell cycle (2)

5.3 Two differences between mitosis in plant and animal cells (2)

5.4 Two types of tumour (2)

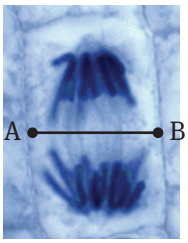
5.5 Three types of medical treatment for cancer. (3) [11]

Question 6: Tables

Tabulate the differences between mitosis in plant and animal cells. (8) [8]

Question 7: Drawings

Study the micrograph of a cell in mitosis, taken with a magnification of 1 500 ×.



7.1 Draw the cell twice its size. Use drawing rules. (8)

7.2 Label the following on your drawing: cell wall; chromatid; cytoplasm. (3)

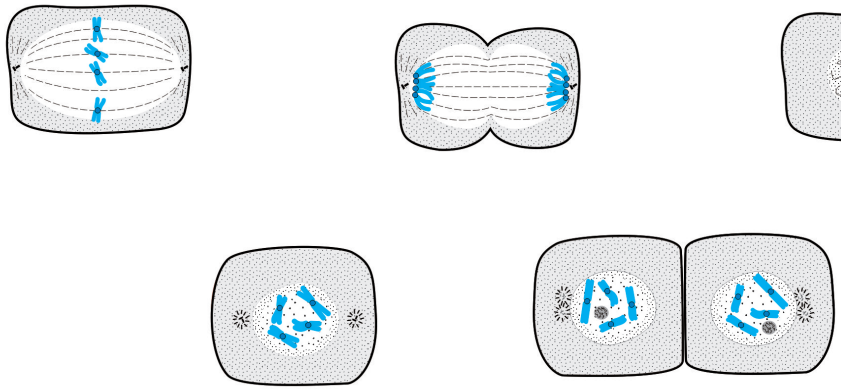
7.3 Calculate the actual width of the cell between points A and B. (5) [16]

Question 8: Graphs

Draw a bar graph for the following cancer occurrence information in men: Lung & bronchus 17%; Prostate 12%; Stomach 11%; Colon & rectum 10%; Liver 8%. [10]

Question 9: Contextual

Study the diagram below and answer the questions that follow.



9.1 Organise the diagrams to represent the correct sequence of events. (5)

9.2 State TWO differences between this process and the same process occurring in plants. (2)

9.3 Explain the difference between the chromosomes seen in diagram A and diagram E. (2) [9]

Question 10: Essay

Write an essay explaining the cell cycle and how it involves mitosis. Use the animal cell as an example. [20]

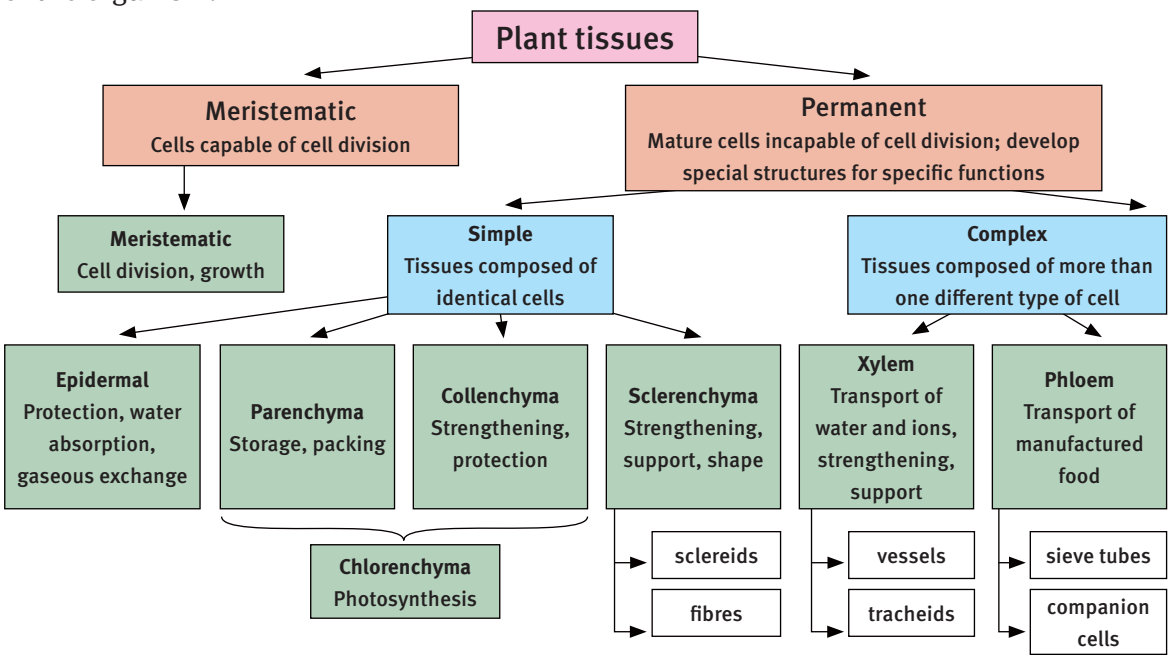
TOTAL MARKS: 110

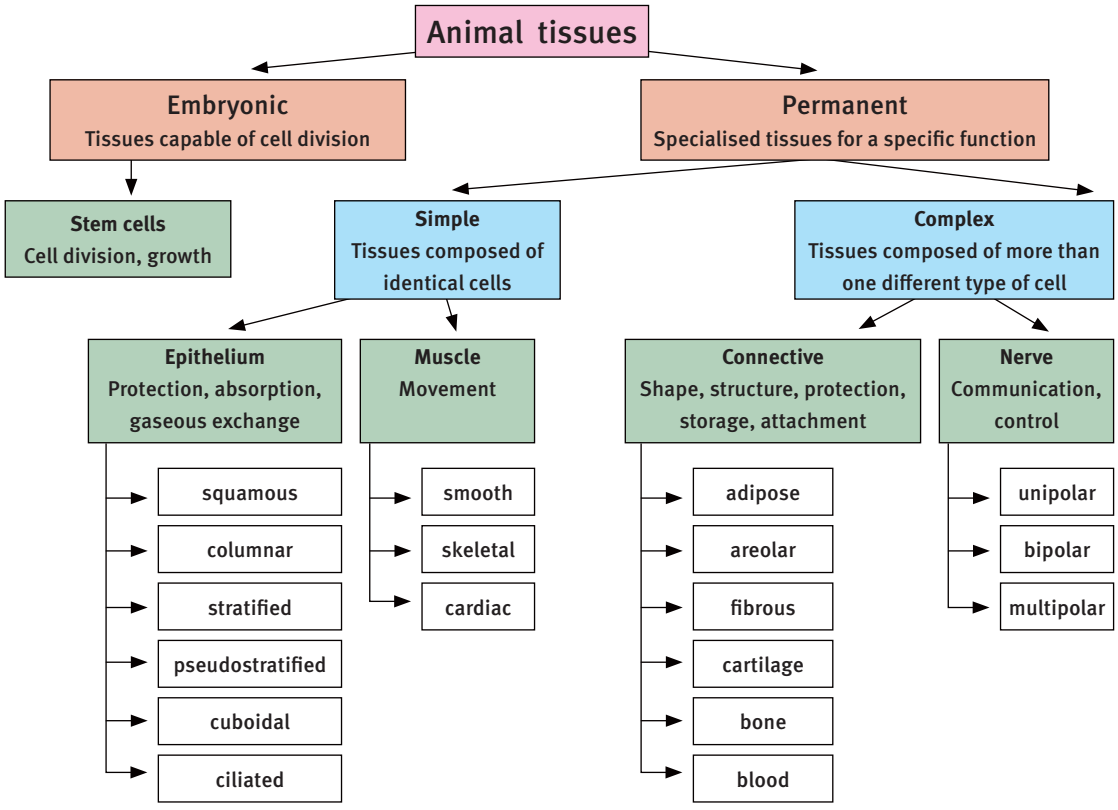
Topic 4

Plant and anumal tissues

Overview

Cells work in harmony as different tissues that carry out all the functions and activities needed for living. Tissues, cells and their metabolic processes are actively interacting with the external and internal environments and changing regularly to ensure survival of the organism.





1 Tissues

- Tissues are made up of identical cells that share a common function, or of different cells that collectively share a common specialised function.
- They make up organs in plants and animals that have a specific purpose in maintaining the life of the living organism.

2 Plant tissues

All plants are made up of:

- meristematic tissue (embryonic) – tissue that makes new cells for growth
- permanent tissues – tissues that do not divide and grow further; they develop special structures for specific functions.

2.1 Meristematic tissue

Meristematic tissue can be found in:

- apical meristems – tissue that makes a plant grow longer from its tips
- lateral meristems – tissue that makes a plant grow thicker or wider.

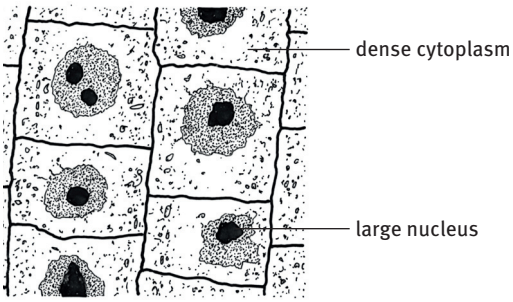


FIGURE 4.1 What does meristematic tissue look like?

Table 4.1 Structure and function of meristematic tissue

Structure	Function
• Thin-walled, immature cells that divide often • Cells tightly packed in layers or rows • No intercellular spaces • Single large nucleus • Dense cytoplasm • Small or no vacuole	• Make new cells for growth • Some new cells stay meristematic • Some cells differentiate and become permanent tissues

2.2 Permanent tissues

Permanent tissue can be divided into three groups:

- dermal tissue – covers the plant
- vascular tissue – transports water and nutrients
- ground tissue – fills the space between the epidermal and vascular tissues, and performs other functions.

2.2.1 Dermal tissue

Dermal (epidermal) tissue is on the outside of the plant.

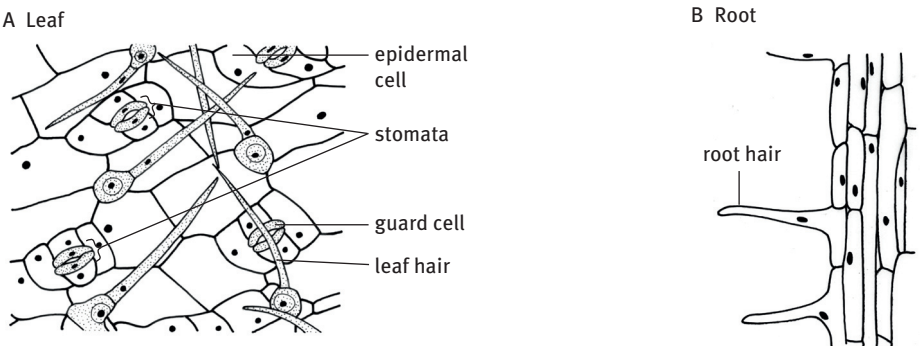


FIGURE 4.2 What does epidermal tissue look like?

Table 4.2 Structure and function of epidermal tissue

Structure	Function
• Single layer of tightly packed, thin-walled cells • Cover the plant • Aerial parts covered with a waxy layer – cuticle • Cuticle protects plant • Cuticle prevents too much water loss • Often adapted for extra functions, e.g. root hairs increase surface area to absorb water	• Forms a skin to cover and protect plant • Controls movement of water out of plant • Roots absorb water

2.2.2 Ground tissues

Ground tissues include parenchyma, chlorenchyma, collenchyma and sclerenchyma.

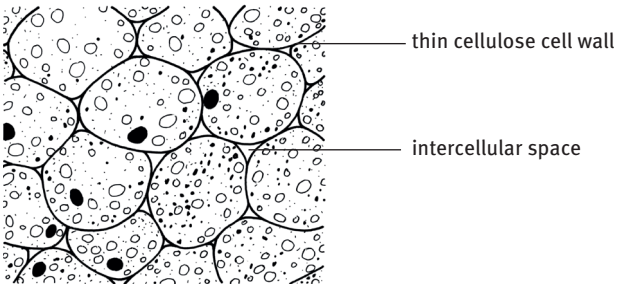


FIGURE 4.3 What does parenchyma tissue look like?

Table 4.3 Structure and function of parenchyma tissue

Structure	Function
• Many-sided, thin-walled cells • Large vacuoles • Loosely packed • Large intercellular spaces	• Store food and water • Allow gases, water and substances to move throughout the plant

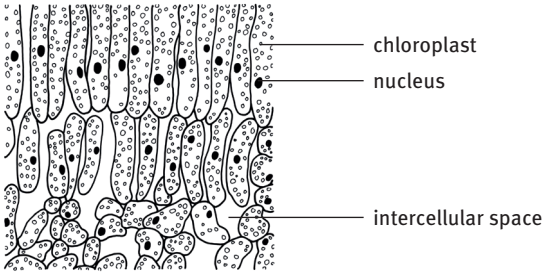


FIGURE 4.4 What does chlorenchyma tissue look like?

Table 4.4 Structure and function of chlorenchyma tissue

Structure	Function
• Parenchyma tissue with chloroplasts in cells • Irregular or column-shaped in leaf mesophyll • Large intercellular spaces in spongy parenchyma of leaf • Small intercellular spaces in palisade parenchyma of leaf	• Performs photosynthesis • Makes up mesophyll (internal tissue) of leaf • Stores starch • Allows gases, water and substances to move between cells

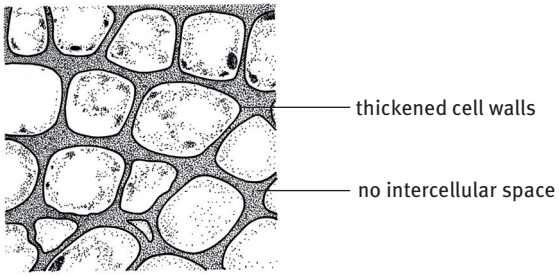


FIGURE 4.5 What does collenchyma tissue look like?

Table 4.5 Structure and function of collenchyma tissue

Structure	Function
• Cell wall thickened at corners of cells • Cells tightly packed with no intercellular spaces	• Collenchyma cells give flexible support to parts of plant

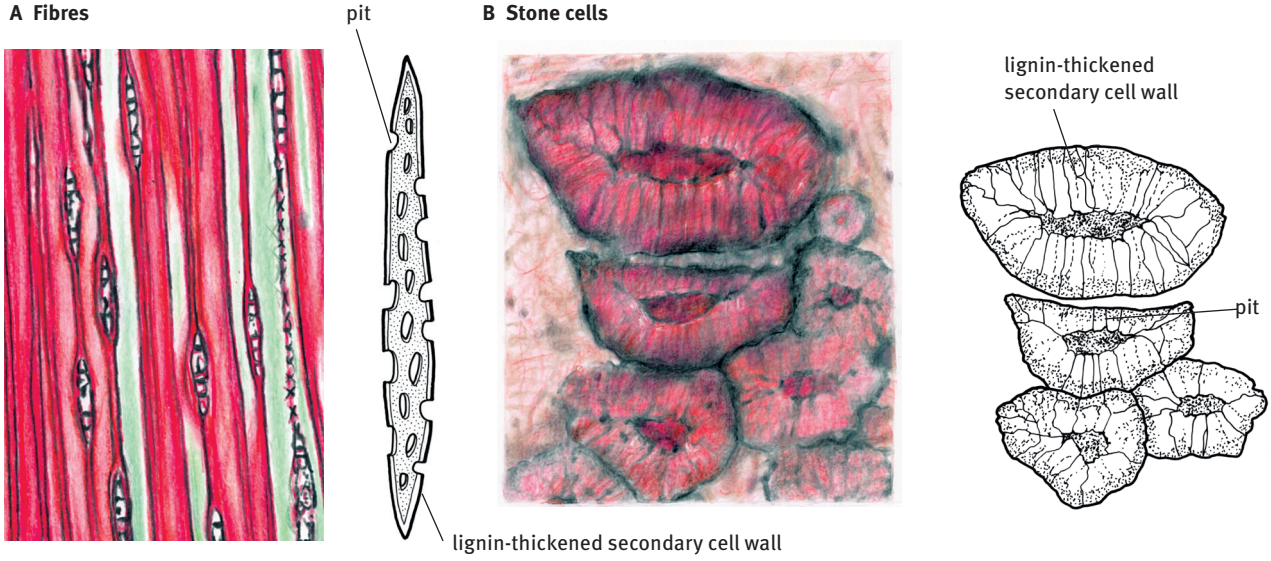


FIGURE 4.6 What does sclerenchyma tissue look like?

Table 4.6 Structure and function of sclerenchyma tissue	
Structure	**Function**

• Two types of sclerenchyma:
  • long and slender fibres
  • short and irregular sclereids (stone cells)
• Cell walls thickened evenly with lignin – strong
	• Provide structure and support

2.2.3 Vascular tissues

Xylem and phloem are the vascular tissue found in plants. Vascular means that they are vein-like tubes and can easily transport substances.

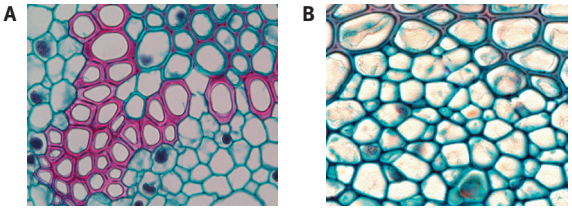


Figure 4.7 What does xylem tissue look like?

Table 4.7 Structure and function of xylem tissue	
Structure	**Function**

• Three types of non-living, empty, tube-like cells:
  • vessel elements
  • tracheids
  • sclerenchyma fibres
• Living parenchyma cells
• Cell walls contain lignin
• Walls of vessels and tracheids have pores – pits
• Patterned secondary thickening: annular, spiral, pitted
• Vessels have no cross walls forming tubes
• Tracheids and fibres have pointed tips with holes – perforation plates
	• Transports water and mineral salts (ions)
	• Takes substances from roots, up stem, to leaves
	• Give support, strength and structure

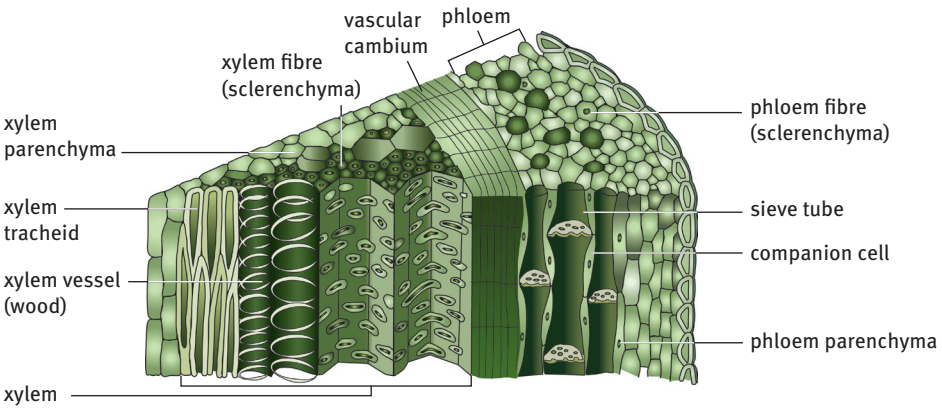


Figure 4.8 What does phloem tissue look like?

Table 4.8 Structure and function of phloem tissue	
Structure	**Function**

• Has three live cell types:
  • sieve tubes
  • companion cells
  • parenchyma cells
• Has one dead cell type:
  • sclerenchyma fibres
• Sieve tubes have no nuclei; kept alive by companion cells
• Where the sieve tubes meet, walls form a sieve plate; together, they form a continuous pipeline
	• Transports manufactured organic food produced through photosynthesis
	• Takes it from leaves to the rest of plant

3 Animal tissues

- Animal tissues are made up of identical cells that share a common special function, or of different cells that share a common special function.
- Vertebrate animals or humans have more than 100 easily recognisable specialised cells. These are organised into different tissues that make up the organs in the various systems:
  - the digestive system
  - the excretory system
  - the circulatory system.
- All vertebrates are made of embryonic tissues (when they are growing embryos) and then four kinds of adult, permanent tissue:
  - epithelial
  - muscle
  - connective
  - nerve.

3.1 Embryonic tissue

Embryonic tissue can be divided into two kinds of stem cells:

- embryonic stem cells – tissue in an embryo that produces all other tissues during growth
- adult stem cells – tissue in adult organisms that produces new tissue cells to replace old and damaged ones.

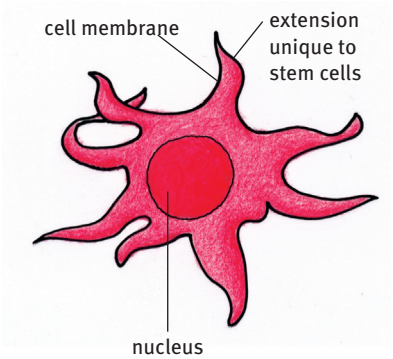


Figure 4.9 What does a stem cell look like?

Table 4.9 Structure and function of embryonic tissue	
Structure	**Function**
• Embryonic stem cells • Adult stem cells • Large nucleus • Cellular extensions of cytoplasm	• Produces cells for specialised tissues • Replaces old and damaged cells and tissues

3.2 Permanent tissue

The four groups of permanent tissue have different structures and functions. In general they are:

- epithelial tissue – tissue that covers, lines and secretes
- muscle tissue – tissue that moves different body parts
- connective tissue – tissue that binds and supports other tissues
- nerve tissue – tissue that transmits chemical and electrical control signals.

3.2.1 Epithelial tissue

Some epithelial tissues are:

- squamous – which means 'flat-shaped'
- columnar – which means 'tall'
- stratified – which means 'in layers'
- pseudostratified – which means it seems to be in layers but is not (pseudo = false)
- cuboidal – which means 'like a cube'
- ciliated – which means the cells have tiny hairs.

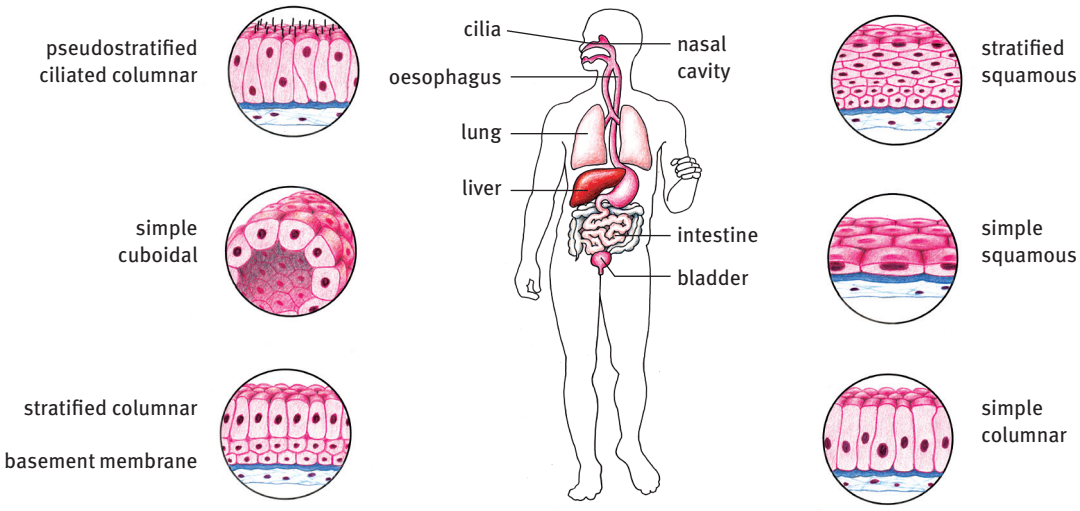


Figure 4.10 What is the structure and location of the different epithelial tissues?

Table 4.10 Structure and function of epithelial tissue	
Structure	**Function**

• Has three cell types:
  • flat squamous cells
  • cuboidal cells
  • columnar cells
• Found in layers:
  • single layer: simple epithelium
  • many layers: stratified epithelium
• Cells lie on basement layer (membrane) – connects epithelium to other tissues
• May contain special cells or structures: goblet cells, cilia (hairs)
	• Line body surfaces inside and outside
	• Make up glands that secrete sweat, enzymes, hormones, milk, sebum, oils
	• Allow gases, water, nutrients, mineral salts in solution to pass through
	• Goblet cells secrete mucus that helps with movement over epithelium layer
	• Cilia remove dust particles from internal surfaces

3.2.2 Muscle tissue

There are three types of muscle tissue. They are listed in table 4.11. Note the meaning of these terms:

- involuntary – happens without you thinking about it
- striated – striped
- voluntary – you choose to do/move it.

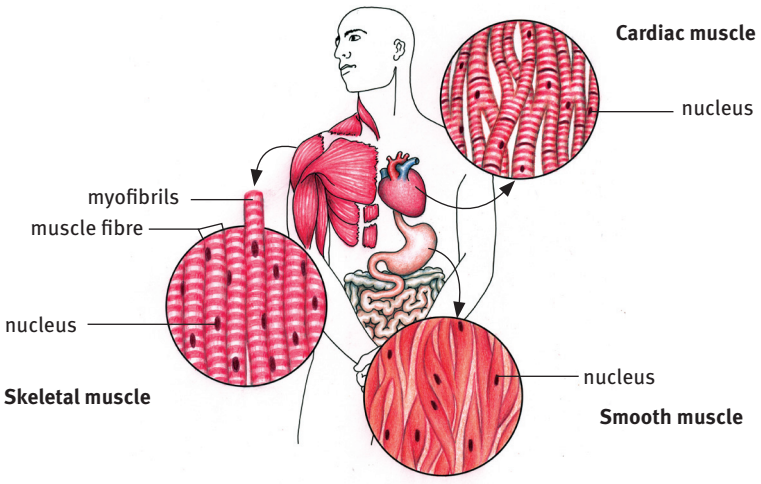


FIGURE 4.11 What is the structure and location of different muscle tissues?

Table 4.11 Structure and function of muscle tissue	
Structure	**Function**

• Consists of three tissue types:
  • skeletal striated voluntary muscle
  • cardiac striated involuntary muscle
  • smooth, unstriated involuntary muscle
• Made of muscle fibres
• Nuclei found on side; may be more than one
• Striated has contraction fibrils – myofibrils
	• For voluntary actions: walking, lifting, etc.
	• For involuntary contracting and relaxing of organs: heart, blood vessels, bladder, stomach, etc.

3.2.3 Connective tissue

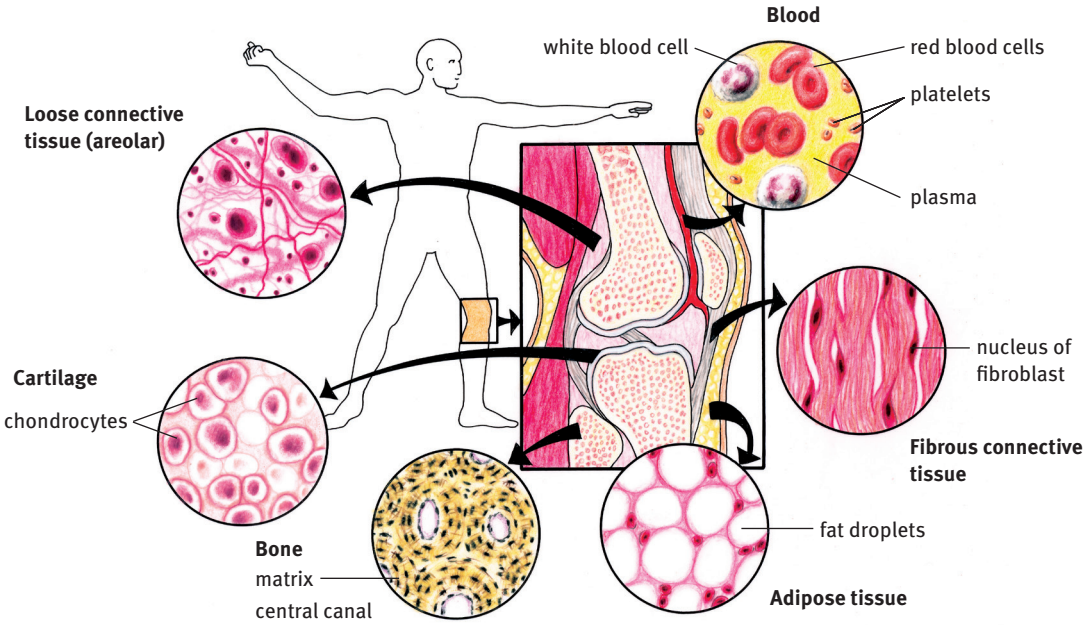


FIGURE 4.12 What is the structure and location of different connective tissues?

Table 4.12 Structure and function of connective tissue

Structure	Function

• Has six tissue types:
  • adipose
  • areolar
  • fibrous (tendons attach muscle to bone, ligaments attach bone to bone)
  • cartilage
  • bone
  • blood
• Made of similar or different specialised cells
• Most have a matrix to hold cells and fibres
• May contain fibres:
  • reticular fibres bind matrix material
  • white collagen fibres for strength
  • yellow elastin fibres for stretch
	• For giving structure, shape, strength
	• For protecting, insulating, packing, storing, attaching, transporting
	• Reduces friction
	• Blood transports many substances: digested food, hormones, enzymes, gases and excretory waste products

3.2.4 Nerve tissue

- Receptors sense, get or receive messages or signals – for example: pressure sensor (Pacinian corpuscle).
- Effectors send, transmit or transfer messages to carry out tasks.
- Nerves are made of cells called neurons.
- Sensory neurons carry impulses from receptors to the central nervous system (CNS).
- Motor neurons carry impulses from the CNS to the muscles and glands, which are effectors.
- Neurons are unipolar, bipolar and multipolar and sense changes, manage activities and communicate.

- Axons are covered by Schwann cells with spaces between them called Nodes of Ranvier.
- Axons end up in fine extensions called terminal fibres or terminal branches.

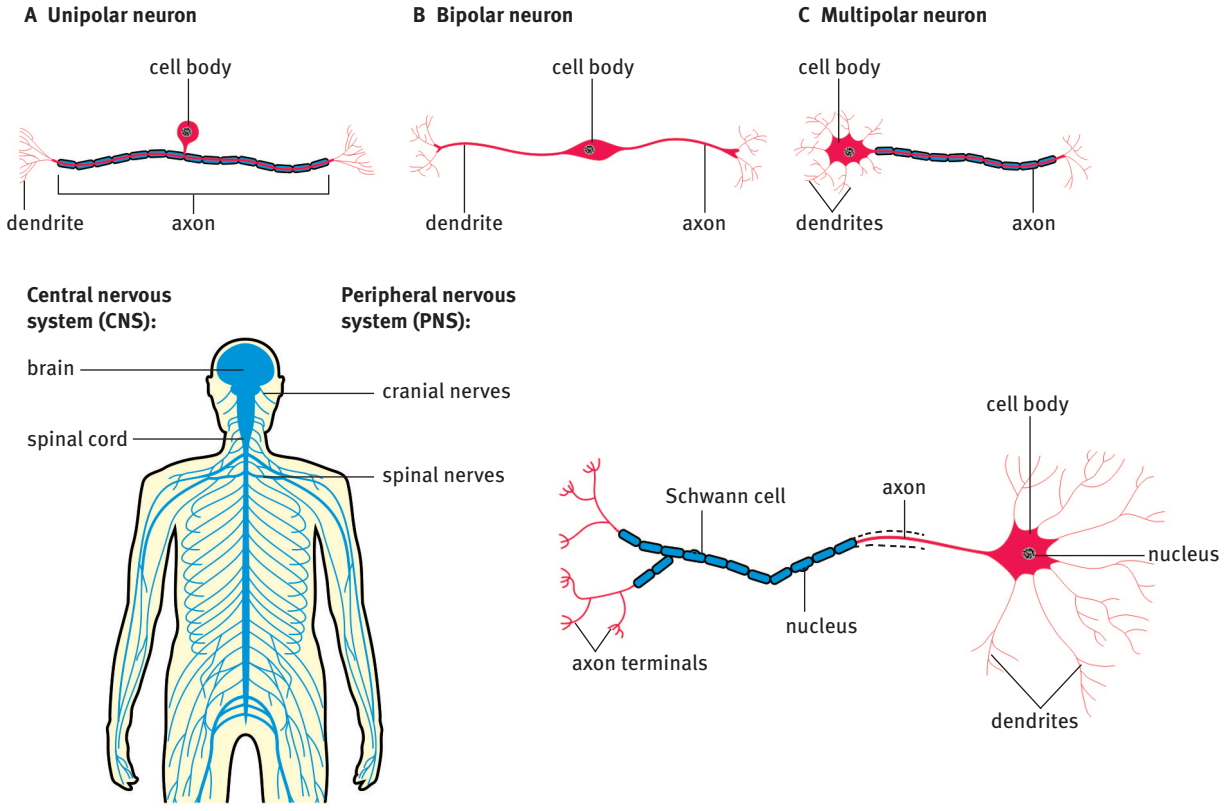


FIGURE 4.13 What is the structure and location of nerve tissue?

Table 4.13 Structure and function of nerve tissue

Structure	Function

• Has three main types of cell:
  • unipolar neuron (sensory)
  • bipolar neuron (sensory / inter neuron)
  • multipolar neuron (motor)
• Made of a cell body – soma
• Cell body has cytoplasmic extensions:
  • dendrites: get impulses in neuron
  • axons: send impulses from neuron
• Most have linked cells to support what they do, e.g. Schwann cell
	• Pick up (sense) changes in the internal and external environment
	• Manage physical, mental and regulatory activities
	• Send signals between receptors and effectors
	• Chemical co-ordination

4 Indigenous knowledge and biotechnology

4.1 Traditional technology

- Indigenous knowledge is held by traditional healers.
- There are two groups of traditional healers:
  - diviners – communicate with ancestral spirits to diagnose problems and ailments
  - herbalists – use knowledge of animals, plants and minerals to diagnose illness and prescribe remedies.

4.1.1 Complementary medicines

- Traditional technology and its vast cultural knowledge provide complementary medicines such as ointments, tonics, teas and extracts that have been used with other forms of treatment.
- Many of the sources of curative agents and compounds come from indigenous plants.

4.2 Medical biotechnology

- Formal medical research uses active chemical substances in plants. It tests whether they can provide cures or drugs to help with ailments and disease.
- Machines, like electron microscopes and heart-lung machines, have also been invented to help with medical conditions and for further reseach.

4.3 Ethics and legislation

- Our world is full of diversity in the plant and animal world, as well as in our human society with all its different beliefs, views and approaches.
- Ethics questions actions as right or wrong and is linked to research using living organisms.
- Bioethics, the ethics of life, asks questions about how we should act towards the Earth and all life that shares the planet.
- Sometimes legislation is passed about this.
- People often follow an either-or approach: we either approve of something or we don't. This also applies to traditional technology and medical biotechnology. Many people believe in either modern medicine or in alternative and traditional medicines, without seeing the value of both.
- Both systems try to diagnose the causes of diseases, treat diseases and keep people in good health.
- Modern societies have found that laws need to be passed to regulate research practices and their new products.

4.4 Traditional medicines and healers

- All cultures have a long history of traditional knowledge about substances and compounds found in their daily environment that can be used.
- Traditional healers also use a deep understanding of their own community's interlinked attitudes, feelings and concerns around spiritual, mental and health problems.
- At this time the medical systems of the Nguni, Sotho and Khoisan peoples have not yet been classified and written down, and are passed on from generation to generation by word of mouth.

4.5 Biotechnological issues and ethics

- Modern medical biotechnology and research investigates many fields of health care.
- There is a lot of research and debate about the areas of immunity, vaccines, antibiotics, blood transfusion and cloning.

4.5.1 Immunity

- Immunity is the ability of the body to produce antibodies against infections and to remember infections.
- Your body defends itself by both stopping infections and creating immunity in several ways:
  - barriers to infection – stop infections getting into the body, e.g. mucus, cilia, tears, skin
  - defence reaction – the body kills invading microbes: white blood cells take up microbes through phagocytosis, detoxify poisons, make antibodies
  - natural and acquired immunity – a person may be born with antibodies against specific infections or acquire them through infections entering the body and being fought off during their life time.
- Several infectious childhood diseases like chickenpox and mumps cause your body to make antibodies, so that you do not get these diseases again.
- Red blood cells are not involved in immunity.

4.5.2 Vaccination

- Immunity against disease can be artificially induced through vaccination.
- When you are vaccinated a weakened form of an infectious agent is put into your body by injection.
- The immune system fights the infection and produces immunity.
- Vaccines have been developed for viral diseases such as smallpox, chickenpox, polio, measles, mumps and influenza.

4.5.3 Antibiotics

- Antibiotics are powerful drugs, made from fungi and bacteria and slow down or stop the growth of microbes.
- They are given as injections, tablets or liquids.
- They are not effective against viral infections.

4.5.4 Blood transfusion

- A blood transfusion uses matched blood from a donor to replace blood lost during surgery or in an accident.
- The blood is collected through donation and stored in a sterile blood bank.
- The person from whom the blood is collected is called the donor and the person that receives the blood is called the recipient.
- Blood is transferred by transfusion through a needle inserted into a blood vessel in the recipient's arm.
- Four main blood types are known in humans: A, B, AB and O. When blood is collected, it is classified according to type.
- If a person receives the wrong type they can suffer an immune rejection reaction and may even die.
- The matching of blood works in the following ways:
  - universal donor – people with blood type O can donate blood to recipients with any blood group
  - universal recipient – people with blood type AB can receive blood from donors with any blood group.

Table 4.14 Matching blood types

Recipient's blood type	Safe donor's blood type
A	A or O
B	B or O
AB	A, B, AB or O
O	O

4.5.6 Cloning

- A clone is a group of DNA fragments or population of cells, tissues or organisms that are genetically identical.
- Cloning is a name given to a biotechnological process that makes identical copies of cells and tissues from pre-existing cells and tissues.
- They are produced through the use of biotechnological methods and asexual reproduction methods.
- Identical twins show that humans and animals can also produce clones, naturally.
- Cloning can be:
  - reproductive cloning – to produce identical cells, tissues and organisms
  - molecular cloning – to produce identical genes and useful chemical compounds.
- Plant and animal tissues can be cloned.
- Cloning uses stem cells of animals and humans, and meristematic tissues of plants.

Plant cloning

- Plants have been cloned since ancient times – simply by growing food, e.g. from cuttings or by replanting storage and reproductive organs such as bulbs and tubers.
- Cloning in plants can occur through:
  - vegetative (asexual) propagation – growing plants from roots, stems and leaves of a parent plant
  - tissue culture – growing plants from tissues of a parent plant in a growth medium; single cells, plant cells without cell walls (protoplasts), pieces of leaves (explants), or roots can be used to generate a new plant.
- There are several advantages to tissue culture:
  - production of exact copies – having desirable traits
  - fast growth – quickly produce mature plants
  - increased quantity – produce many plants
  - virus-free stock – fewer losses in horticulture and agriculture.

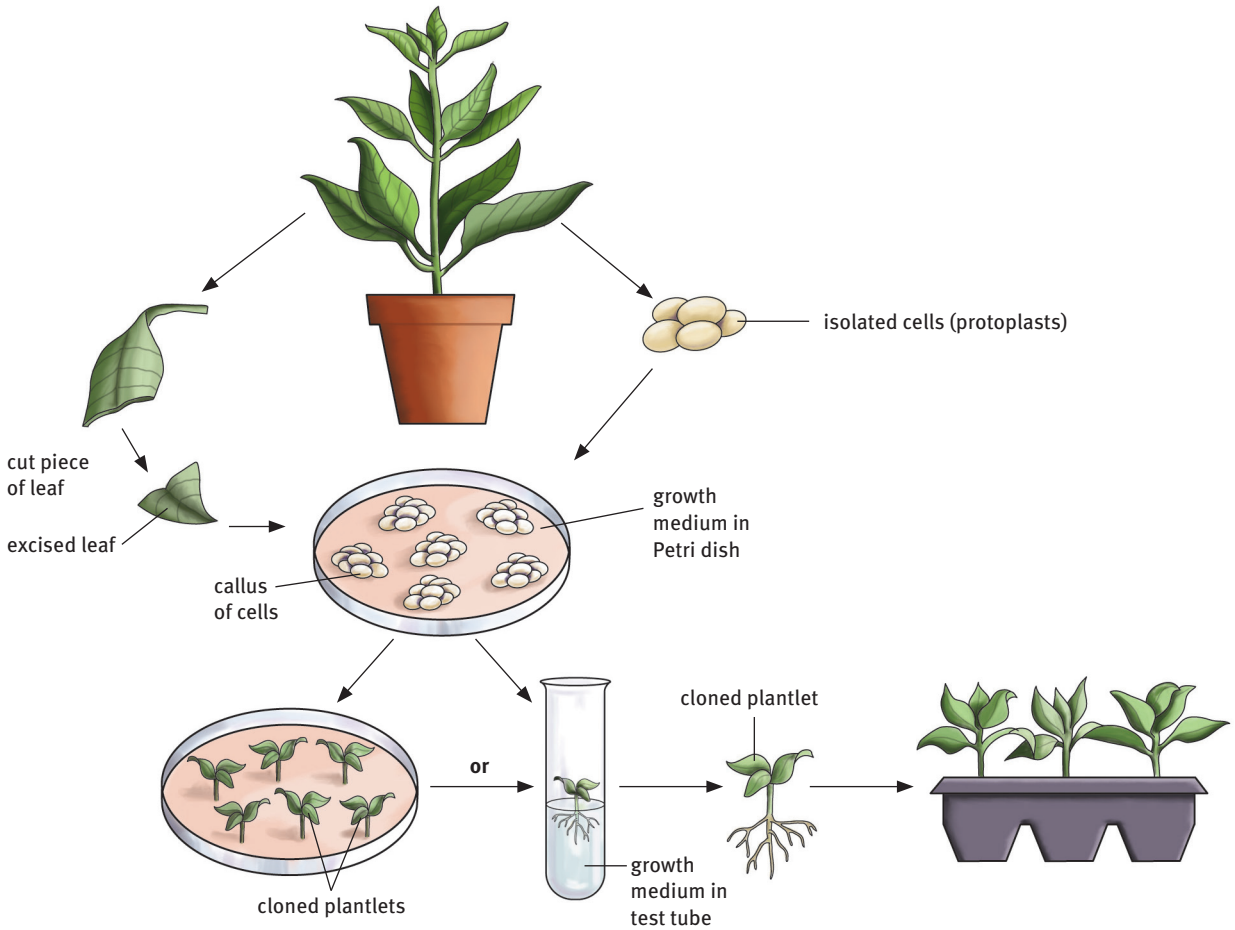


Figure 4.14 How is plant tissue culture performed?

Animal cloning

- Earthworms that are cut in half each re-grow the part that is missing, producing two earthworms. This is regeneration.
- Biotechnology research in cloning has developed different ways of producing animal tissues.
- These tissues are used for important therapeutic purposes, like skin grafting when skin has been burned away and for bone marrow transplants to treat cancer.
- Stem cell research is important to therapeutic cloning.
- A sheep called Dolly was the first reproductively cloned animal.

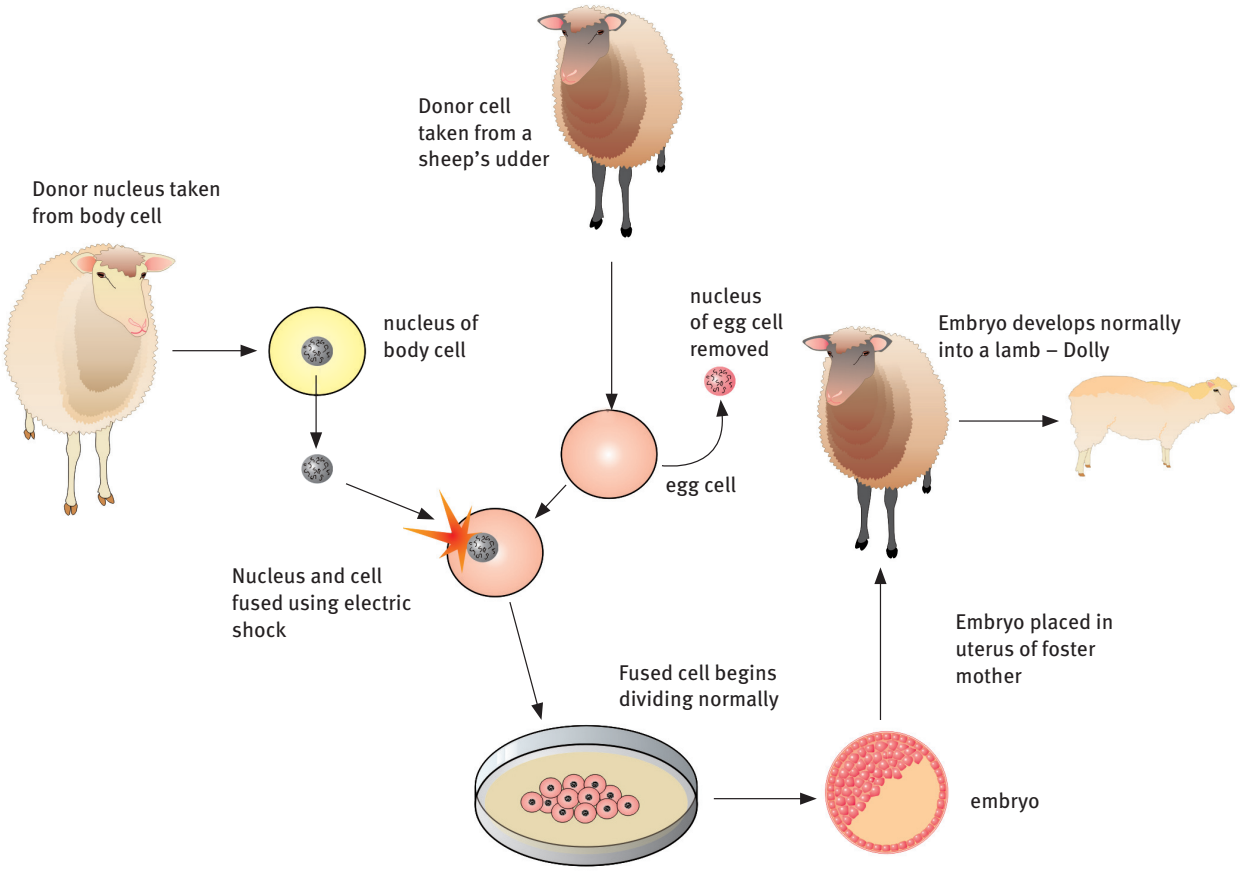


FIGURE 4.15 How was Dolly cloned?

4.5.7 Stem cell research

- The main reason for stem cell research is for advancing therapeutic cloning.
- Therapeutic cloning involves growing tissues that can replace diseased tissues in humans, through tissue transplants.
- Stem cells are embryonic tissue cells that can produce more of themselves and differentiate into a variety of specialised cells forming different tissues.
- All stem cells produce clones of, and contain, the same genes.
- There are two main groups of stem cells:
  - embryonic stem cells – embryo cells that can differentiate into all cell types, making them very useful
  - adult stem cells – tissue stem cells that replace old and damaged cells in an adult.

- Stem cells can be taken from three places:
  - 'in vitro' fertilised egg cells – egg cells that have been fertilised by sperm cells in special laboratory containers and not in the mother ('in vivo')
  - umbilical cord and placenta of foetuses, while being carried by the mother, through medical equipment inserted into the womb
  - bone marrow and liver tissue.
- Stem cells can be used to:
  - manage diseases and disorders and provide possible cures for major diseases such as leukaemia, Alzheimer's disease, osteoporosis, sickle cell anaemia and diabetes
  - replace tissues and organs, e.g. through skin transplants
  - deliver gene therapies for disease like diabetes
  - deliver chemotherapeutic agents to manage cancers like leukaemia.

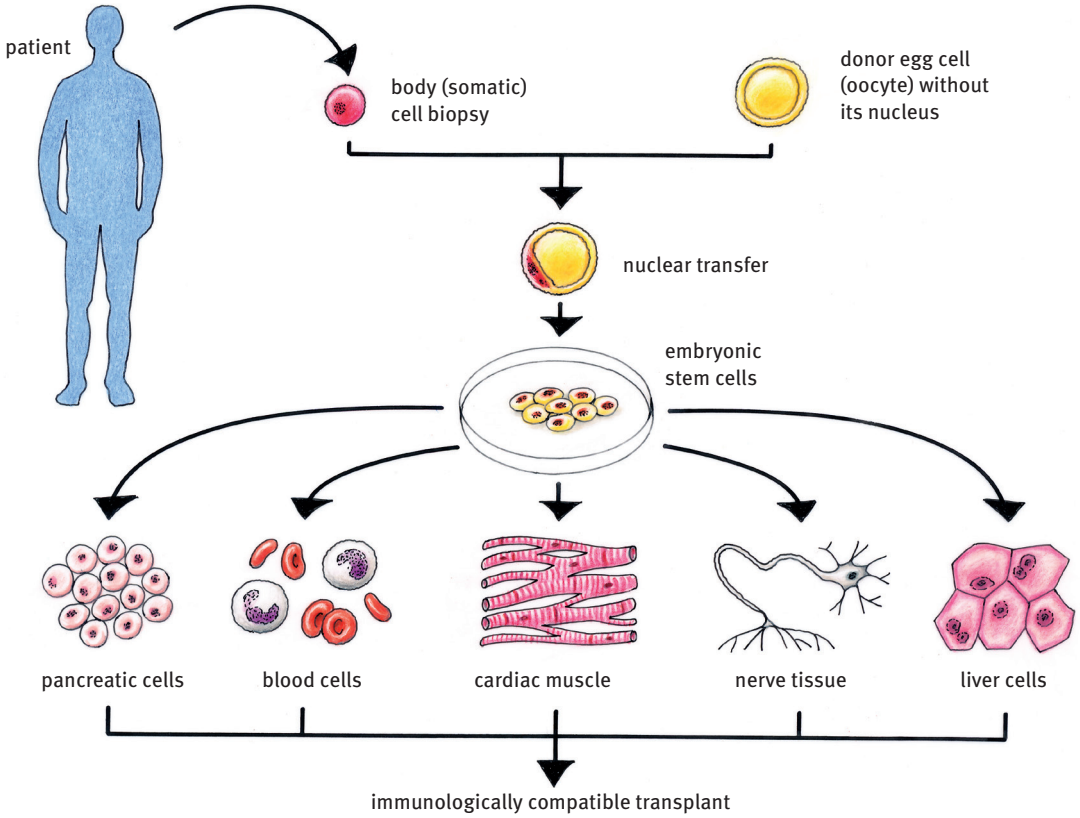


FIGURE 4.16 How is therapeutic cloning performed using stem cells?

4.5.8 Ethics and legislation around stem cells and cloning

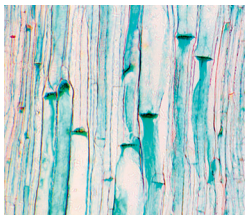
- Cloning and stem cell research have caused strong reactions – most objections are on moral or religious grounds.
- Many governments of countries in which stem cell research and cloning is done have passed laws to set out the type of research that may be done and where stem cells may be harvested from.

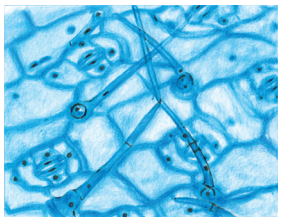
Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

Study diagrams (i) to (iv) below and use them to answer questions 1.1 to 1.8.


(i)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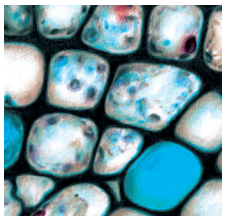
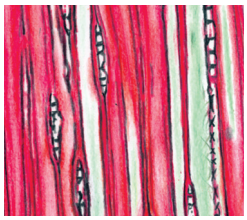

(iii)


(iv)

1.1 The main function of tissue (i) is the:

A transport of organic food
B transport of water
C storage of food and water
D storage of organic food made. (2)

1.2 Parts A and B in diagram (ii) are responsible for:

A water absorption and gaseous exchange
B osmosis and water absorption
C gaseous exchange and transpiration
D reproduction and osmosis. (2)

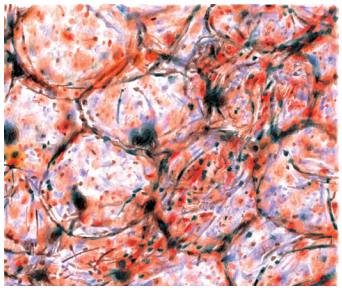
1.3 The difference between plant tissue (iv) and parenchyma tissue is that parenchyma tissue has:

A secondary thickening and pores
B sieve plates and companion cells
C chloroplasts and perforation plates
D intercellular spaces and thin cell walls. (2)

1.4 Plant tissues made of specialised cells that are differentiated to perform particular functions, are known as:

A permanent
B meristematic
C cambium
D primary meristems. (2)

1.5 Which tissue does this micrograph show?



A meristematic
B xylem
C sclerenchyma
D parenchyma (2)

1.6 Which ONE of the following is associated with phloem?

A vessels
B sieve tubes
C fibres
D stomata (2)

1.7 The diameter of a field of view under high power of a light microscope was measured to be 0,4 mm. When certain animal cells were examined under the microscope under high power, 8 cells edge to edge occupied the diameter. What was the average diameter of these cells?

A 0,2 µm
B 0,05 mm
C 3,2 mm
D 0,50 µm (2)

1.8 In which of the following cells would you expect mitochondria to be most numerous?

A bone cells
B fat storage cells
C muscle cells
D nerve cells (2)

1.9 Which of the following tissues can be considered as connective tissue?

(i) blood
(ii) cartilage
(iii) skin
(iv) ligaments
(v) squamous epithelium

A (i), (iii), (v)
B (ii), (iii), (iv)
C (i), (ii), (iv)
D (iii), (iv), (v) 2)

1.10 Nerve cells are known as:

A neurons
B mast cells
C leucocytes
D fibroblasts. (2) [20]

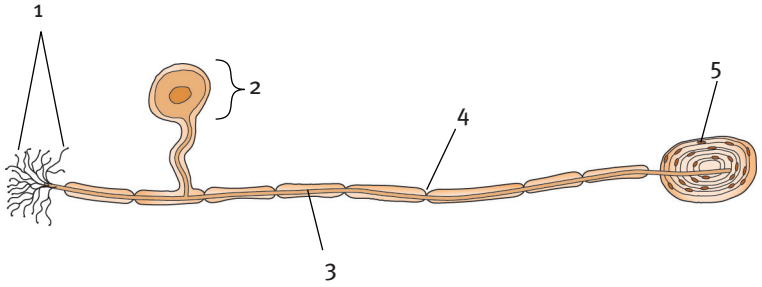
Question 2: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

2.1 The plant tissue in which guard cells and root hairs are found (1)
2.2 Unspecialised tissue in plants found in root tips and buds (1)
2.3 The tissue that attaches muscle to bone (1)
2.4 The tissue that is responsible for voluntary movement (1)
2.5 The type of neuron that senses environmental changes (1)
2.6 The hard, white tissue found at the ends of bones in joints (1) [6]

Question 3: Diagrams

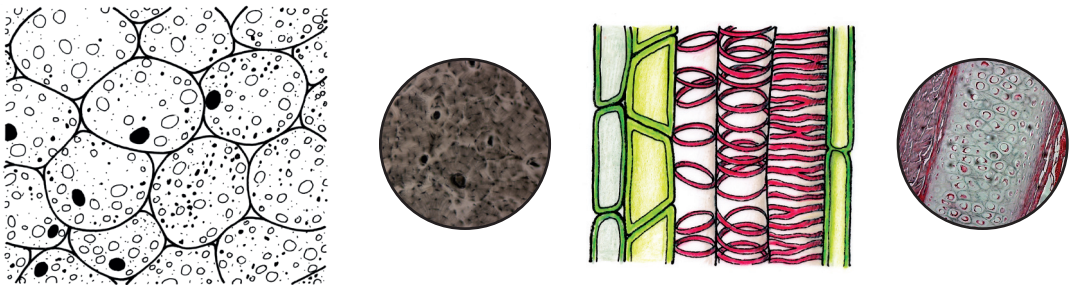
3.1 Study the diagram below and provide labels for the parts numbered 1 to 5.



(5)

3.2 Identify each of the tissues in the diagrams below.

(a) (b) (c) (d)



(8) [13]

Question 4: Missing words

Select the most appropriate words from the list given below, to complete the given paragraph. Each word may be used more than once.

smooth, striated, ligaments, tendons, cardiac, voluntary, involuntary, skeletal

Movement is brought about by ___4.1___ muscles that cause the bones of the skeleton to move. Muscles are joined to bone through ___4.2___. Heart tissue is made of ___4.3___ muscle. It beats continuously and is known as ___4.4___ muscle. The bladder and stomach are made of ___4.5___ muscle which can be controlled to a certain extent. [5]

Question 5: Short response

5.1 Explain the following scientific terms:

- **5.1.1** vaccination
- **5.1.2** blood transfusion
- **5.1.3** antibiotic
- **5.1.4** stem cells
- **5.1.5** cloning. (10)

5.2 Provide TWO answers for each of the following:

- **5.2.1** Types of fibres found in connective tissue (2)
- **5.2.2** Parts making up the stomata (2)
- **5.2.3** Transport tissues in plants (2)
- **5.2.4** Major groups of blood cells in humans. (2)

5.3 Provide THREE answers for each of the following:

- **5.3.1** Types of muscle tissue found in mammals (3)
- **5.3.2** Types of thickened cells making up xylem (3)
- **5.3.3** Tissues used for strengthening and support in plants (3)
- **5.3.4** Shapes in which epithelium tissue is found in mammals. (3)

5.4 Provide FOUR answers for the following:

- **5.4.1** General categories of parts found in blood tissue. (4) [34]

Question 6: Tables

Tabulate the differences between structure and function for the following tissues: parenchyma, chlorenchyma and xylem. [14]

Question 7: Comprehension

Read the extract below and answer the questions that follow.

Scientists Successfully Clone Cat

David Braun, National Geographic News, February 14, 2002

The kitten, called CC (abbreviation for carbon copy), almost two months old, appears healthy and energetic, although she is completely unlike her tabby surrogate mother. The cat was cloned by transplanting DNA from Rainbow, a female three-coloured (tortoise shell or calico) cat into an egg cell whose nucleus had been removed, and then implanting this embryo into Allie, the surrogate mother. Researchers obtained the cells used to make the clone from the skin cells of 'donor' cats. Eggs from other cats were used for the next step. Their chromosomes were removed and replaced with the DNA from the frozen cells of Rainbow, creating cloned embryos which were then transplanted into the surrogate mother, Allie.

'CC's coat colour suggests that she is a clone, and a genetic match between CC and the donor mother confirms this,' the researchers say.

Out of 87 implanted cloned embryos, CC is the only one to survive — comparable to the success rate in sheep, mice, cows, goats, and pigs, the scientists say.

7.1 Draw a flow diagram to show the process of CC's cloning. (6)

7.2 Define the terms 'clone', 'donor' and 'surrogate mother' as used in the text. (6) [12]

Question 8: Case study

8.1 Read the case study and answer the questions that follow.

On Monday morning, fifteen-year-old Peter Jones woke up with a number of red spots on his body. His grandmother immediately knew that they were symptoms of the viral disease chickenpox. Peter attends Forest View Secondary School and the school had not made any announcement about an outbreak of chickenpox. Fourteen days ago Peter attended a weekend get-together for skateboarders from around the country. The incubation period (the time between exposure to the virus and the appearance of symptoms) for chickenpox is more or less two weeks.

8.1.1 What can Peter's grandmother do to help prevent the spread of the disease? (1)

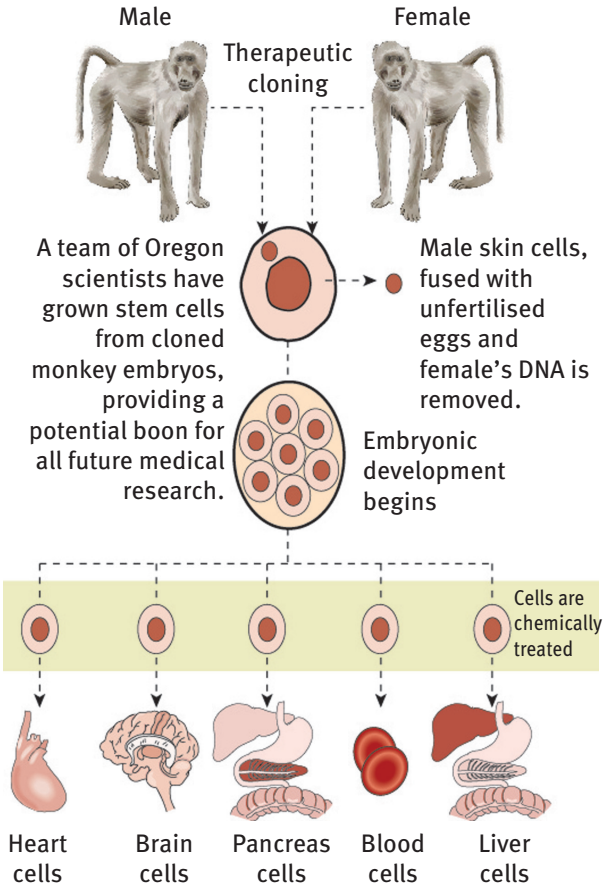
8.1.2 Name ONE precaution that Peter should use to help prevent the disease from spreading. (1)

8.1.3 Should Peter return to school if other children who have had chickenpox continue to attend school? Give reasons for your answer. (2)

8.1.4 Should Peter be given antibiotics to help clear up the chickenpox? Explain. (2) [6]

8.2 Read the information provided and answer the questions below.

Stem cell cloning evolves



8.2.1 Define 'cloning'. (2)

8.2.2 Name TWO advantages of cloning animal tissues. (4) [6]

8.3 Read the following case study and answer the questions that follow.

Cultivating bean plantlets

A farmer wanted to increase the crop yield of bean plants for all year round cultivation. Using biotechnology techniques, protoplasts (cells) from a desired variety were isolated from embryonic (meristematic) tissues and leaf cuttings and maintained in a nutrient-rich, sterile growth medium. The protoplasts and tissues were grown into plantlets using tissue culture methods (Fig. 1).

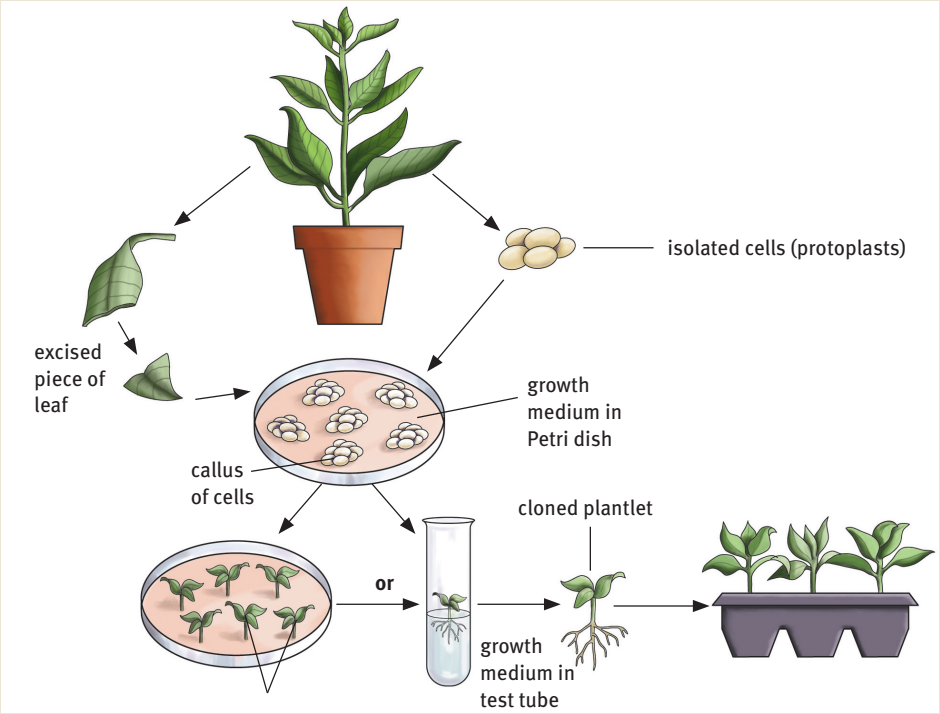


Fig. 1: Growing up bean plantlets

8.3.1 What was the aim of the investigation? (2)

8.3.2 State an hypothesis for this investigation. (2)

8.3.3 List the method followed for the investigation. (4)

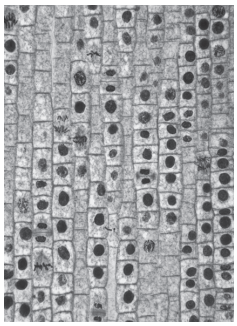
8.3.4 What is tissue culture? (1)

8.3.5 Give another name for this method of propagation. (1) [10]

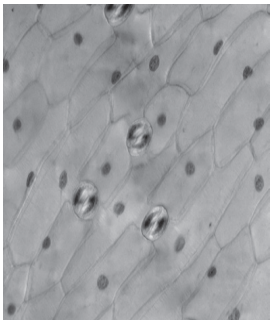
Question 9: Contextual

9.1 Study the Study the micrographs of plant tissues below and answer the questions that follow.

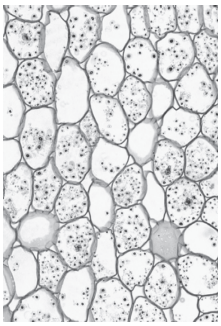
A



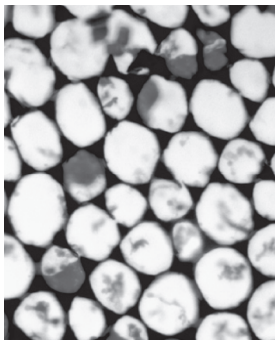
B



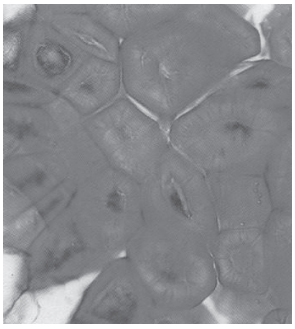
C



D



E



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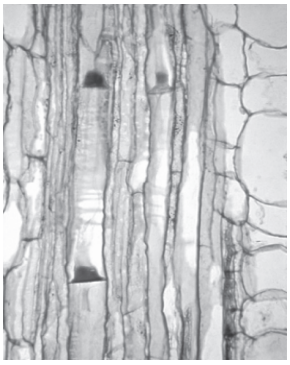


9.1.1 Identify the plant tissues in A to G. (7)

9.1.2 Why do meristematic cells have large nuclei? (1)

9.1.3 What does tissue differentiation mean? (2)

9.1.4 State the main function of the following tissues:

(a) meristematic

(b) epidermal

(c) parenchyma

(d) xylem

(e) phloem. (5)

9.1.5 What characteristic makes xylem adapted for strength and support? (2)

9.1.6 How are sieve tubes supported and kept alive? (2)

9.1.7 Compare parenchyma, chlorenchyma and collenchyma in a table. Consider their structure and function. (10) [29]

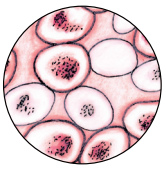
9.2 Study the animal tissue drawings and micrographs provided below and answer the questions that follow.

A

B

C

D



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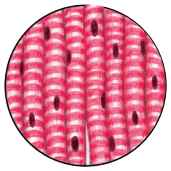

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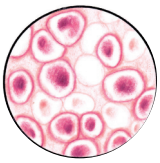

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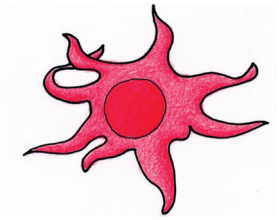


9.2.1 Identify the animal tissues in A to G. (7)

9.2.2 Why do stem cells have large nuclei? (2)

9.2.3 What does tissue differentiation mean? (2)

9.2.4 State the main function of the following tissues:

(a) stem cells

(b) epithelial

(c) tendon

(d) blood

(e) cartilage. (5)

9.2.5 What characteristic makes bone adapted for strength and support? (2)

9.2.6 How are nerve cells supported and protected? (2)

9.2.7 Compare the structure and location of cardiac, skeletal and smooth muscles in a table. (10) [30]

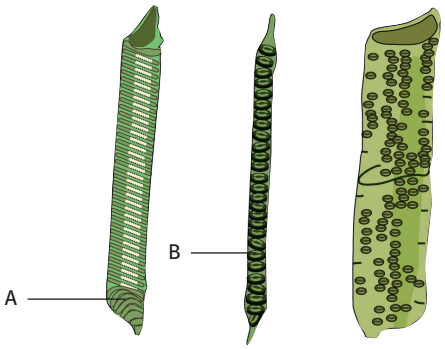
9.3 Study the drawings below of cells taken from a plant tissue and answer the questions.

9.3.1 Identify the tissue shown by the parts below. (2)

9.3.2 Label the parts of the cells indicated by A and B. (2)

9.3.3 What is the function of this tissue? (2)

9.3.4 Explain THREE ways in which the structure of this tissue enables it to carry out its support and transport function. (9) [15]



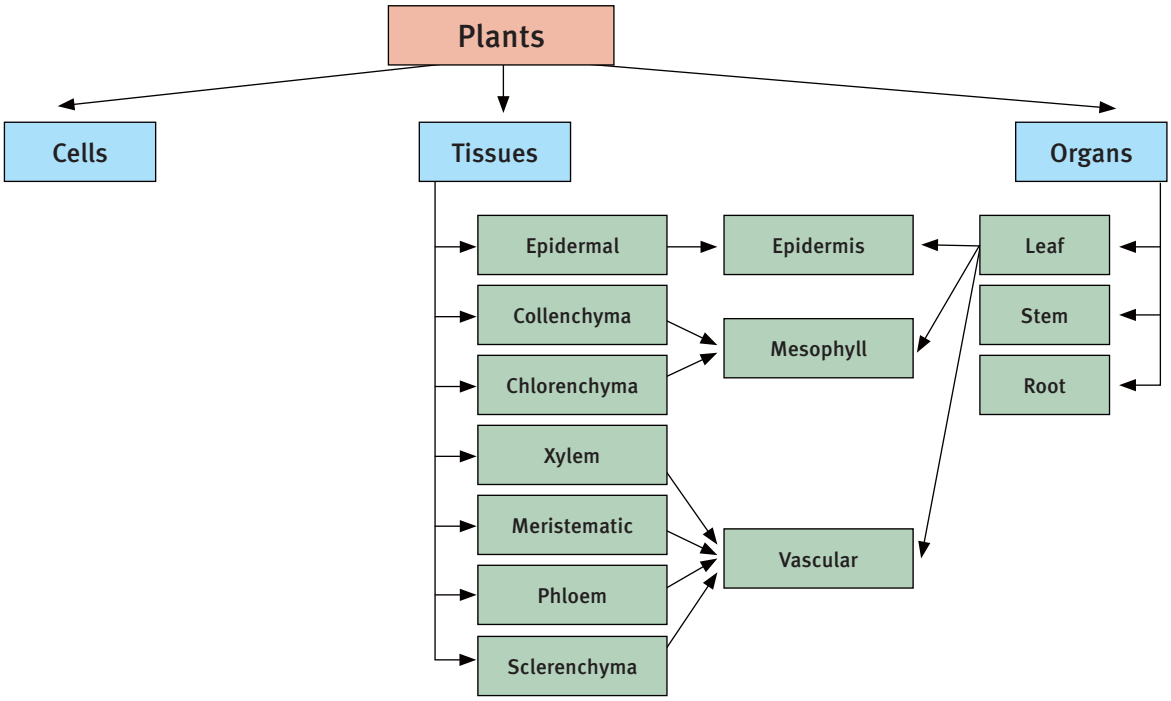
TOTAL MARKS: 200

Topic 5

Organs

Overview

The organs of living organisms are made of tissues and perform essential life processes. The structure and function of tissues help organs to function. This topic focuses on the plant leaf.



1 Plant organs

- Plant tissues make up the organs of plants.
- Roots, stems, leaves, flowers and fruit are plant organs.

2 Plant leaves

- Monocotyledonous (isobilateral) leaves have parallel veins and no petiole.
- Dicotyledonous (dorsiventral) leaves have pinnate or palmate veins.
- The external features of a dicotyledonous leaf are:
  - lamina – leaf blade
  - apex – point of leaf
  - petiole – leaf stalk
  - margin – edge of the leaf
  - mid rib – main vein
  - leaflet – small part of a compound leaf.

- Leaves are responsible for:
  - photosynthesis
  - gaseous exchange
  - transpiration.
- The internal tissue regions of the leaf are: epidermis, mesophyll and vascular bundles.
- The epidermis is the outer region of the leaf.
  - The cells are transparent to let sunlight through to the inner tissues for photosynthesis.
  - A cuticle covers the epidermis for protection and prevention of water loss.
  - Stomata are found in the leaf epidermis and control gaseous exchange and transpiration for the plant.
- The mesophyll makes up the body of the plant leaf.
  - It is made of chlorenchyma and contains chloroplasts for photosynthesis.
  - Palisade parenchyma is important for photosynthesis.
  - Spongy parenchyma is important for photosynthesis, gaseous exchange and transpiration.
- The vascular bundles (veins) are made of xylem and phloem.
  - Xylem transports water to the leaves.
  - Phloem carries sugars away from the leaves.

3 Structures and related functions of a plant leaf

Leaves are adapted for gaseous exchange, photosynthesis, and water regulation through transpiration.

3.1 Leaf structures for gaseous exchange

Leaf adaptations for gaseous exchange are:

- stomata
- thin epidermis
- large surface area
- thin leaf
- spongy parenchyma
- moist exchange surface
- transport system.

3.2 Leaf structures for photosynthesis

Leaf adaptations for photosynthesis are:

- stomata
- thin epidermis
- transparent epidermal cells
- thin leaf
- large surface area

- palisade parenchyma
- spongy parenchyma
- moist exchange surface
- transport system
- many chloroplasts.

3.3 Leaf structures for water regulation

Leaf adaptations for water regulation through transpiration are:

- transport system
- thick cuticle
- thin leaf
- few stomata on dorsal surface
- many stomata on ventral surface
- large surface area
- many intercellular spaces
- moist exchange surface
- regulatory mechanism.

4 Movement of substances to and from the leaf

- Substances that move through the leaf are:
  - water
  - carbon dioxide
  - oxygen
  - sugars.
- Carbon dioxide and oxygen move into the leaf through diffusion.
- Water moves between the cells through osmosis.
- Oxygen and water vapour move out of the plant through diffusion.
- Glucose moves in and out of cells through active transport.

4.1 Movement of carbon dioxide

- Carbon dioxide for photosynthesis is made during cellular respiration.
- It leaves the plant during the day through the stomata, and at night by diffusion.
- Carbon dioxide also enters during the day, from the atmosphere through the stomata, into the intercellular spaces.
- It also diffuses in through the epidermal layer.
- Once inside the leaf, it moves by diffusion through the intercellular spaces and into the cells across the cell wall.
- Movement into the leaf through the epidermis is slow, but movement into the leaf through the stomata is quick.

4.2 Movement of water

- The movement of water into the leaf occurs by diffusion from water carried in the xylem tissue within the stem, and from the vascular bundles in the leaf.
- Once the water has left the vascular bundles it moves:
  - between the cells – by diffusion in the cell walls and intercellular spaces, moving from cell to cell
  - into the cells – through osmosis across the cell membrane
  - out of the leaf – by diffusion through the stomata as water vapour through a process called transpiration.

4.3 Movement of sugars

- Glucose sugar is made in the chloroplasts of the palisade parenchyma and spongy parenchyma.
- Glucose dissolves in water and moves in solution out of the cell and into the phloem tissue of the vascular bundle.
- It is then transported to other parts of the plant for their metabolic functions.
- Starch made from excess glucose is stored in the chloroplasts of the leaf and exposed parts of the stem and root system, during the day.
- It is then used up as needed, during the day and at night through cellular respiration.

4.4 Movement of oxygen

- Oxygen moves into the leaf through the epidermis and stomata by diffusion.
- The movement of oxygen out of the leaf occurs by diffusion from the intercellular spaces, through the stomata, into the surrounding atmosphere.
- It also diffuses across the cell membrane and into the intercellular spaces, and then out through the epidermal layer.
- Diffusion is slow, but movement out through open stomata is quick.

5 Regulation of gas movement by stomata

Gaseous exchange of oxygen and carbon dioxide in the leaf occurs through the stomata.

Table 5.1 Opening and closing of a stoma

Stoma opening	Stoma closing
1 Occurs during daylight hours	1 Occurs at night
2 Guard cells photosynthesise	2 Guard cells stop photosynthesising
3 Glucose concentration increases	3 Glucose concentration decreases
4 Endosmosis of water into guard cells	4 Exosmosis of water out of guard cells
5 Guard cells become turgid	5 Guard cells become flaccid
6 Thin outer walls of guard cells stretch outwards	6 Thin outer walls of guard cells relax inwards
7 Pore opens	7 Pore closes
8 Gaseous exchange and transpiration occurs	8 Gaseous exchange and transpiration stops

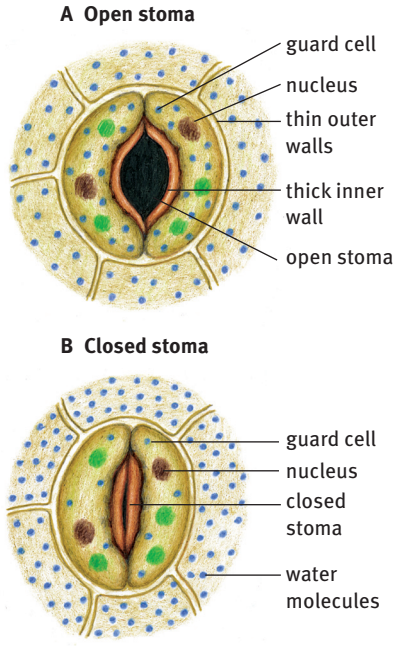


Figure 5.1 How do the stomata open and close?

Questions

Question 1: True/false

Read each of the statements 1.1 to 1.5 provided below.
Decide if each statement is scientifically *correct* or *incorrect*.
If *correct*, write down the word 'true' next to the question number.
If *incorrect*, write down the word 'false' next to the question number, and *rewrite* the sentence to show the change made by *underlining the changed text*.

1.1 The opening and closing of the stomata is caused by guard cells. (2)

1.2 Organic substances are mainly transported by the phloem of the plant. (2)

1.3 The xylem in the veins of the leaf lies closer to the dorsal side of the leaf than the phloem. (2)

1.4 The dorsal and ventral leaf surfaces of isobilateral leaves look different. (2)

1.5 Glucose sugar is made in the chloroplasts of the palisade parenchyma and spongy parenchyma. (2) [10]

Question 2: Scientific terminology

Give the scientific term for each of the following descriptions.

Write the term next to each question number.

2.1 The type of plant with parallel-veined leaves (1)

2.2 The bud which occurs in the axil formed between the leaf and the stem (1)

2.3 The transparent covering of the epidermis of leaves and stems (1)

2.4 Special epidermal cells which allow for gaseous exchange (1)

2.5 The tissue that lies between the upper and lower epidermis in leaves (1)

2.6 The loss of water vapour from the aerial parts of plants (1)

2.7 The process whereby food is manufactured in plants (1)

2.8 The most important photosynthetic tissue in the mesophyll of the leaf (1)

2.9 Epidermal cells controlling the size of the stomata (1)

2.10 The loss of water in the form of vapour in plants (1)

2.11 Spongy parenchyma and palisade parenchyma (1)

2.12 The element necessary for the formation of chlorophyll (1) [12]

Question 3: Matching columns

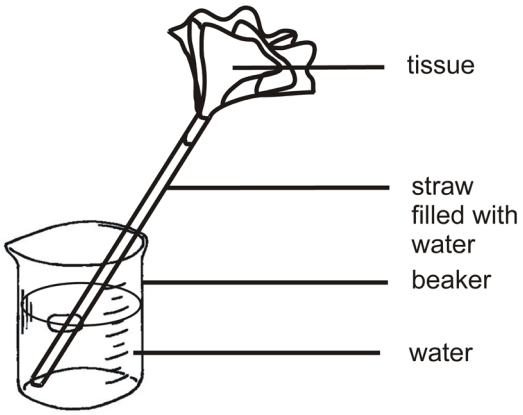
Match the item in COLUMN I with the statement in COLUMN II. Write only the letter (A–G) next to the question number (3.1–3.6).

Column I	Column II
3.1 Parenchyma 3.2 Collenchyma 3.3 Sclerenchyma 3.4 Phloem 3.5 Xylem 3.6 Epidermis	A Translocation of organic substances B Characteristic thickening at corners C Function is photosynthesis and respiration D Single layers of cells with stomata E Stone cells and fibres F Annular, reticulate, pitted and spiral vessels G Thin-walled with intercellular air spaces

[6]

Question 4: Diagrams

4.1 The following items can be used to represent a model of transpiration in a plant. Draw and label a schematic diagram of a plant and show which structures may be represented by the parts shown below.



(8)
[8]

Question 5: Short response

5.1 5.1.1 What is the main function of the palisade layer in a leaf? (2)

5.1.2 List TWO functions of the spongy mesophyll cells. (4)

5.1.3 Name the TWO main tissues found in the vein of a leaf and describe one function of each tissue. (4)

5.2 Provide TWO answers for each of the following.

5.2.1 Layers of tissue found on the inside in the middle of a plant leaf, between the two epidermis layers (2)

5.2.2 Parts making up the stomata (2)

5.2.3 Processes occurring in the leaf that use the stomata for gaseous exchange (2)

5.3 Provide THREE answers for each of the following.

5.3.1 The major sections of a leaf (3)

5.3.2 The gases that move through the stomata (3)

5.3.3 Parts of the epidermis of a leaf that have essential functions (3)

5.4 What is the function of the guard cells during the day? (2)

5.5 Give a definition or briefly explain each of the following:

5.5.1 diffusion (3)

5.5.2 osmosis (4)

5.5.3 transpiration. (5)

5.6 Name the factors exerting a direct influence on:

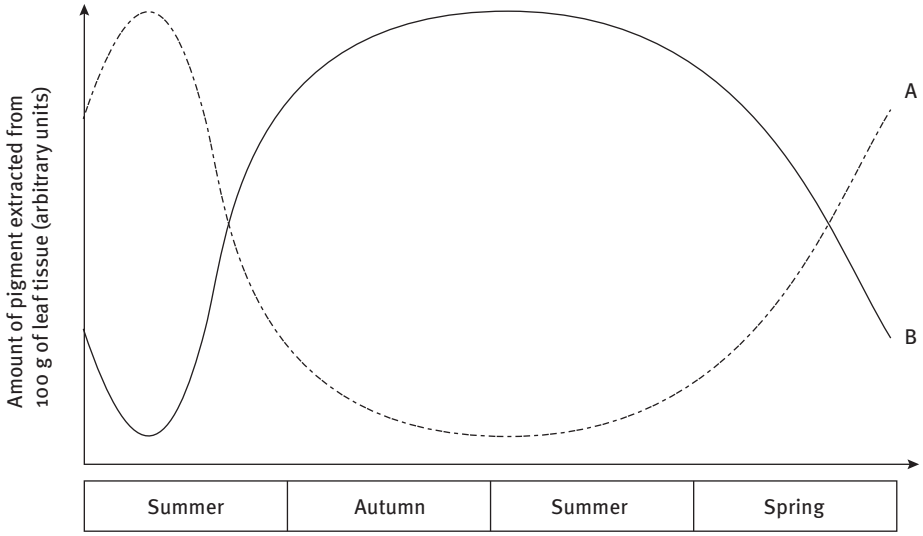
5.6.1 diffusion (2)

5.6.2 osmosis (2)

5.6.3 transpiration. (3) [46]

Question 6: Graphs

The data represented in the graph below is a process occurring in leaves during the year. The pigments chlorophyll and carotene (orange-yellow) were isolated from the leaves throughout the year.



7.1 Which curve represents the amount of chlorophyll extracted from the leaves? (2)

7.2 What process is occurring in the leaves between summer and spring? (2)

7.3 Name the collective group of organelles that contain chlorophyll and carotene. (1)

7.4 Provide a suitable heading for the graph. (2)

7.5 What process occurs in leaf and stem buds during spring, when growth occurs? (1) [8]

Question 7: Paragraph

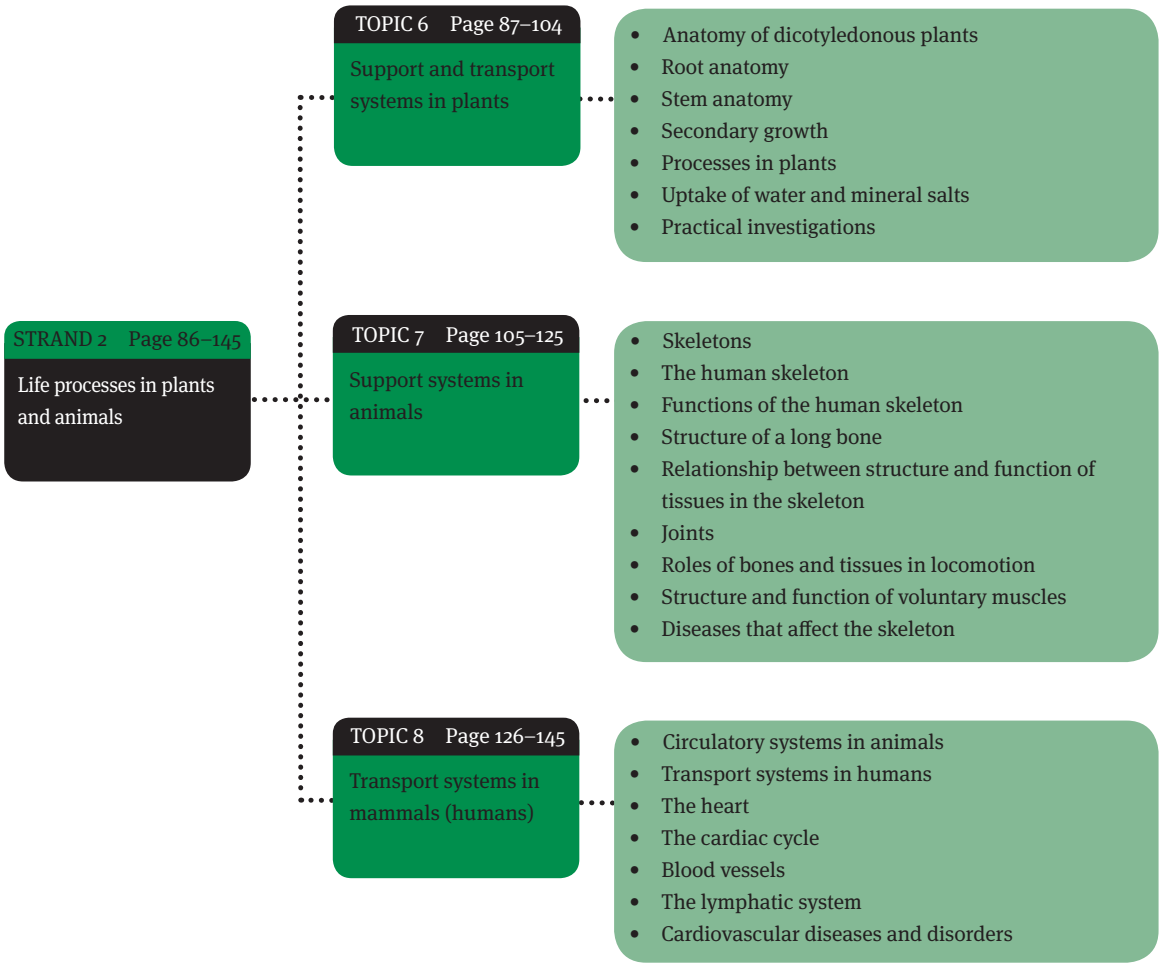
Briefly describe the process of transpiration as it takes place in the leaves of mesophytes. (Note: Absorption of H_2O = opposite of transpiration) [15]

TOTAL MARKS: 105

Strand 2

Life processes in plants and animals

Overview

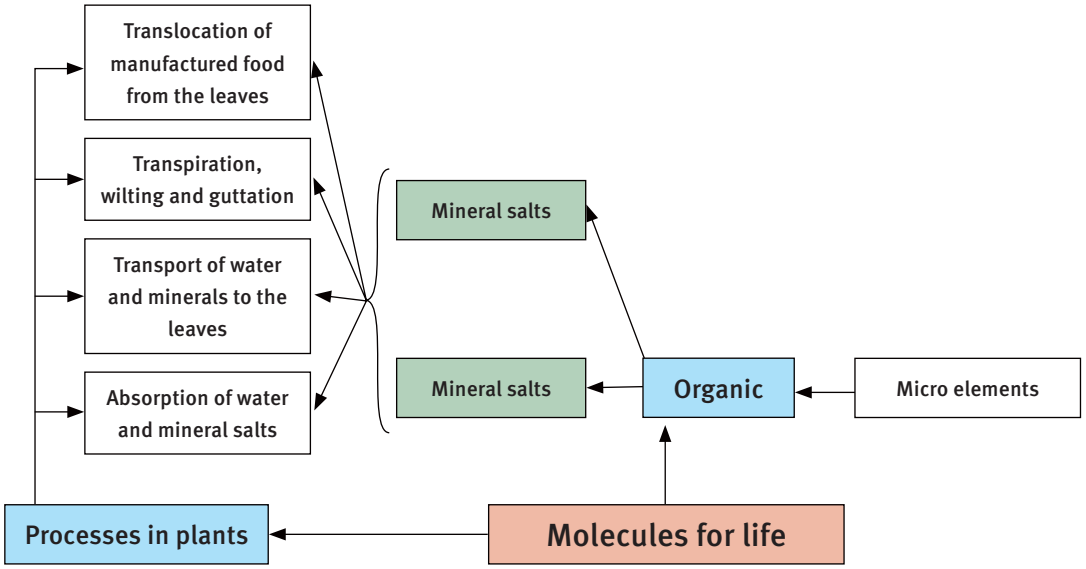


Topic 6

Support and transport systems in plants

Overview

Plants are organisms that live a stationary life, in one place. A plant cannot move away from changing environmental conditions, as an animal can do. So, the plant's support systems need to deal with changes in the environment during its lifetime, and adjust to the organism growing larger, year by year. An essential part of a plant is its transport system that moves substances from root to leaf, and back again.



Topic 6

1 Anatomy of dicotyledonous plants

- Plants are stationary organisms.
- A plant's support systems need to deal with changes in the environment during its lifetime, and adjust to the organism growing larger, year by year.
- The anatomy of a plant supports its needs and the processes that meet those needs: strength and support, uptake of water and mineral salts, translocation and transpiration.
- Seed plants are divided into two groups:
  - gymnosperms – which are non-flowering plants; examples are pine trees, yellowwood trees and cycads
  - angiosperms – which are flowering plants; examples are crop plants like sunflowers, and fruit trees like orange trees and marula trees
- Angiosperms are themselves divided into two groups:
  - dicotyledons (dicots)
  - monocotyledons (monocots).

1.1 Plant tissues

- Tissues found in plants are: meristematic, epidermal, parenchyma, chlorenchyma, aerenchyma, collenchyma, sclerenchyma, xylem, phloem.
- The structure of these tissues lets them give support, protection and structure in all plant organs: the roots, stems, leaves, flowers, fruit and seeds.

1.2 Support and transport tissues in plants

- Support tissues – collenchyma, sclerenchyma and xylem
- Transport tissues – xylem and phloem

1.2.1 Collenchyma and sclerenchyma tissue

- Collenchyma – strengthening tissue beneath the epidermis in young stems
- Sclerenchyma – strengthening, support and protection tissue found in the pericycle

1.2.2 Xylem tissue

- Xylem transports water and dissolved mineral salts.
- It is made of xylem vessels, tracheids, sclerenchyma fibres and parenchyma.

Table 6.1 Structural features of xylem tissue	
Xylem parts	**Structural feature**
Xylem vessels	Xylem vessels have these features: • Primary cell wall made of cellulose • Dead cells with no cytoplasm • Long, cylindrical cells • Narrow to wide diameter • Perforated cross walls (holes present or absent) • Form continuous tubes • Thick secondary lignin cell walls • Secondary cell walls found in patterns: annular, spiral, scalariform and pitted.
Xylem tracheids	Xylem tracheids have these features: • Structurally similar to vessels • Dead cells with no cytoplasm • Ends of the cells are pointed • Perforations in cross walls forming perforation plates • Narrow diameter.
Xylem sclerenchyma fibres	Xylem sclerenchyma fibres have these features: • Primary walls made of cellulose • Thick secondary cell walls made of lignin • No patterning • Dead cells with no cytoplasm • Long, thin cells with sharp points • Small narrow cavities.
Xylem parenchyma	Xylem parenchyma has these features: • Structure as other parenchyma tissue.

1.2.3 Phloem tissue

- Phloem transports manufactured organic foods.
- It is made of sieve tubes and companion cells.

Table 6.2 Structural features of phloem tissue	
Phloem parts	**Structural features**
Sieve tubes	Phloem sieve tubes have these features: • Primary cell wall made of cellulose • No secondary lignin cell walls • Living cells with cytoplasm and no nucleus • Long, cylindrical cells • Narrow to wide diameter • Sieve plate in cross walls (with holes so cytoplasm passes through from cell to cell) • Form continuous tubes • Large vacuoles making up cell body, with cytoplasmic threads.
Companion cells	Phloem companion cells have these features: • Primary cell wall made of cellulose • No secondary lignin cell walls • Living cells with dense cytoplasm and a nucleus • Complete cells with cross walls, tiny in size • Found next to sieve tubes to manage the sieve tube metabolism.
Phloem sclerenchyma fibres	Phloem sclerenchyma fibres have these features: • Primary cell walls made of cellulose • Thick secondary cell walls made of lignin • No patterning • Dead cells with no cytoplasm • Long, thin cells with sharp points • Small narrow cavities.
Phloem parenchyma	Phloem parenchyma has these features: • Structure as other parenchyma tissue.

2 Root anatomy

2.1 Functions of root systems in plants

The functions of root systems are:

- anchorage – to stop plants from falling over when there is wind and rain
- support – for stems and leaves
- storage – providing a site of food storage so the plant can grow and survive
- nutrient uptake – to absorb water and elements (ions) in solution
- transport – to translocate (move) water and nutrients to stems and leaves of the plant
- reproduction – modified roots like carrots, sweet potato and radishes produce new plants.

2.2 Origin of root systems in plants

- The primary embryonic root is the first part of the plant that emerges from a germinating seed in dicotyledonous plants.
- It is called the radicle or primary root.

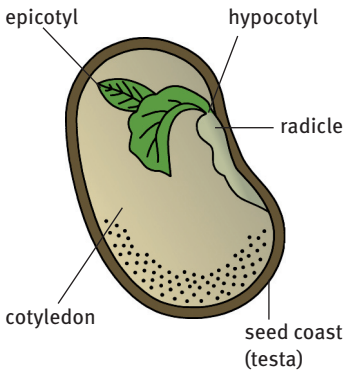


Figure 6.1 Germinating dicotyledonous seed

2.2.1 Types of root systems

There are two main types of root systems:

- Tap root systems – in dicotyledons, the radicle develops lateral roots that branch outwards and create a collection of roots, called a tap root system.
- Fibrous or adventitious root systems – in monocotyledons, the radicle dies and is replaced with a second set of adventitious roots that form a fibrous root system; these adventitious roots do not branch out from the primary embryonic root.

2.2.2 Support tissues and transport tissues in root systems

- Roots contain collenchyma, sclerenchyma and xylem.
- Xylem and sclerenchyma help to transport water and mineral salts in the stele.
- Phloem transports organic food from the leaves to the roots for growth and storage.

2.2.3 External and internal dicotyledonous plant root structure

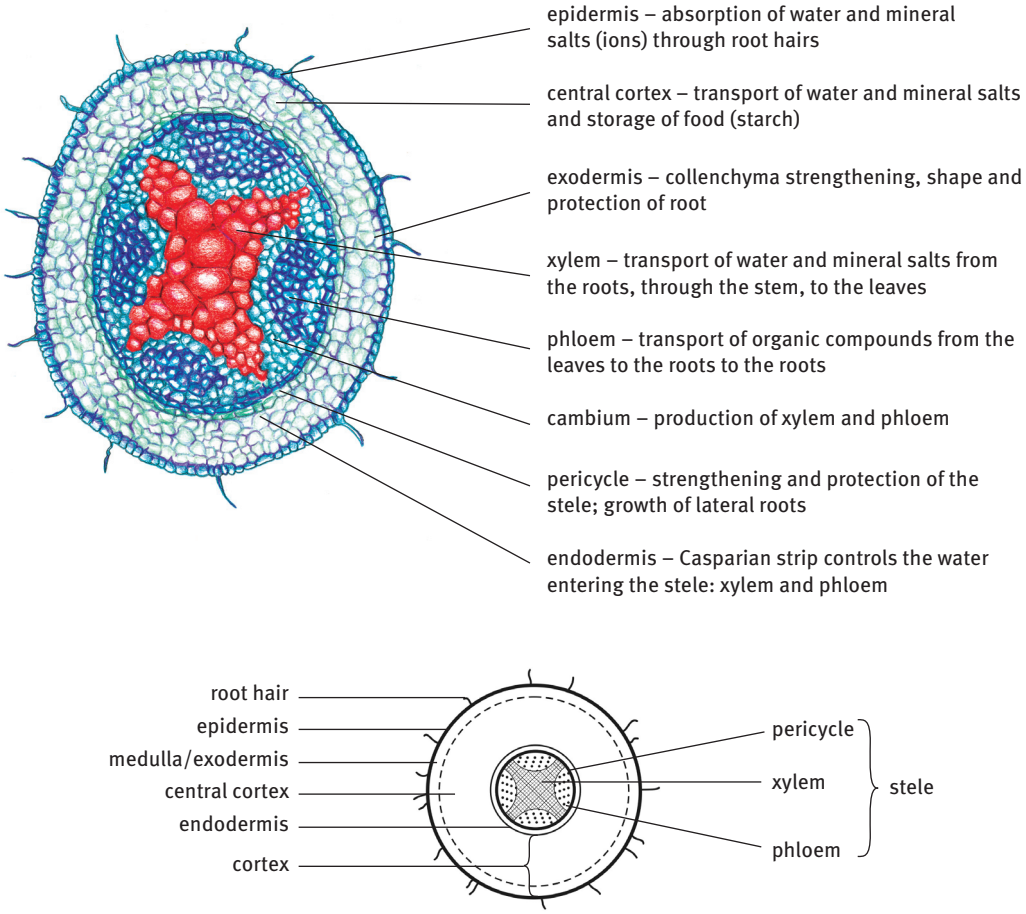


Figure 6.2 Dicotyledonous root anatomy and tissue map

3 Stem anatomy

The external and internal structure of dicotyledonous plant stems differ from those of monocotyledonous plant stems.

3.1 Classification of plant growth forms

The growth forms of plants are classified into groups based on what their stems are like:

- herb – no woody tissue
- shrub – woody, several stems from the base, lower than trees, about 25 cm to 1 m tall
- tree – woody, usually one main stem, usually more than 5 m tall
- vine – woody or herbaceous, stem climbing or twining.

3.2 Functions of stems in plants

The functions of stems include:

- transport – to translocate water and dissolved mineral elements (ions) and dissolved sugars
- support and positioning – to hold leaves, flowers and fruit
- storage – to store nutrients for growth and survival
- reproduction (asexual)
- protection.

3.3 Origin of stems in plants

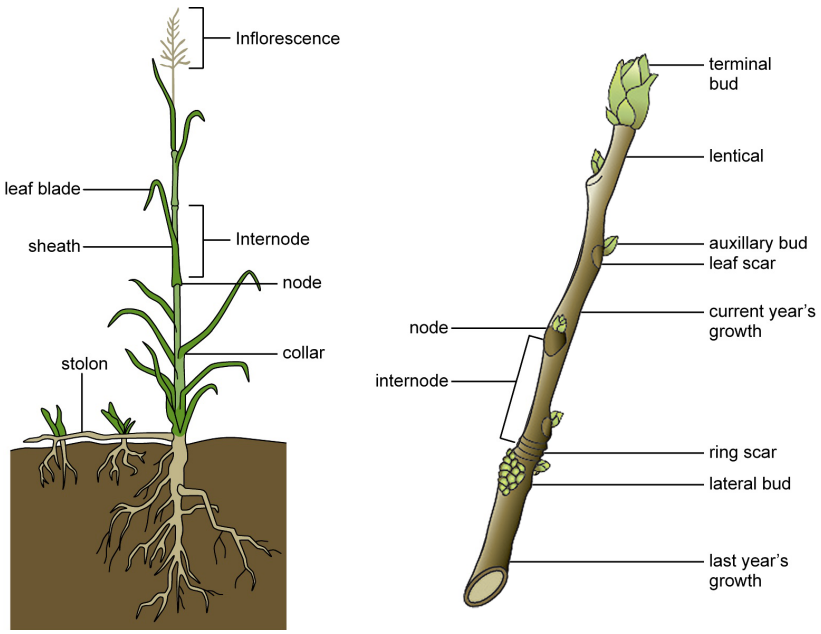
- Dicotyledonous plants – the radicle absorbs water and a young shoot (plumule) emerges from the seed; the stem develops from the growing tip (epicotyl) of the embryonic shoot (plumule).
- Monocotyledonous plants – the coleorhiza is the first part to grow out of the seed, followed by the radicle; the coleoptile is pushed up through the ground until it reaches the surface; the first leaves of the plumule emerge through this protected opening.

3.4 Stem tissues for strength, support and transport

- Support and strength – collenchyma, sclerenchyma and xylem tissues in woody and herbaceous plants
- Transport tissues – xylem and phloem, found in vascular bundles

3.4.1 External structure of a dicotyledonous stem

Dicotyledonous stems may be herbaceous or woody.



a) herbaceous dicotyledonous stem b) woody dicotyledonous branch

Figure 6.3 External structure of a monocotyledonous and dicotyledonous stem

3.4.2 Internal structure of a dicotyledonous stem

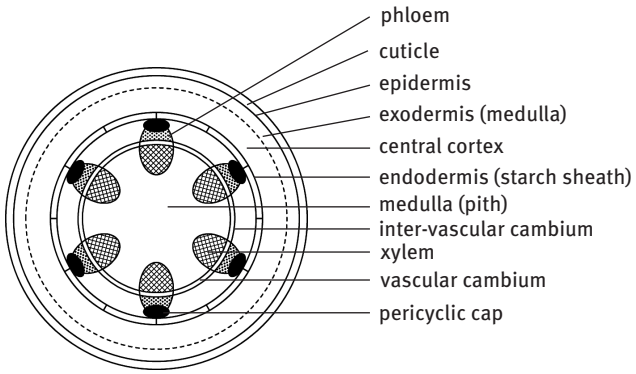


Figure 6.4 Dicotyledonous stem tissue map

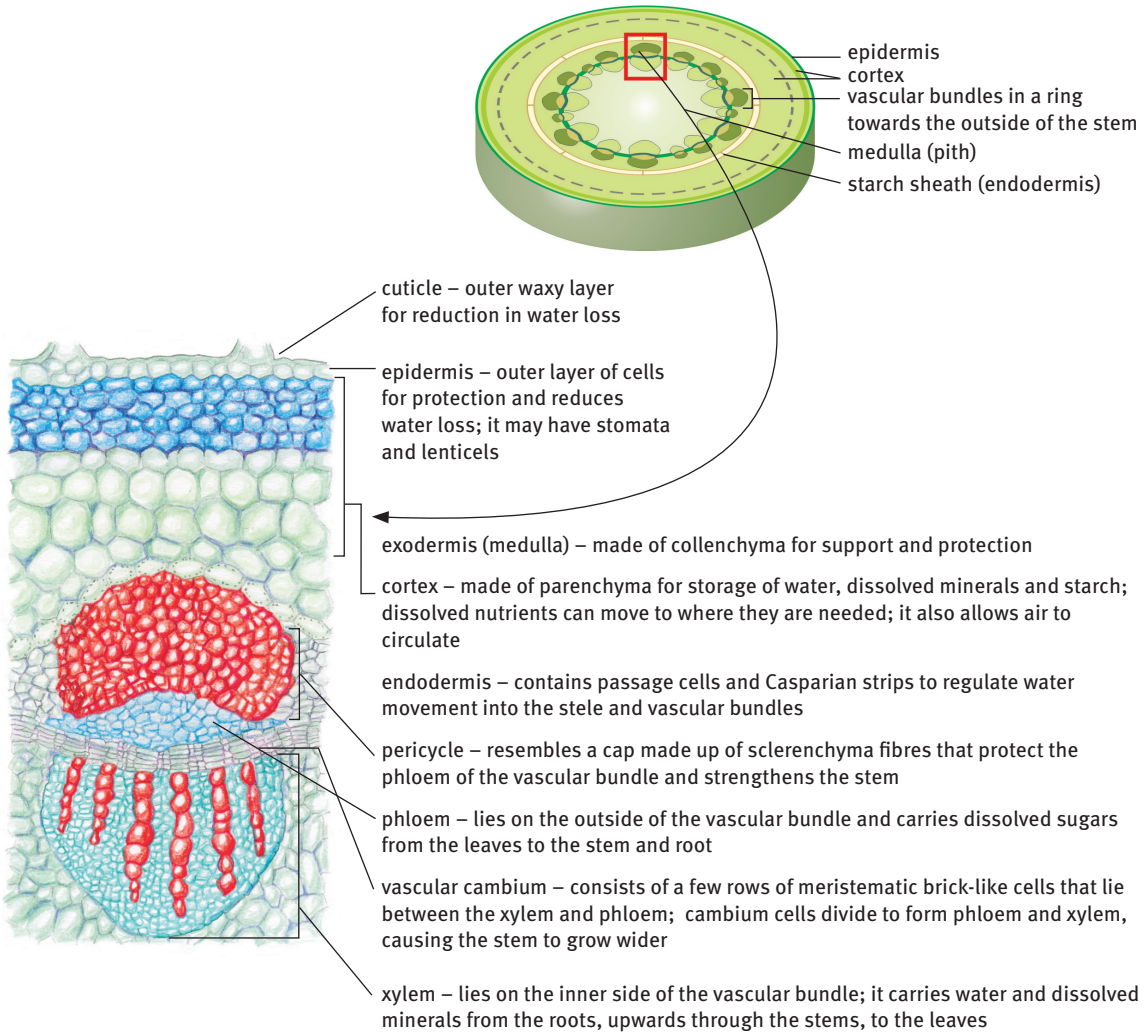


Figure 6.5 Dicotyledonous stem anatomy and structure of a vascular bundle

4 Secondary growth

- Plants that grow for longer than two years are known as perennials. As they grow taller, their stems and roots need to grow wider to provide support. This is known as secondary growth.
- This increase in the thickness of the shoots and roots of a vascular plant is as a result of new cells forming in the cambium.

4.1 Cork cambium

- Cambium is secondary meristematic tissue found in roots and stems of plants.
- Parenchyma cells in the outside layer of the cortex form cork cambium through cell division; it produces cork cells which form bark, which slowly replaces the epidermis of the stem.
- Bark protects the plant and allows it to carry on growing bigger.

4.1.1 Annual rings, heart wood and sap wood

- Annual rings (or growth rings) are the rings that can be seen in a cross section of a woody stem.
- Each annual ring is made of a light summer wood region and a dark winter wood region.
- Heart wood is the old xylem that is found at the centre of the stem.
- Sap wood is the new xylem that is found just under the bark.
- A tree trunk's annual rings can tell us about the age of the tree and the climatic conditions that the tree experienced.

4.2 Lenticels

- Lenticels are pores that form in cork cambium of woody plants.
- Lenticels allow gaseous exchange between the air outside and the living tissues inside the stem.

5 Processes in plants

5.1 Transpiration

- Transpiration is the loss of water in the form of water vapour from leaf surfaces. Water can be lost through:
  - stomata – this is known as stomatal transpiration
  - the cuticle – this is known as cuticular transpiration.
- The evaporation of water from the leaves creates a suction force that pulls water up the plant from the roots to the leaves. This is known as transpiration pull.
- The large amount of evaporated water produced through transpiration is an essential part of the water cycle in nature.

5.1.1 Relationship between leaf structure and water loss

Leaf anatomy limits water loss (evaporation) through the following:

- cuticle – the waxy layer covering the epidermis reduces cuticular transpiration
- guard cells – control the rate of stomatal transpiration by opening and closing the stomatal pores
- location and number of stomata – most stomata are found on the shaded, cooler underside (ventral surface) of leaves, with fewer on the upper (dorsal) surface; this means less water transpires
- position and shading – leaf position on the stem allows for some leaves to be shaded by others, and so reducing evaporation
- leaf size – larger leaves lose more water than smaller ones as their surface area is greater
- leaf hairs (trichomes) – hairs reduce water evaporation through diffusion.

5.1.2 Function of stomata during transpiration

The way stomata open and close is known as the stomatal mechanism.

Table 6.3 The stomatal mechanism

During the day	During the night
1 Photosynthesis occurs in the chloroplasts of the guard cells.	1 No photosynthesis occurs in the chloroplasts of the guard cells.
2 Glucose produced from photosynthesis collects in the guard cells.	2 Glucose is used up in the guard cells to provide energy.
3 Water moves into the guard cells by osmosis, causing them to expand.	3 Water moves out of the guard cells by osmosis, causing them to become soft and collapse.
4 Guard cells bend outwards causing the stomatal pore to open.	4 Guard cells bend inwards causing the stomatal pore to close.
5 Water diffuses out of the leaf.	5 Water cannot diffuse out of the leaf.

5.1.3 Effect of environmental factors on transpiration

- Transpiration rate is influenced by changes in:
  - temperature
  - light intensity
  - humidity
  - air movement (wind).
- Air pressure and soil moisture also have an effect on transpiration.

Table 6.4 Effect of different environmental factors on transpiration			
Environmental factor	**Rate of transpiration**	**Environmental factor**	**Rate of transpiration**
Increase in temperature	increase	Decrease in temperature	decrease
Increase in light intensity	increase	Decrease in light intensity	decrease
Increase in humidity	decrease	Decrease in humidity	increase
Increased air movement (wind)	increase	Decreased air movement (wind)	decrease
Increase in air pressure	decrease	Decrease in air pressure	increase
Increase in soil moisture	increase	Decrease in soil moisture	decrease

5.2 Wilting and guttation in plants

- Wilting is a condition that arises when more water is lost through transpiration than is taken up by the plant roots. If the plant stays wilted, it will die of dehydration.
- Guttation is a process of water loss in the form of water droplets through hydathodes along leaf margins. Hydathodes are special pores found in the epidermis of certain plants. Guttation occurs when more water is absorbed into the plant from the roots than that lost from the leaves through transpiration and evaporation.

6 Uptake of water and mineral salts

6.1 Absorption of water and mineral salts from soil into root

- Water is mostly absorbed from the soil through root hairs.
- Water moves from the soil into the root by osmosis.
- Osmosis is the spontaneous movement of water molecules from a high concentration to a low concentration across a semi-permeable membrane.
- The water passes through the semi-permeable cell membrane and tonoplast.
- Some mineral salts (ions) are actively taken up by plant cells through the cell membrane using energy. This is active transport.

6.2 Movement of water through the root into the stele

- There are three pathways by which water may move through the root tissue to the central stele:
  - Apoplast pathway – the movement of water along the cell walls and intercellular air spaces in the plant tissue, without crossing any membranes. At the endodermis, apoplast water movement is prevented by the Casparian strip.
  - Symplast pathway – the route followed by water through the interconnected cytoplasm (symplast) of adjacent cells; water moves from cell to cell through the plasmodesmata.
  - Transmembrane (transcellular) pathway – the water passes through the cell membrane on one side, moves through the cell, and leaves the cell through the cell membrane on the other side. It then enters the next cell in the series, and so on.

- At the endodermis, the Casparian strip prevents water moving through into the stele. The passage cells of the endodermis control the entry of water into the stele.
- Water passes through the pericycle and enters the root xylem.

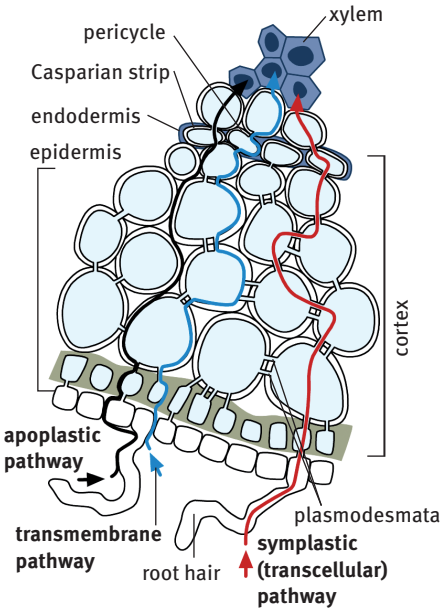


Figure 6.6 The three pathways for movement of water through the root into the stele

6.3 Transport from the stele of the root to the leaves

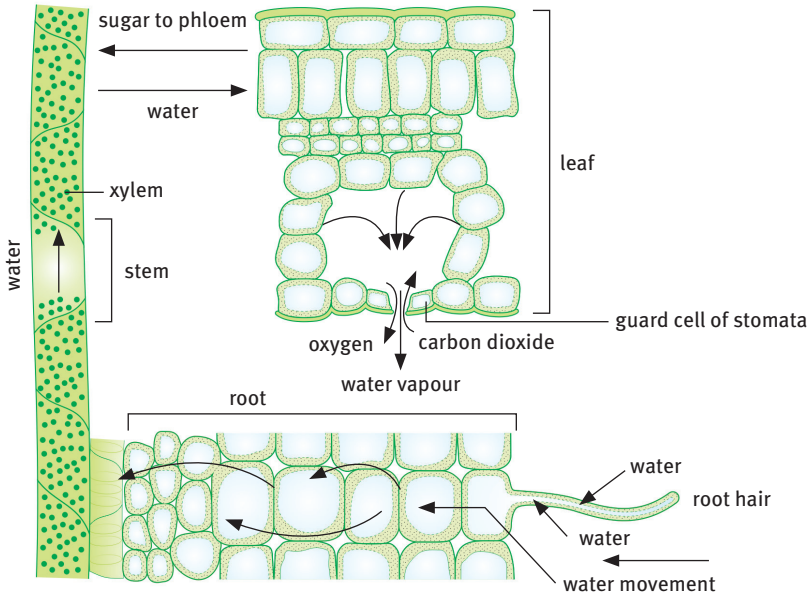


Figure 6.7 Movement of water and sugar through the plant

- The movement of water and mineral elements (ions or salts) from the source (the root hairs) to the sink (the leaves) is called translocation.
- Root pressure is created by ongoing osmosis of water into the root – it forces water to rise up the stem against the force of gravity.

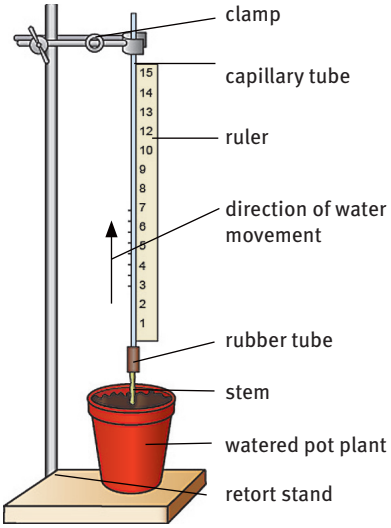
- Capillarity (capillary movement) is the ability of water to move through the tracheids, fibres and vessels of xylem tissue by itself, due to the interaction between the forces of adhesion and cohesion:
  - adhesion forces – water molecules are attracted to the xylem they are moving through, causing water to 'climb' up inside the xylem tissue
  - cohesion forces – water molecules are attracted to each other and 'holding together' to pull water along.

6.4 Translocation of food from leaves to other parts

- The movement of sucrose sugar from the leaves (source) to the rest of the plant (sink) is also known as translocation.
- The companion cells actively load sucrose sugar into the sieve tubes in the mesophyll of leaves. Chemical energy is used for this process.
- Sugar gathers in the sieve tubes, causing water to move into the sieve tubes by osmosis.

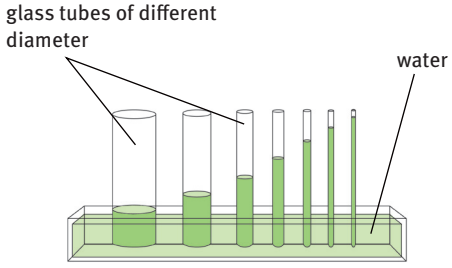
7 Practical investigations

Aim: To investigate root pressure



Result: Water rises in the capillary tube from ongoing osmosis into the root pushing water up the tube.

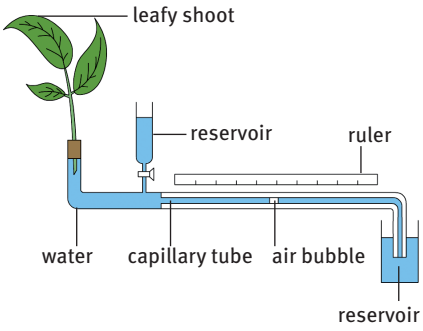
Aim: To investigate capillarity



Result: Water rises in the glass tubes to different heights against gravity using adhesion and cohesion forces.

Aim: To investigate the rate of transpiration

speed of movement of air bubble (mm/s) × cross-sectional area of capillary tube (mm^2) = rate of water uptake (mm^3/s)



Result: Air bubble moves at different rates.

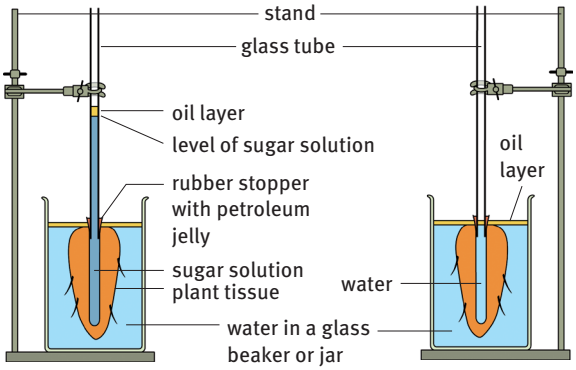
The rate of transpiration is fast in:

- high temperature
- wind
- low humidity.

The rate of transpiration is slow in:

- low temperature
- no wind
- high humidity.

Aim: To investigate the movement of water into the root

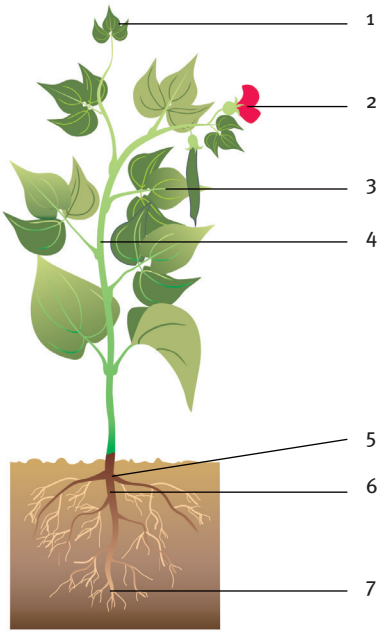


Result: Water rises in the capillary tube of the experiment, but not in the control, due to endosmosis.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

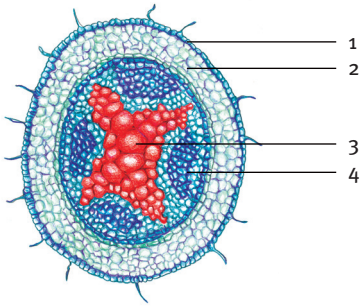


1.1 Two parts of a plant where cells with large prominent nuclei and small vacuoles are found, are:

A 2 and 3
B 3 and 5
C 1 and 7
D 5 and 6. (2)

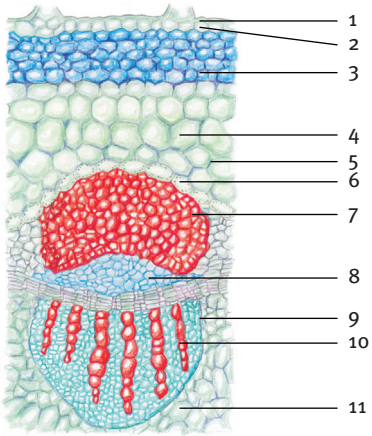
1.2 Casparian strips:

A direct water movement towards the xylem
B absorb water from the soil
C are found in the pericycle of the root
D transport mineral ions across membranes. (2)



1.3 Water and mineral salts are mainly transported through:

A 1
B 2
C 3
D 4. (2)



1.4 Which parts of the diagram are respectively responsible for:

- the transport of water,
- storage,
- the transport of sugar, and
- reduction of water loss?

A 1, 4, 8, 11
B 10, 4, 8, 1
C 2, 6, 8, 9
D 10, 7, 5, 3 (2)

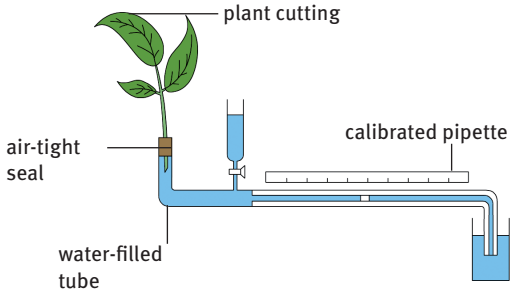
1.5 What is the order of the structures provided through which a water molecule were to move on its journey through a leaf from the xylem to the atmosphere during transpiration?

1. atmosphere
2. palisade parenchyma
3. guard cell
4. sub-stomatal chamber
5. spongy parenchyma

A 2, 5, 4, 3, 1
B 5, 2, 3, 4, 1
C 1, 3, 4, 2, 5
D 2, 3, 4, 5, 1 (2)

1.6 The aim of the investigation set up in the diagram is to:

A show the loss of water through transpiration
B demonstrate the effects of capillarity
C investigate the movement of water through osmosis
D prove that cell walls are permeable to water.



(2)

1.7 Gaseous exchange in older deciduous plants, during winter, takes place through the:

A epidermis
B stomata
C lenticels
D guard cells. (2) [14]

Question 2: True/false

Read each of the statements 2.1 to 2.10 provided below.
Decide if each statement is scientifically correct or incorrect.
If correct, write down the word 'true' next to the question number.
If incorrect, write down the word 'false' next to the question number, and rewrite the sentence to show the change made by underlining the changed text.

2.1 Parenchyma forms the bulk of an herbaceous plant body. (2)

2.2 The main function of phloem in a stem is to translocate water and mineral salts (ions). (2)

2.3 Water is transported against the force of gravity from the roots to the rest of the plant. (2)

2.4 The epidermis secretes a waxy layer to protect the plant against the harmful sunlight. (2)

2.5 Tissues mainly associated with mechanical support in plants are collenchyma, sclerenchyma and xylem. (2)

2.6 Between the xylem and phloem is a tissue called cambium, which is responsible for secondary growth. (2)

2.7 In a dicotyledonous stem vascular bundle, the primary xylem is found on the outside and the primary phloem towards the inside. (2)

2.8 The medullary rays occur in the xylem tissues and assist in radial transport of substances. (2)

2.9 The pericycle is made of collenchyma tissue. (2)

2.10 Phloem and xylem tissues are found in the stele of roots. (2) [20]

Question 3: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

3.1 The main substance transported by xylem (1)

3.2 The type of conductive tissue in the plant that consists of sieve tubes and companion cells (1)

3.3 The type of conductive tissue that consists of vessels, tracheids and fibres (1)

3.4 The tissue on the outer layer of the plant organs (1)

3.5 The force that causes water molecules to 'stick to' the xylem they are moving through (1)

3.6 A function of lignin in sclerenchyma tissue (1)

3.7 The meristematic tissue between the xylem and the phloem in vascular bundles (1)

3.8 The xylem is arranged in the shape of an 'X' in the cross section of this organ (1)

3.9 The band of suberin (wax) in the endodermis which regulates water movement from the cortex to the xylem (1)

3.10 Tissue that conducts water and strengthens the plant (1)

3.11 The process during which water evaporates through the stomata (1)

3.12 The movement of a substance from its source to a sink (1)

3.13 Water loss from hydathodes (1)

3.14 The band that prevents water moving between the cells of the endodermis in roots (1)

3.15 Concentric regions of spring and autumn wood seen in a woody stem (1) [15]

Question 4: Matching columns

Match the item in COLUMN I with the statement in COLUMN II.

Write only the letter (A–J) next to the question number (4.1–4.10).

Column I		Column II
4.1	Dicotyledonous root	A Water droplets from edges of leaves
4.2	Stele	B Layer on surface of leaf that prevents water loss
4.3	Endodermis	C Xylem and phloem
4.4	Transpiration pull	D Pericycle cap of vascular bundle
4.5	Root pressure	E Movement of water up a stem against gravity
4.6	Guttation	F X-shaped xylem tissue
4.7	Apoplastic	G Excessive loss of water
4.8	Cuticle	H Constant osmosis of water into the root
4.9	Sclerenchyma	I Regulation of water into xylem
4.10	Wilting	J Movement of water through cell walls only

[10]

Question 5: Short response

5.1 Tabulate SEVEN differences between the internal anatomies of a dicotyledonous root and stem as seen in cross section (transverse section). (14)

5.2 Name THREE processes that assist water movement from the root to the leaves of plants. (6)

5.3 Explain what would happen to the water in plants if the soil was over-fertilised with mineral salts. (4)

5.4 Explain how the leaves of plants are adapted structurally to allow and prevent the evaporation of water. (10) [34]

Question 6: Data response

The following transpiration rate data was collected for a plant under study over a single day in calm air conditions and sunlight.

Time (h)	Volume of water per hour ($cm^3.h^{-1}$)
0	0
1	4
2	8
4	15
6	6
8	1

6.1 Plot the data as a suitable graph. (9)

6.2 Explain the pattern (trend) seen in the graph. (6)

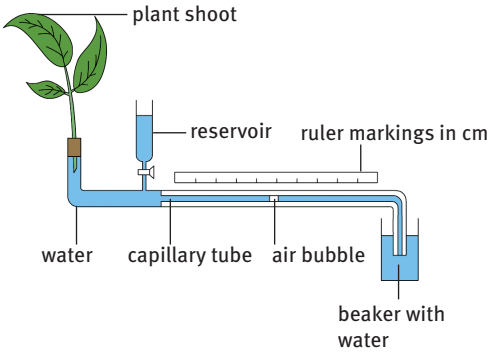
6.3 Why was the transpiration rate the highest at four hours into the investigation? (2)

6.4 Explain what was occurring in the guard cells of the stomata at four hours into the investigation. (8)

6.5 How would these results be affected on a windy day? (3) [28]

Question 7: Contextual

The apparatus shown below was used to investigate a certain phenomenon. Study the diagram and answer the questions that follow.



7.1 Identify the apparatus in the diagram. (1)

7.2 Name THREE factors that can increase the rate of transpiration. (3)

7.3 State THREE precautions that need to be considered in the investigation design to make sure that the results obtained are accurate and reliable. (3) [7]

Question 8: Paragraph

Explain how xylem, sclerenchyma and collenchyma are adapted for the function of support in plants. (10) [10]

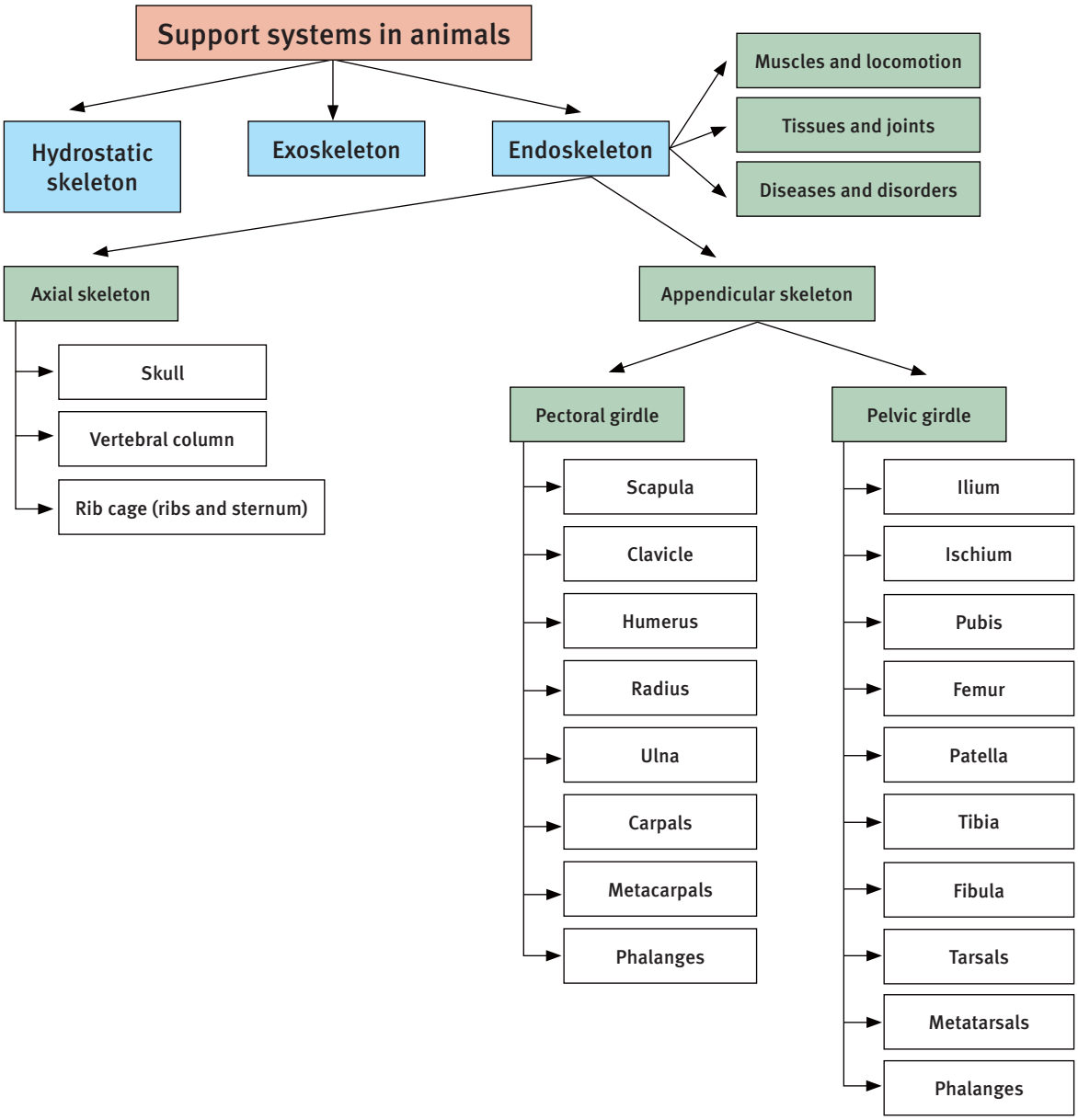
TOTAL MARKS: 138

Topic 7

Support systems in animals

Overview

Animals are organisms that live in many different environments. They are able to move when conditions are unfavourable. For this reason there are a variety of support systems seen in animals living in these differing environments. By far the most amazing, is the support system found in vertebrates – it provides support, protection and flexible movement. In this topic you will compare the different support systems of animals and then focus on the human support system and locomotion.



1 Skeletons

- Every living organism, whether it is unicellular or multicellular, needs support to keep its shape and to move.
- Unicellular organisms are shaped by their cell membranes or cell walls.
- Soft-bodied multicellular invertebrates that live in water (sea snails, anemones and jellyfish) and in moist land environments (earthworms and snails) have a fluid hydrostatic skeleton (body compartment filled with fluid under pressure).
- Multicellular invertebrate arthropods (such as insects, crustaceans and arachnids) have an exoskeleton. The exoskeleton support system is a chitinous or calcerous hard covering on the outside ('exo' means 'outside') of a body, which supports and protects internal tissues.
- Multicellular organisms such as mammals, fish, birds and reptiles, have a rigid framework called the endoskeleton that makes the shape of the organism and helps it to move.
  - The endoskeleton support system is made of soft or hard bones, joints, muscles, tendons and ligaments and is found inside ('endo' means 'inside') a body.
  - A soft endoskeleton is made of cartilage (as in sharks).
  - A hard endoskeleton is made up of bone (as in vertebrates).
  - Endoskeletons protect the soft body tissues and allow for free movement, greater growth and strength.

Table 7.1 Advantages and disadvantages of different animal support systems

Advantages		
Hydrostatic	**Exoskeleton**	**Endoskeleton**
• Water animals can increase in size because support of water reduces effects of gravity • Land animals easily burrow into soil for protection • Movement needs little energy because it is helped by water or moist land environment	• Plates of armour to support and protect soft internal tissues and organs • Muscles and organs are inside for protection • Provides shape and structural support • Prevents dehydration • Provides good leverage for muscle action	• Greater flexibility • Can grow with increase in size • Limited energy needed for more growth because skeleton is added to, not replaced • Gives shape and structural support • Bones can vary in size to support mass
Disadvantages		
Hydrostatic	**Exoskeleton**	**Endoskeleton**
• No solid support for muscles, limbs or appendages • Land animals cannot increase in size because of the limited support of their muscles • If land animals got bigger they would collapse under their own weight • No escape from predators • Cannot quickly escape or make defence movements • No protective tissues • Must have a moist or water habitat to survive and prevent dehydration	• Limits the size of the animal • Creates difficulties in growth • Animal needs to moult to increase in size • Uses a lot of energy in the re-growth stage after each moulting	• No overall protection to the body (but vital organs well protected) • Muscles located on outside, so can be easily damaged • Does not prevent dehydration • Poor leverage for muscle action

1.1 Developmental progression and support for a terrestrial lifestyle

- During the history of life on Earth, animals moving onto land from the sea developed a support system for a terrestrial, or land-based, lifestyle.
- The development of support and locomotion follows this pathway of organisation:

unicellular ▶ multicellular hydrostatic ▶ multicellular exoskeleton ▶ multicellular endoskeleton

2 The human skeleton

- The word 'skeleton' means the firm framework of the body of an animal, which supports and protects the body.
- The human skeleton consists of 206 bones.
- The bones of the skeleton can be grouped into four categories based on shape: long bones, short bones, flat bones and irregular bones.

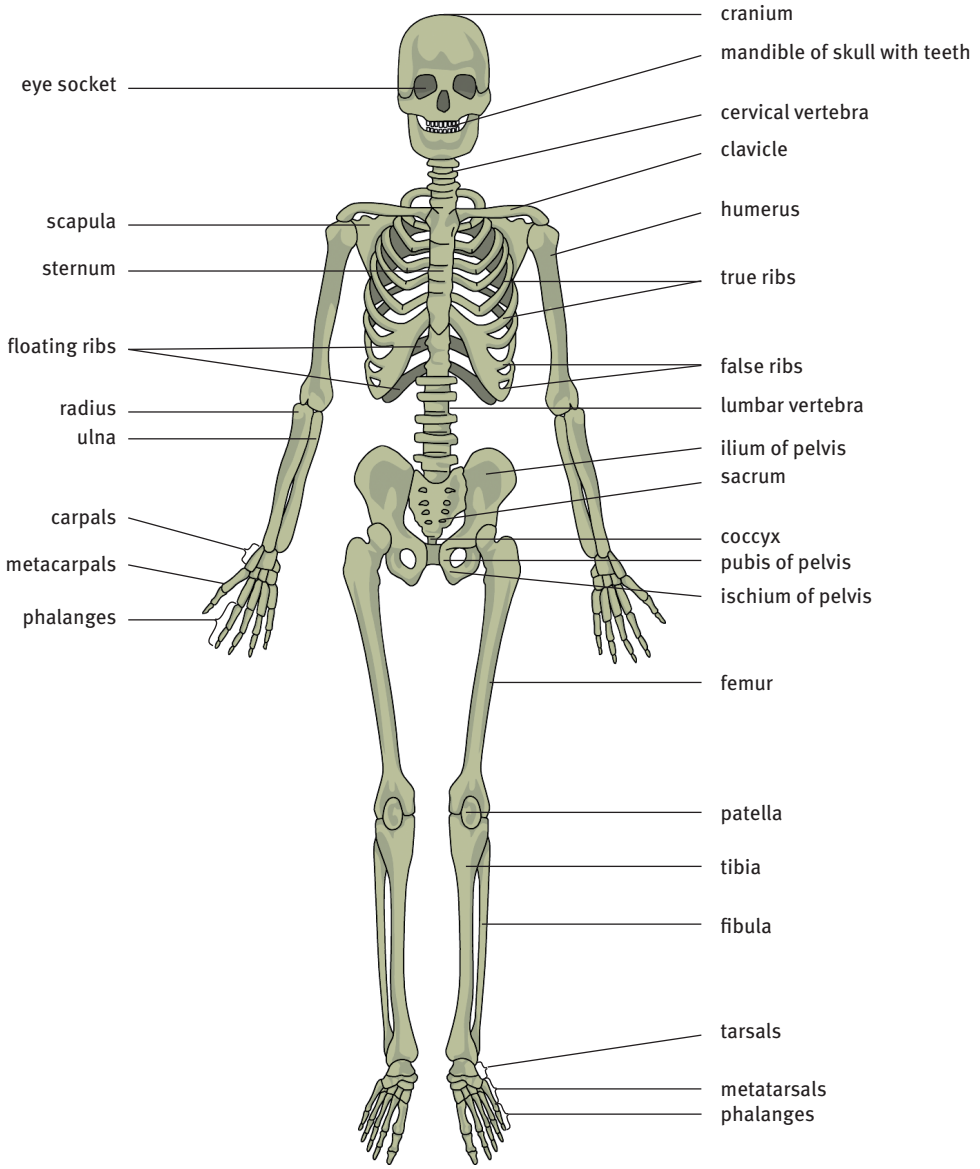


Figure 7.1 The human skeleton

2.1 Axial skeleton

The axial skeleton is divided into the:

- skull
- vertebral column
- ribs and sternum.

2.1.1 The skull

- The skull of mammals consists of 22 bones that form the cranium and the skeleton of the face.
- There are three pairs of cavities in which the following sense organs are situated: smell, sight and hearing.
- The facial skeleton is the anterior part of the skull and is formed mainly by the upper (maxilla) and lower (mandible) jaws that are directly connected to the teeth.
- At the base of the skull are two condyles that fit into the atlas (first cervical vertebra) of the vertebral column.
- This articulation enables the head to move up and down.
- Between these two condyles is a large opening (the foramen magnum) through which the spinal cord in the vertebral column passes.
- Teeth are found in the upper and lower jaws.

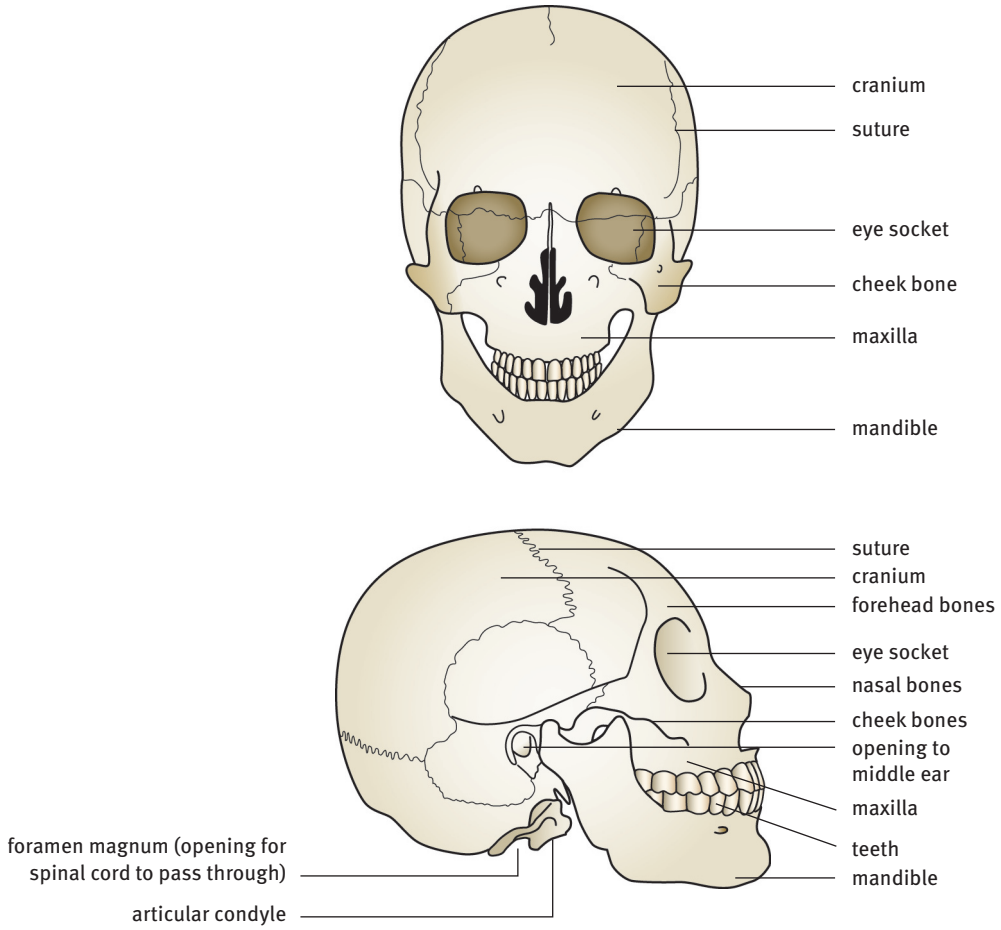


Figure 7.2 The human skull

2.1.2 Different types of teeth in mammals

- All mammals have two sets of teeth during their lifetime: a temporary milk set and a permanent set.
- Humans have 20 milk teeth and 32 permanent teeth.
- The teeth are symmetrically arranged in both the upper and the lower jaws.
- Chewing is the main purpose of teeth in humans and there are four types, each of which has its own function:
  - incisors – cut and bite food into small pieces
  - canines – help to hold and tear or bite food
  - premolars and molars – compress and grind food into fine particles.
- The dental formula for humans is $\frac{2:1:2:3}{2:1:2:3}$.
- Each side of the jaw has 2 incisors, 1 canine, 2 premolars and 3 molars on both the upper and lower side of the mouth.

2.1.3 The vertebral column

The vertebral column (spinal column or the backbone) is made of irregular bones (vertebrae).

- The flexible vertebral column goes from the skull to the pelvis and forms the central axis of the body.
- It surrounds and protects the delicate spinal cord, which runs through its central cavity.
- It is a point of attachment for the ribs, the pectoral girdle and the pelvic girdle.
- It provides flexible movement and absorbs shock.
- It provides entry and exit for nerves and blood vessels.

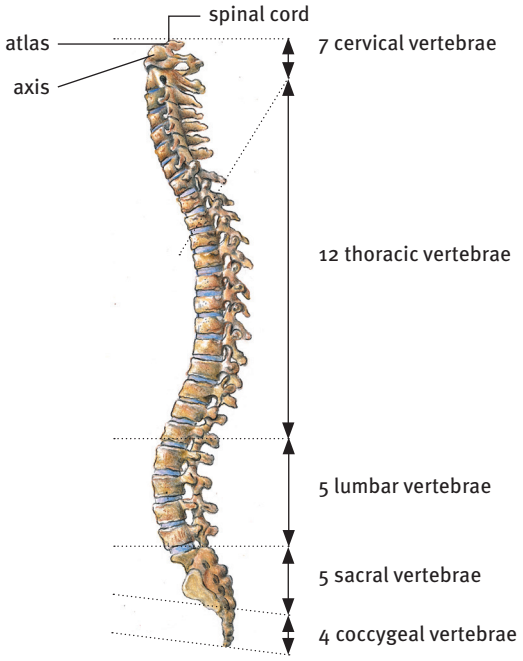


Figure 7.3 The human vertebral column

2.1.4 The thorax

- 12 pairs of ribs, the sternum and the thoracic vertebrae form the bony rib cage around the thoracic cavity which contains the heart and lungs.
- The ribs and sternum aid the mechanism of breathing.

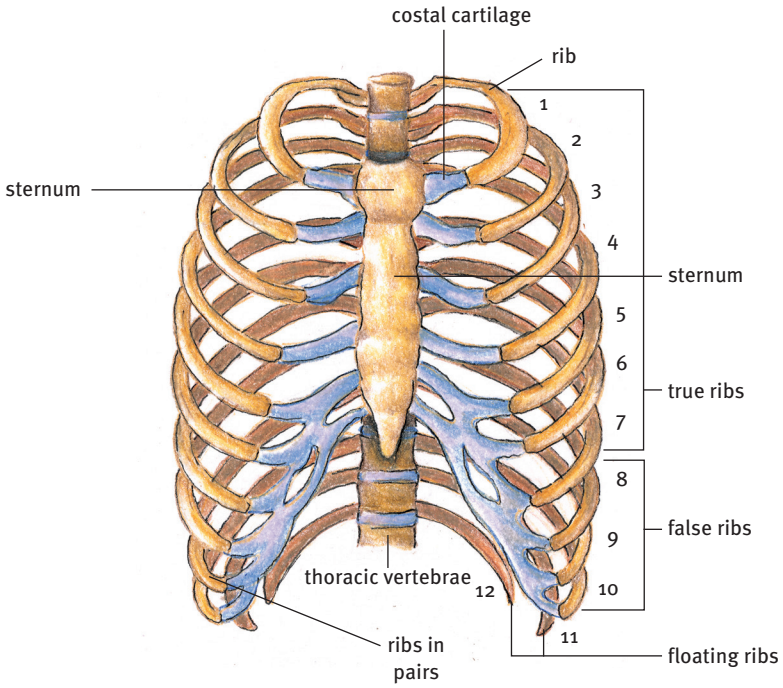


FIGURE 7.4 The human thoracic rib cage

2.2 Appendicular skeleton

- The word 'appendicular' means 'connected to'.
- The appendicular skeleton consists of:
  - the pectoral (shoulder) girdle and the upper limbs (arms)
  - the pelvic (hip) girdle and the lower limbs (legs).
- The bones in the pectoral (shoulder) girdle connect the bones of the arms, the forearms, the wrists and the hands to the axial skeleton.
- The arm bones fit into the glenoid cavity at the shoulder.

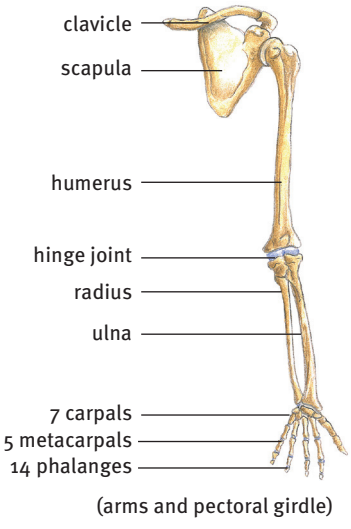
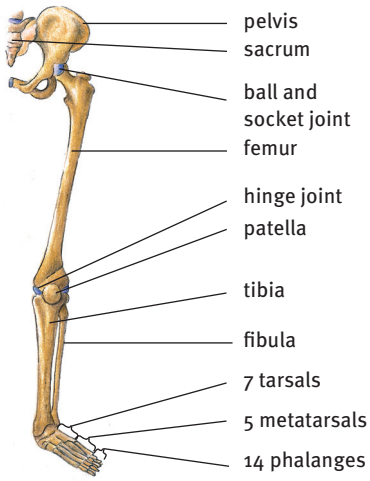


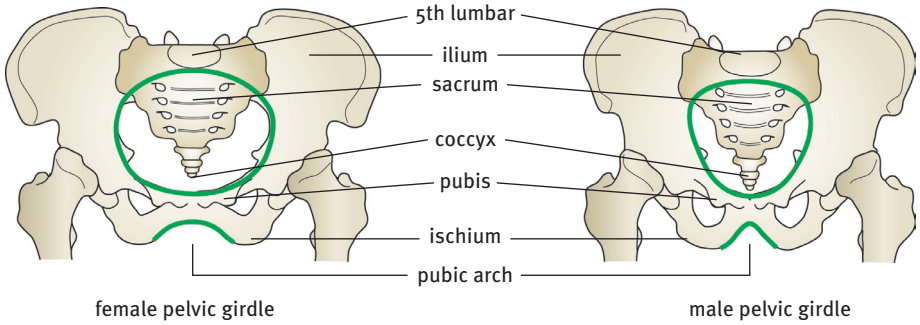
FIGURE 7.5 The pectoral girdle and upper limbs

- The pelvic (hip) girdle connects the bones of the legs, the ankles and the feet to the axial skeleton.
- The leg bones fit into the acetabulum cavity of the pelvis.



(legs and pelvic girdle)

Figure 7.6 The pelvic girdle and lower limbs



female pelvic girdle male pelvic girdle

Figure 7.7 The female and male pelvis

Table 7.2 Differences between the human pectoral and pelvic girdles

Pectoral girdle	Pelvic girdle
• Flexible	• Rigid
• Scapulae are free from vertebral column	• Pelvic bones are attached directly to vertebral column
• Glenoid cavity of scapula is shallow	• Acetabulum cavity of pelvis is deep

3 Functions of the human skeleton

The general functions of the human skeleton are:

- movement and locomotion – joints and leavers with muscles
- protection – vital internal organs: brain, heart, lungs, liver
- support, strength and shape – muscles, internal organs
- storage of minerals – calcium, magnesium and phosphate
- hearing – the three ossicles (smallest bones in inner ear) help hearing
- formation of blood cells – red and white blood corpuscles are formed in bone marrow.

4 Structure of a long bone

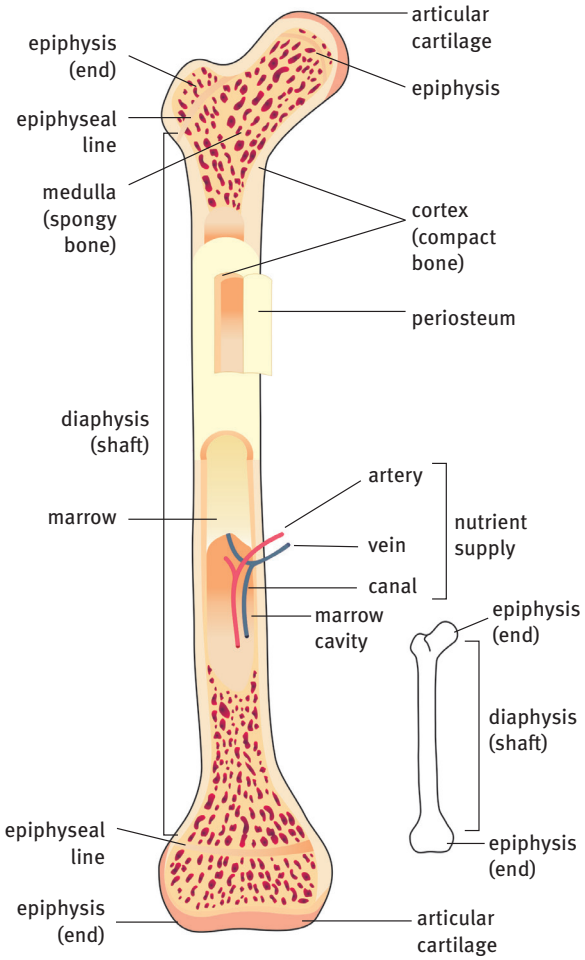


Figure 7.8 Structure of a long bone

5 Relationship between structure and function of tissues in the skeleton

- Bones in the endoskeleton of vertebrates can be thought of as organs because they are a collection of different tissues performing a common function.
- Bone – the most rigid (hard) tissue; makes up the bones in the skeleton; provides support and protection for the body; forms blood cells in the bone marrow; stores mineral salts like calcium
- Blood – a connective tissue made of plasma, red and white blood cells, and platelets; flows in arteries, veins and capillaries; transports dissolved substances
- Striated skeletal muscle tissue – attached to bones by tendons; assists in movement by contraction
- Hyaline cartilage – tough, flexible and elastic tissue; covers the ends of bones in joints, acts as a shock absorber to prevent injury during movement and impact
- Dense fibrous connective tissue – strong and flexible; white fibrous connective tissue: found in tendons (binds muscles to bones); yellow fibrous connective tissue: found in ligaments (binds bone to bone).

6 Joints

- A joint in the vertebrate skeleton is where two or more bones unite, for example the elbow or knee.
- The function of a joint is to help with movement.
- The amount a joint can move depends on the type of joint and its function.

6.1 Main types of joints found in the human body

- Joints are classified into three groups, according to the amount of movement which they provide:
  - fixed joints (also called immovable joints) – allow no movement, e.g. the sutures of the skull
  - partly moveable joints – allow little movement, e.g. between vertebrae of the vertebral column
  - freely moveable joints, also called synovial joints – allow free movement.
- Fibrous joints hold the teeth in the jaw sockets.

6.1.1 What is the structure of a synovial joint?

- Synovial joints prevent the bones from rubbing against each other. The ends of the bones are covered with cartilage and the whole joint is lubricated with synovial fluid. This reduces friction.
- There are four main kinds of movable joint:
  - ball-and-socket joints – in shoulders and hips
  - hinge joints – in the elbows, knees, knuckles and toes
  - pivot joints – between the bottom of the skull and the atlas
  - gliding joints – in the wrists and ankles bones.

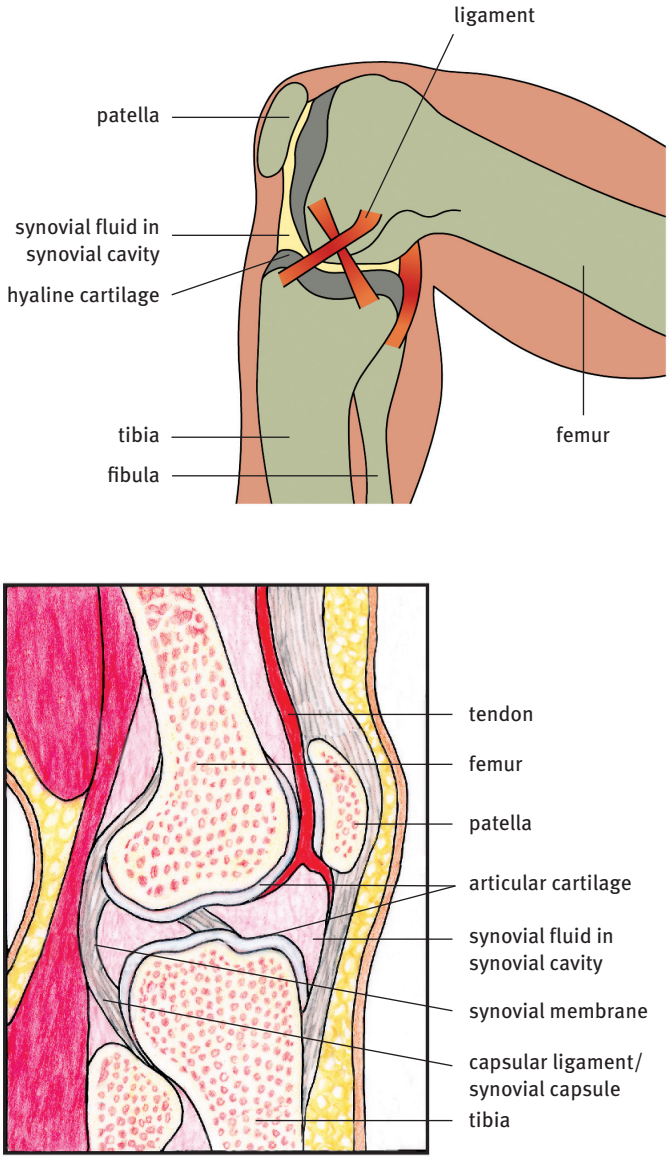


FIGURE 7.9 Structure of the synovial joint

7 Roles of bones and tissues in locomotion

7.1 Role of bones

- Bones:
  - provide structure and strength
  - transmit force and/or motion from one part of the body to another.
- Bones need to have great resistance to prevent them becoming deformed when they carry heavy loads.

7.2 Role of joints

- Joints:
  - connect the bones of the skeleton and make it stable and mobile
  - prevent the bones from disconnecting.
- Most joints allow for motion.

7.3 Role of ligaments

- Bones are connected by ligaments, which gives them extra stability and strength.
- Ligaments connect the bones and the joint capsule.

7.4 Role of tendons

- Tendons join muscles to bones.
- Tendons improve how the muscles perform in a range of movements.
- In movement that needs little mechanical power (e.g. steady-speed running) tendons reduce the work performed by the muscles. This is because they store and release mechanical energy regularly during movement.
- The stretch and recoil of tendons also allows muscles to operate equally and develop strong forces.

7.5 Role of antagonistic muscles

The biceps and triceps of the arm work in opposite directions and are therefore known as antagonistic muscles.

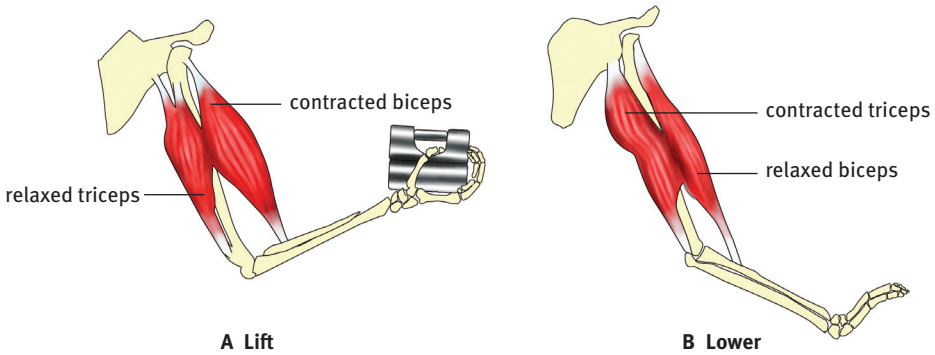


FIGURE 7.10 Function of antagonistic muscles

7.6 Role of cartilage

- Cartilage allows bones to move easily against each other.
- Cartilage also forms a joint capsule which encloses the ends of the bones and so connects and protects them.

8 Structure and function of voluntary muscles

- Movement such as running, lifting your arm, and sitting are controlled by voluntary skeletal muscles.
- Muscle cell bundles are enclosed by connective tissue, which in turn is covered with an outer sheath.
- Inside the muscle cell bundles there are muscle fibres.
- Each fibre consists of light and dark bands which make it looked striped.
- Muscle fibre cells contain a cytoplasm (sarcoplasm), many nuclei and mitochondria to provide the energy when the muscle contracts.
- Each muscle fibre is itself made up of tiny fibres called myofibrils.
- During movement these myofibrils contract, and so make the fibre shorter.
- This means the muscle also shortens – that is, contracts.

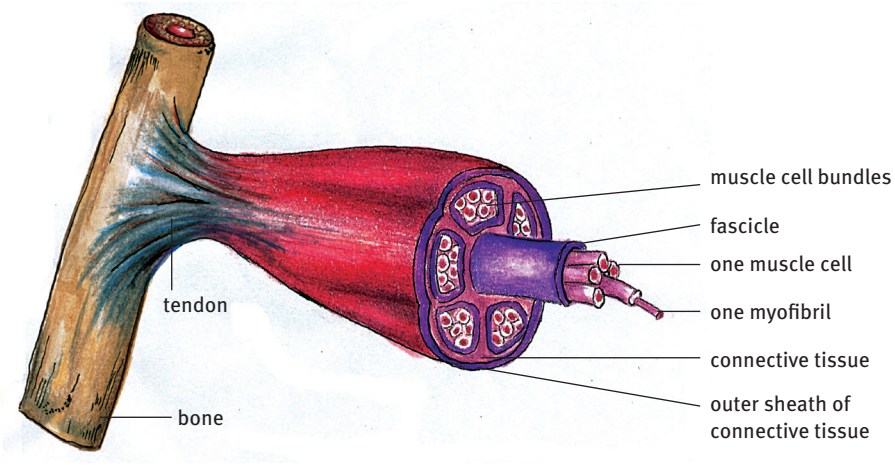


Figure 7.11 Structure of skeletal muscle

9 Diseases that affect the skeleton

- Genetic factors and the effects of gravity on Earth are the natural causes of many natural human disorders of the musculo-skeletal system.
- The system is also affected by the ongoing mechanical work people perform during their lives.
- Other causes of problems are lack of exercise and the process of aging.

9.1 Rickets in children

- The minerals calcium and phosphorus and the vitamins A and C are essential for strong and healthy bones.
- Children who do not get these essential nutrients in their diet can develop a disease called rickets – the leg bones are weak and bend due to the weight of the body.

9.2 Osteoporosis

- Osteoporosis is a disease that causes bone to lose mass and the bone tissue to break down.
- New bone is not being laid down as fast as old bone is wearing out – bones become weaker and weaker, and the sufferer risks breaking bones.
- In younger people osteoporosis is caused by lack of food (starvation), diabetes, lack of vitamin C, and over-activity of the adrenal glands, plus not enough exercise.

9.3 Arthritis

- Arthritis is an illness that can cause pain and swelling in the joints.
- The two most common ones are rheumatoid arthritis and osteoarthritis:
  - osteoarthritis – most common form of arthritis; comes with age and sometimes follows an injury to a joint
  - rheumatoid arthritis – occurs when the body's defence system does not work properly; affects joints, bones (often in the hands and feet), and organs.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 Should a periosteum be distinguished in an animal, this animal will belong to the:

A Vertebrate
B Mollusca
C Arthropoda
D Arachnida. (2)

1.2 Skeletal muscles are:

A without transverse striations and not controlled voluntary
B without transverse striations and controlled voluntary
C transversely striated and under voluntary control
D transversely striated and not under voluntary control. (2)

1.3 If you want bone to be flexible, you must:

A remove the minerals
B heat it
C place it in water
D remove the cartilage. (2)

1.4 A skeletal muscle fibre is:

A spindle-shaped and tapered at the ends
B spindle-shaped with stripes
C long and cylindrical with stripes
D striped and branched. (2)

1.5 Striated muscle fibres contract:

A slowly and relax slowly
B voluntary and automatically
C rapidly and voluntarily
D slowly and voluntarily. (2)

1.6 Which of the following cannot be associated with cartilage?

A sarcolemma
B chondrocytes
C lacuna
D fibrocytes (2)

1.7 Which of the following is not a long bone?

A tibia
B humerus
C femur
D vertebra (2)

1.8 The small fibres found in a skeletal muscle cell are:

A myofibrils
B nerve fibres
C capillaries
D collagen. (2)

1.9 Along which route do the nutrients for bone cells move?

A Lacunae ⇢ Haversian canals ⇢ canaliculi
B Haversian canals ⇢ canaliculi ⇢ lacunae
C Canaliculi ⇢ lacunae ⇢ Haversian canals
D Canaliculi ⇢ lacunae ⇢ Haversian canals (2)

1.10 Nutrients in bone move to the osteoblasts through the:

A perichondrium
B venules
C lamellae
D Haversian canals. (2) [20]

Question 2: True/false

Read each of the statements 2.1 to 2.10 provided below.
Decide if each statement is scientifically correct or incorrect.
If correct, write down the word 'true' next to the question number.
If incorrect, write down the word 'false' next to the question number, and rewrite the sentence to show the change made by underlining the changed text.

2.1 Snails have a hydrostatic skeleton. (2)
2.2 The collar bone is called the sternum. (2)
2.3 Calcium is a vital mineral in the formation of bone. (2)
2.4 Mammals have an exoskeleton for structure, support and protection. (2)
2.5 The biceps and triceps are an antagonistic muscle pair. (2)
2.6 Vertebrae are known as irregular bones. (2)
2.7 Arthritis is a disorder of the joints. (2)
2.8 Muscles are joined to bones by ligaments. (2)
2.9 The shaft of a long bone is the epiphysis. (2)
2.10 Hyaline cartilage covers the ends of bones for easy movement. (2) [20]

Question 3: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

3.1 The type of cartilage covering the articular surface in the thoracic vertebra (1)
3.2 The thin membrane surrounding a muscle fibre (1)
3.3 The microscopic canals found in long bones in which blood vessels and nerves occur (1)
3.4 The type of cartilage joining ribs to the sternum (breastbone) (1)
3.5 Microscopic space/hollow in bone in which bone cells are found (1)
3.6 Striated muscles are an example of this type of muscle (1)
3.7 Muscles under control of the will (1)
3.8 The filament that contracts and relaxes within muscle cells (1) [8]

Question 4: Matching columns

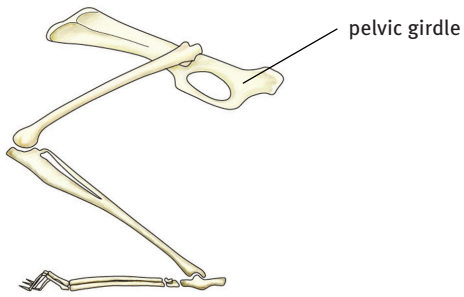
Match the structure in COLUMN I with the function in COLUMN II.
Write only the letter (A–L) next to the question number (4.1–4.11).

Column I		Column II	
4.1	joint	A	Transmits pull of muscle to bone
4.2	synovial fluid	B	Holds bones together at a movable joint
4.3	tendon	C	Covers bone surfaces at a movable joint
4.4	ligament	D	Helps reduce friction in movable joint
4.5	cartilage	E	Contracts to produce movement
4.6	muscle	F	Region of contact between two bones
4.7	gliding joint	G	Between femur and acetabulum
4.8	hinge joint	H	Occurs between the bones of the skull
4.9	pivot joint	I	Between radius and carpals
4.10	ball-and-socket joint	J	Elbow and knee joint
4.11	suture	K	Between carpals and metacarpals
		L	Between the atlas and the axis

[11]

Question 5: Diagrams

5.1 The diagram shows a rabbit's hind leg.



On it, draw muscles which would:

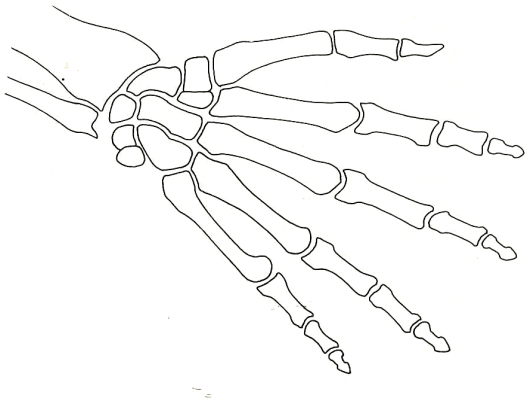
(i) extend the leg at the knee

(ii) flex the foot at the ankle

(iii) flex the leg at the knee.

Label each muscle with the appropriate numeral (i) to (iii). [3]

5.2 The drawing shows the bones of the hand.

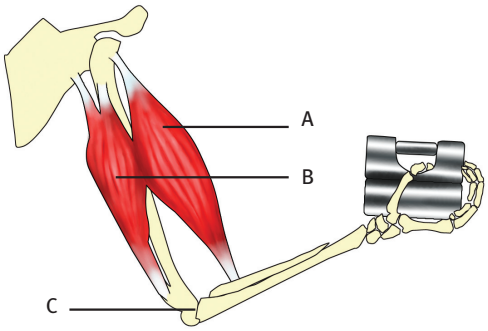


5.2.1 Draw the outline of the fingers, palm and wrist. (1)

5.2.2 Assume that the drawing represents your own hand. By how much has the drawing been reduced? (2)

5.2.3 Where would you expect to find the muscles which flex the fingers? (2) [5]

5.3 Study the diagram and answer the questions.



5.3.1 Write down the names of the bones that are visible. (8)

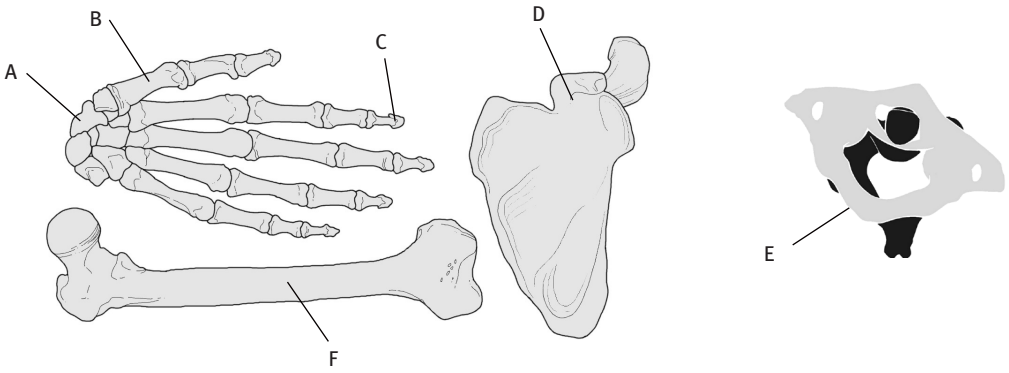
5.3.2 Name the muscles labelled A and B. (2)

5.3.3 Muscles A and B work together causing movement. Explain what happens when each one contracts. (4)

5.3.4 Name the kind of joint found at C and describe its movement. (3) [17]

5.4 Draw and label the knee joint and add the antagonistic muscles that are involved in the movement of the hinge joint. [18]

5.5 Look at the diagram below and classify all the bones in the appropriate column in the table provided. Write only the letters that correspond with each bone into the correct place in the table.



	Flat bones	Long bones	Irregular bones	Short bones
Axial skeleton				
Appendicular skeleton				

[6]

5.6 Study the two diagrams, A and B, provided below.

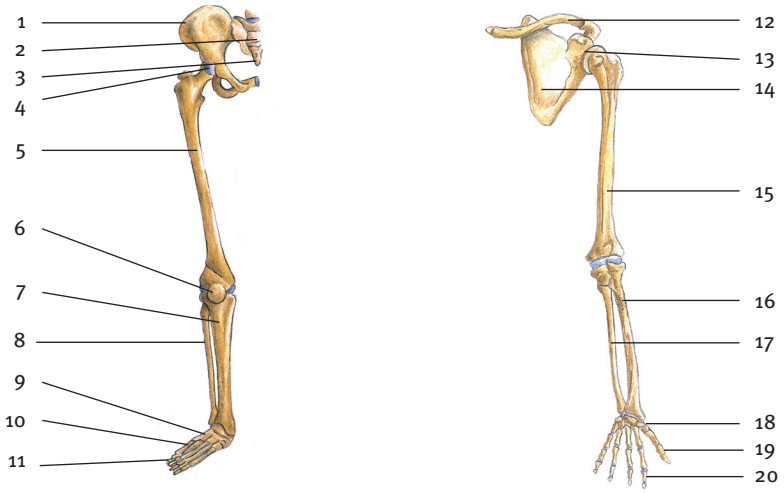


Diagram A Diagram B

5.6.1 Provide headings for both diagrams. (2)

5.6.2 Provide labels for structures 1 to 20. (20) [22]

Question 6: Short response

6.1 Describe two features of the elbow joint that help it to move smoothly. (2)

6.2 People who have broken ribs must be treated very carefully. Why? (2)

6.3 How do animals like the cockroach overcome the disadvantages of their skeleton? (1)

6.4 Tabulate TWO advantages and TWO disadvantages to crabs of having an exoskeleton. (5)

6.5 List the functions of the human skeleton. (6)

6.6 If a baby falls, it is less likely to break the bones of its skeleton than an adult. Why? (2)

6.7 Name THREE common disorders of the musculo-skeletal system. (3) [21]

Question 7: Contextual

Study the diagram below of part of the axial skeleton and answer the questions that follow.

7.1 Provide labels 1 to 5 on the diagram. (10)

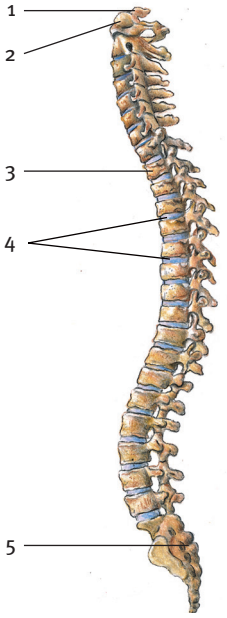
7.2 Name the bone that connects the neck to the skull. (1)

7.3 List THREE functions of the vertebral column. (3)

7.4 What is the function of the atlas and the axis? (2)

7.5 Label 4 is made up mostly of cartilage. List TWO functions of label 4. (2)

7.6 What is a slipped disc? (2) [20]



Question 8: Case study

Read through the following text carefully and answer the questions that follow.
A few answers are not in the text, but it is possible that you may know them.

What is osteoporosis?

Osteoporosis is a condition of porous bones. This is a condition which affects millions of elderly people all over the world. You have all witnessed it: a little old lady bent over at right angles walking with a stick, a grandparent who has fallen and broken a hip (probably the hip broke first which then caused the fall). The tragedy is that there is no cure for it, but it can be prevented with sensible living.

Between puberty and midlife, sex hormones (oestrogen in women and testosterone in men) maintain bone tissue by stimulating osteoblasts to form new bone. After menopause both men and women produce smaller amounts of these hormones. As a result, the osteoblasts become less active, so less bone mass is formed. Bones become more porous and lighter, which results in bones fracturing very easily.

Although osteoporosis affects the whole skeleton, the spongy bone of the spine is affected the most. Osteoporosis is responsible for loss of height (due to shrinking of the backbone), hunched backs, bone fractures, and severe pain.

Although most common in women over the age of 50, others at risk include ballet dancers, anorexic females (adipose tissue [fat] is needed to make oestrogen), teenagers on junk-food diets, those who overdo exercise (marathon runners), smokers (this decreases blood levels of oestrogen), nursing mothers, those with a family history of osteoporosis, and those exposed to a long treatment of cortisone.

There is no cure as such for osteoporosis as it is very difficult to reverse poor bone density. The most important aspect of treatment is prevention. Plenty of weight-bearing exercise, such as walking, jogging, tennis, etc. throughout life, increases bone mass above normal values.

Adequate diet and exercise are the best ways of preventing the disease. In post-menopausal women, hormone replacement therapy (HRT) helps prevent the onset of osteoporosis. A drug called etidronate suppresses the functioning of osteoclasts and is being used to treat osteoporosis of the spine.

Adapted from the following sources:
Osteoporosis - http://www.emedicinehealth.com
Etidronate review - http://www.medicalook.com
The Role of Hormone Therapy in the Prevention and Treatment of Osteoporosis - http://www.manbir-online.com

8.1 What does the word 'osteoporosis' mean? (1)

8.2 Which bones of the skeleton are most affected? (1)

8.3 Why is this disease most common in women over the age of 50? (2)

8.4 Why do females such as marathon runners, ballet dancers and anorexics have a high risk of osteoporosis? (2)

8.5 Name TWO elements and a vitamin that nursing mothers may lack which could cause them to develop osteoporosis. (3)

8.6 Why do you think HRT prevents osteoporosis in women? (1)

8.7 Besides HRT, name THREE ways to prevent osteoporosis. (3)

8.8 What drug has recently been used to treat osteoporosis in the spine? (1) [14]

Question 9: Essay

Write an essay on bone disorders, their symptoms, cause and their management. Refer to the disorders rickets, arthritis and osteoporosis. [15]

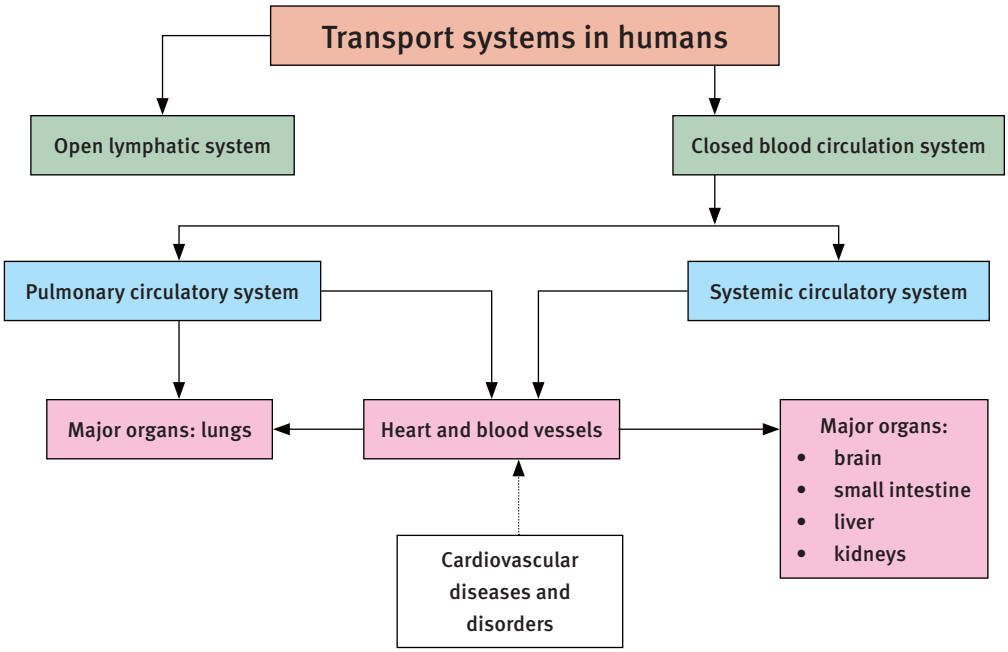
TOTAL MARKS: 200

Topic 8

Transport systems in mammals (humans)

Overview

Mammals are highly energetic. To be able to provide energy to the entire body, quickly, mammals need a well-developed and specialised transport system. It must respond to the changing activities and food and energy needs that support active organisms – like us humans.



1 Circulatory systems in animals

1.1 Open circulatory system

- Blood vessels lead into a cavity, which leads into a network of interior channels and spaces.
- Blood moves freely inside the body cavity in all directions.
- Arthropods are a group of animals consisting mostly of insects that have an open circulatory system.

1.2 Closed circulatory system

- Blood vessels lead from one type of vessel to another, not into a body cavity.
- Blood flows in one direction, continuously.
- Vertebrates have a closed circulatory system.

Table 8.1 Comparison of open and closed circulatory systems

	Open system	Closed system
Organisms	Invertebrates: crabs, spiders and insects	Vertebrates
Location of blood	Body fluid and blood freely fills the body cavity	Blood is contained in the arteries and veins
Efficiency of blood flow	Slow and limited	Fast and good

2 Transport systems in humans

Two types of transport system found in humans are:

- the cardiovascular circulatory system – closed circulatory system
- the lymphatic system – open circulatory system that works with the closed cardiovascular system.

2.1 Cardiovascular circulatory systems

Cardiovascular circulatory systems in vertebrates show a single or double circulation pathway.

2.1.1 Single circulation pathways

- A fish has a venous heart, which means it receives only deoxygenated (oxygen-poor) blood.
- The heart pumps the blood to the gills to get oxygen and from there the blood is pumped to the rest of the body.
- The blood passes only once through the heart, so we say that fish have a single circulation.

2.1.2 Double circulation pathways

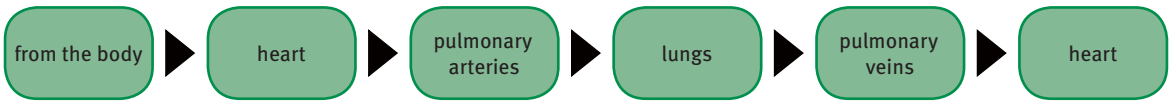
- Amphibians, some reptiles, birds and mammals have an arteriovenous heart, which means it has arteries and veins.
- Arteries carry oxygenated blood and veins carry deoxygenated blood.
- Both are connected to the heart.
- The blood goes twice to the heart and is pumped out twice, which is why it is called a double circulation pathway.
- The first time it is pumped to the lungs (pulmonary circulation) and the second time to the rest of the body (systemic circulation).

2.2 The human blood circulatory system

The heart, the lungs, and the blood vessels work together to make up the circulatory system.

2.2.1 Pulmonary circulation

- Pulmonary circulation is between the heart and lungs.
- It carries mainly deoxygenated blood to the lungs and returns oxygenated blood to heart. The pathway that the blood flows along is:



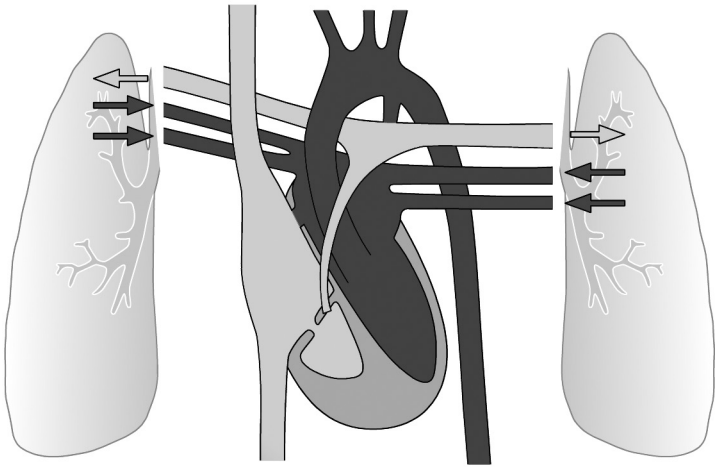
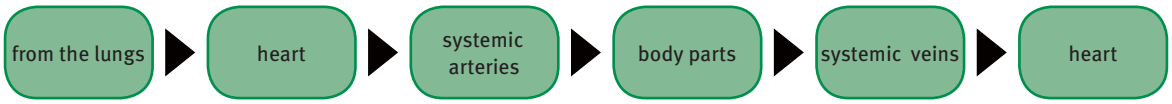


FIGURE 8.1 Pulmonary circulation

2.2.2 Systemic circulation

- Systemic circulation happens between the heart and the entire body (excluding the lungs).
- It carries oxygenated blood to all the parts of the body and returns deoxygenated blood to the heart.
- Blood vessels are named after the organs they serve:
  - pulmonary = lungs
  - cardiac = heart
  - hepatic = liver
  - gastric = stomach
  - renal = kidney
  - mesenteric = intestine.
- The pathway that the blood follows is:



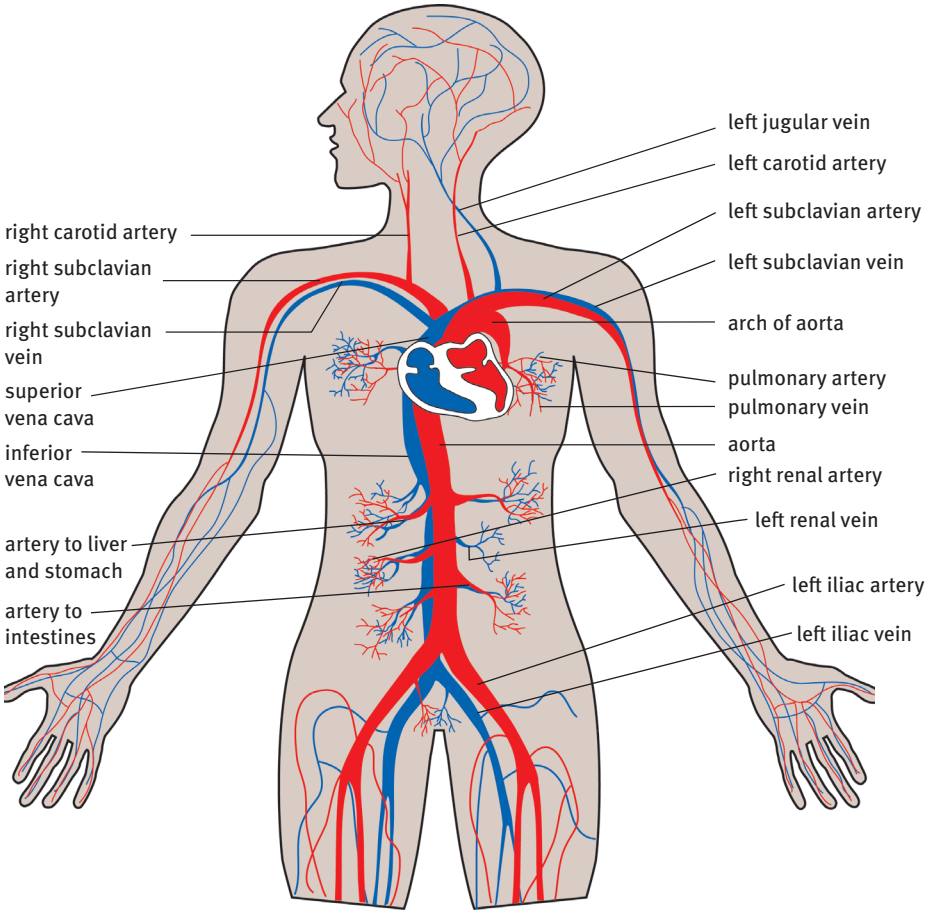


FIGURE 8.2 Systemic circulation: the main blood vessels

3 The heart

The heart is found in the thorax, directly behind the sternum and between the lungs.

3.1 External structure of the heart

The heart:

- has an apex which points to the left
- is covered by a double epithelium lining called the pericardium; the space between the two layers is filled with a fluid called the pericardial fluid, which prevents friction and allows space for movement as the heart beats
- is held in position by the large blood vessels that enter and leave its broader side.

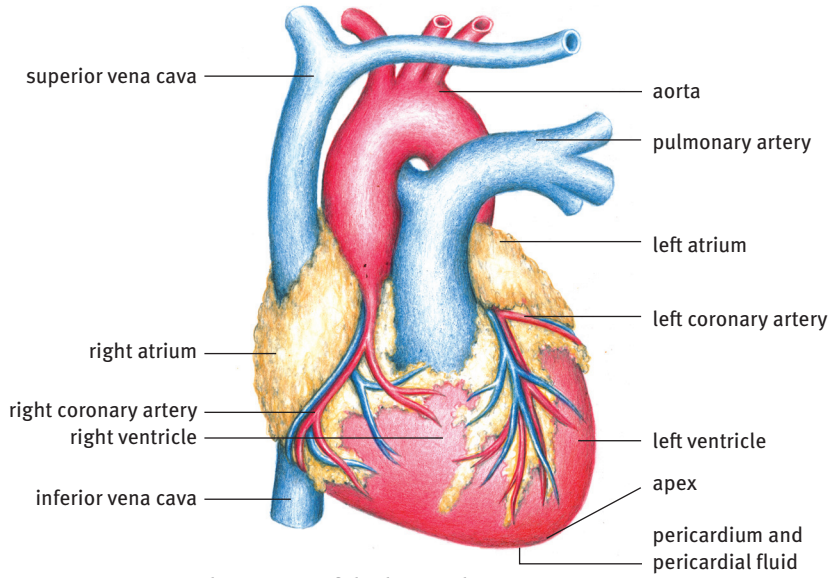


Figure 8.3 External structure of the human heart

3.2 Internal structure of the heart

- The heart:
  - is hollow with muscular walls made of striated cardiac muscle
  - is lined with a single epithelium layer called the endocardium
  - has four cavities called chambers: the upper chambers are the right and left atria (singular: atrium), and the lower chambers are the right and left ventricles; the atria are smaller and less muscular than the ventricles.
- Valves separate each atrium from the ventricle below it; blood flows only from an atrium to a ventricle; thin ligaments are attached to the valves and the ventricle walls.
- Valves are found where the blood vessels attach to the heart.

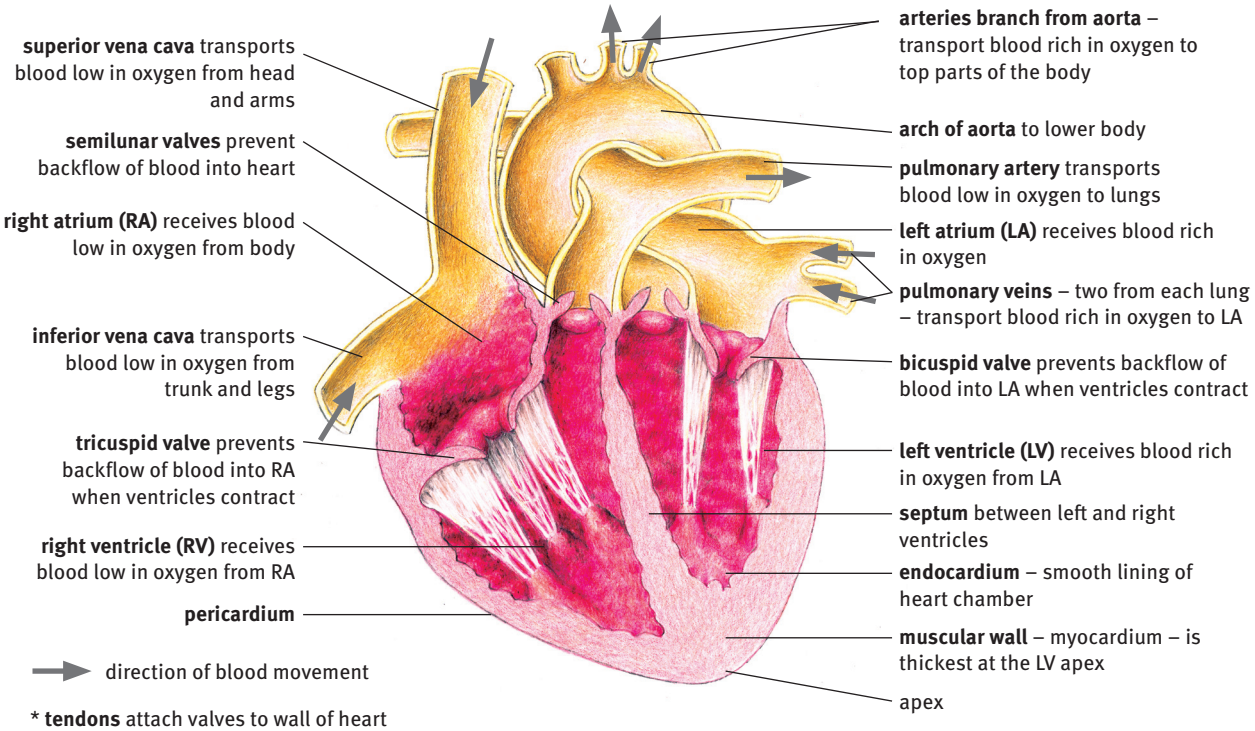


Figure 8.4 Internal structure of the human heart

4 The cardiac cycle

- The cardiac cycle moves blood through the heart.
- The heart distributes blood to all parts of the body through two sets of muscular actions, called contractions.
- The cardiac cycle involves:
  - systole – contraction of the heart muscle
  - diastole – relaxation of the heart muscle.
- The heart beats twice:
  - atrial systole forces blood through the heart into the ventricles
  - ventricle systole forces blood out of the heart.

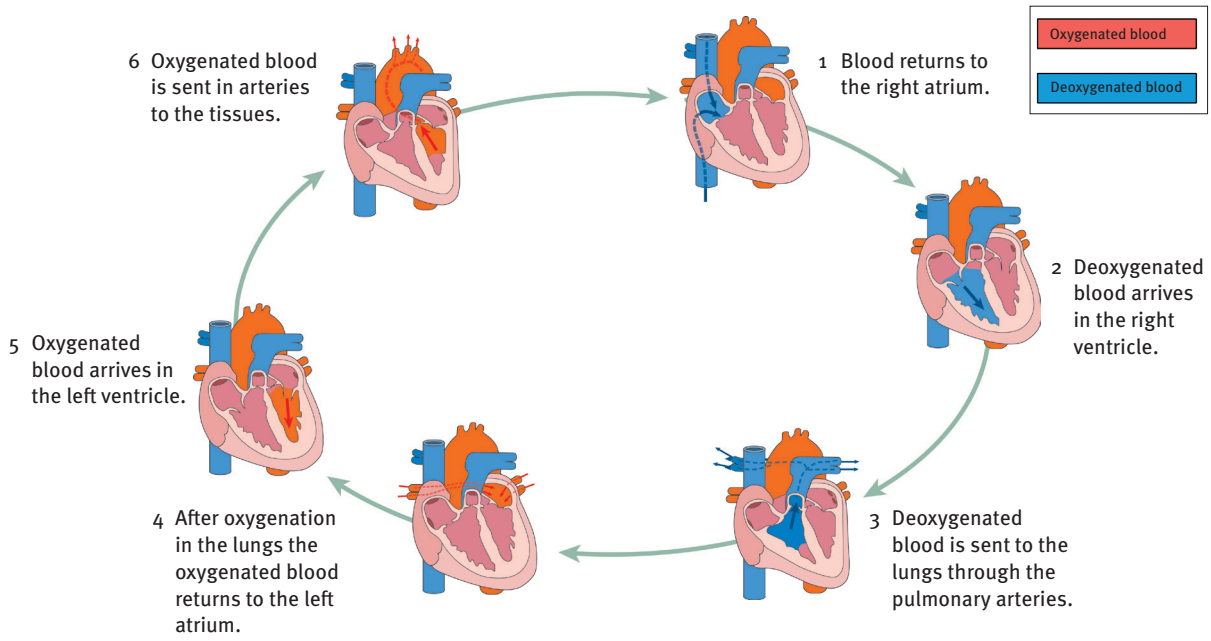


FIGURE 8.5 The cardiac cycle

4.1 Control of the heart beat

- Many factors affect heart beat and circulation. Some of these are temperature, oxygen supply and nervous excitement.
- The stimulus that keeps the heart beat going is the sino-atrial (SA) node – a pacemaker found in the wall of the right atrium.

During the atrial systole (0,1 seconds long):

- the sino-atrial node sends an electrical impulse to the muscle of the left and right atria
- the two atria contract together
- the tricuspid and bicuspid valves open
- blood flows into the two ventricles.

During the ventricular systole (0,3 seconds long):

- electrical signals go through the muscles of the atria to the atrio-ventricular (AV) node
- this signal goes through the atrio-ventricular bundle to the ventricles
- the two ventricles contract together
- blood is forced into the aorta and the pulmonary arteries
- the tricuspid and bicuspid valves close.

During general diastole (0,4 seconds long):

- both the atria and ventricles relax
- the semilunar valves at the base of the aorta and pulmonary artery close, preventing backflow of blood
- blood moves into the atria from the superior and inferior vena cava and the pulmonary veins.

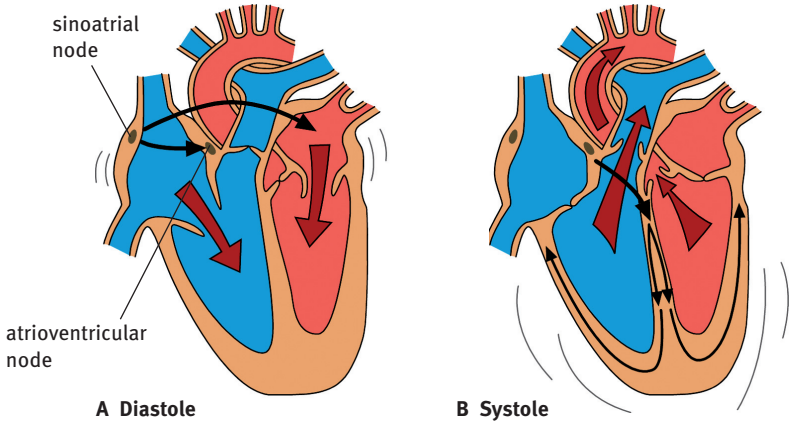


FIGURE 8.6 Control of the heart beat

4.2 Exercise and heart beat

Strong exercise accelerates heart beat in two ways.

- As cellular respiration increases:
  - the level of carbon dioxide in the blood increases
  - receptors in the carotid arteries and aorta are stimulated
  - impulses are transmitted to the medulla
  - the accelerans nerve sends them to the heart
  - heart beat is increased.
- As muscular activity increases:
  - muscle movement drives more blood to the right atrium, which stretches
  - stretch receptors in its wall are stimulated
  - impulses are sent to the medulla
  - the accelerans nerve sends them to the heart
  - heart beat is increased to cope with the extra volume.

5 Blood vessels

5.1 Structure and functions of the different blood vessels

- Arteries:
  - have walls that are three layers thick: one cell layer of squamous epithelium, thick layer of smooth muscle to withstand pressure, surrounded by connective tissue allowing them to stretch
  - move blood away from the heart
  - connect to smaller arteries called arterioles
  - have blood under high pressure being pumped by the heart.

  Arteries that lie close to the skin are called pulse points.

- Veins:
  - have walls that are three layers thick: one cell layer of squamous epithelium, thin layer of smooth muscle, surrounded by connective tissue allowing them to stretch
  - move blood to the heart
  - have semilunar valves (one-way valves), which keeps the blood moving towards the heart and prevents backflow under gravity
  - connect to smaller veins are called venules
  - have blood under very low pressure that flows against gravity.

- Capillaries:
  - are microscopic blood vessels that connect arteries and veins
  - form branching networks that make a big surface area for diffusion
  - have walls that are only one cell layer thick – made of squamous epithelium
  - interchange nutrients, gases and waste.

5.2 Different blood vessel walls

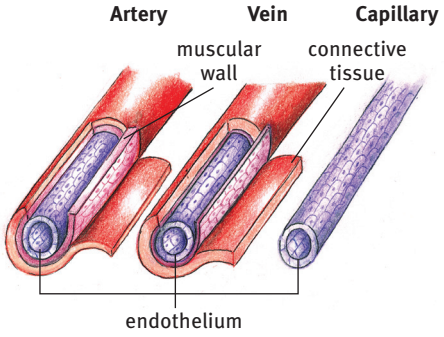


Figure 8.7 Structure of blood vessels

5.3 Blood

Blood is a fluid connective tissue. It consists of a blood plasma which contains red blood cells (erythrocytes), white blood cells (leucocytes), and platelets.

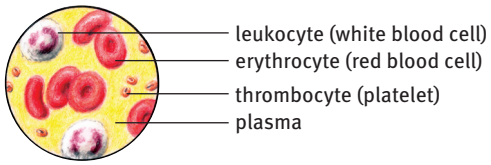


FIGURE 8.8 Composition of human blood

6 The lymphatic system

- The lymphatic system links closely to the cardiovascular system.
- It is a network of organs, lymph nodes, ducts and vessels that produce and transport lymph.
- It helps to circulate tissue fluid from the body tissues and blood capillaries and return it to the bloodstream.
- It is important to the immune system.

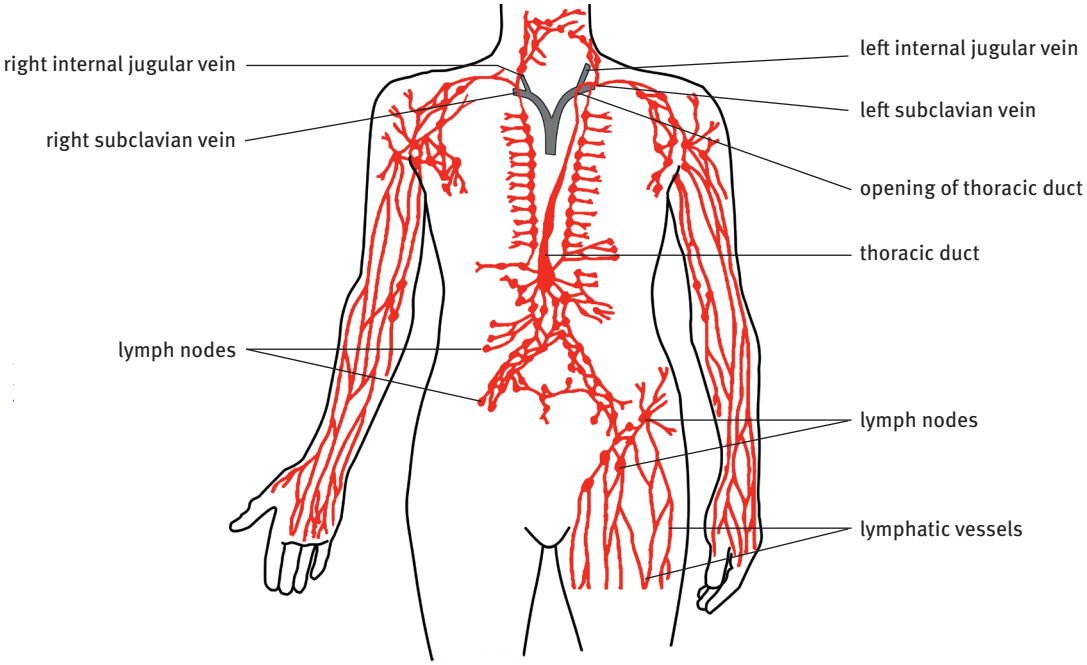
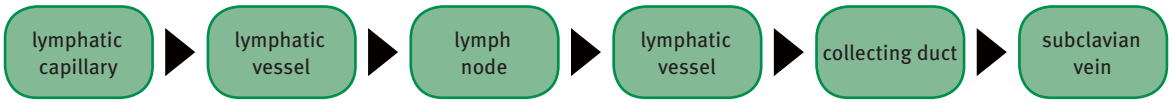


FIGURE 8.9 The human lymphatic system

6.1 Lymph vessels

- Lymph capillaries are found between the tissue cells of all organs, except the nervous system.
- They join to form bigger lymphatic vessels.
- Tissue fluid enters the vessels and is known as lymph.
- Lymph vessels and capillaries form an open circulatory system that has blind endings among the tissues.
- The walls of the lymphatic vessels have the same three layers as the walls of blood vessels, but they are much thinner and almost transparent.
- They have more semilunar valves than veins.

- The two main lymphatic vessels are the:
  - thoracic duct – largest vessel; receives lymph from lower body regions, left arm, and left side of head and neck; empties lymph into left subclavian vein; lymph then becomes part of blood plasma
  - right lymphatic duct – receives lymph from right side of head and neck, right arm, and right thorax; empties lymph into right subclavian vein where it becomes part of blood plasma.
- The typical lymph pathway is:



6.2 Functions of the lymphatic system

The lymphatic system has the following main functions:

- transporting nutrients – carries minerals, proteins, fatty acids and fats from the intestines to various parts of the body
- transporting wastes – collects wastes produced by various cells in the body and sends them into the bloodstream
- manufacturing immune system cells – produces most white blood corpuscles and lymphocytes, which are a core component of the immune system
- drainage – drains excess tissue fluid, undigested food, infectious material, dead cells and other remains
- detoxification – removes bacteria and toxins.

6.3 Blood plasma

- Blood in the capillaries is under great pressure.
- Some of the blood plasma is forced out of the capillaries into the body tissues and surrounds the cells.

6.4 Tissue fluid

- The spaces between body cells are filled with tissue fluid, which is the blood plasma forced out of the capillaries.
- Useful nutrients move from the blood plasma into the tissue fluid and then into the cells.
- Waste materials move out of the cells into the tissue fluid and into the blood plasma.
- Most of the tissue fluid re-enters the blood capillaries but some of it enters lymph ducts of the lymphatic system and becomes lymph.

6.5 Lymph

- The composition of lymph is similar to blood plasma as lymph comes from blood plasma.

- Lymph has:
  - a lower concentration of protein compared to blood plasma
  - similar amounts of inorganic material as blood plasma and tissue fluid
  - smaller amounts of nutrients, except in the digestive system, where the concentrations of fats and glucose are higher.
- Lymph contains a type of white blood cell called a lymphocyte.

6.6 Relationship between blood and lymphatic systems

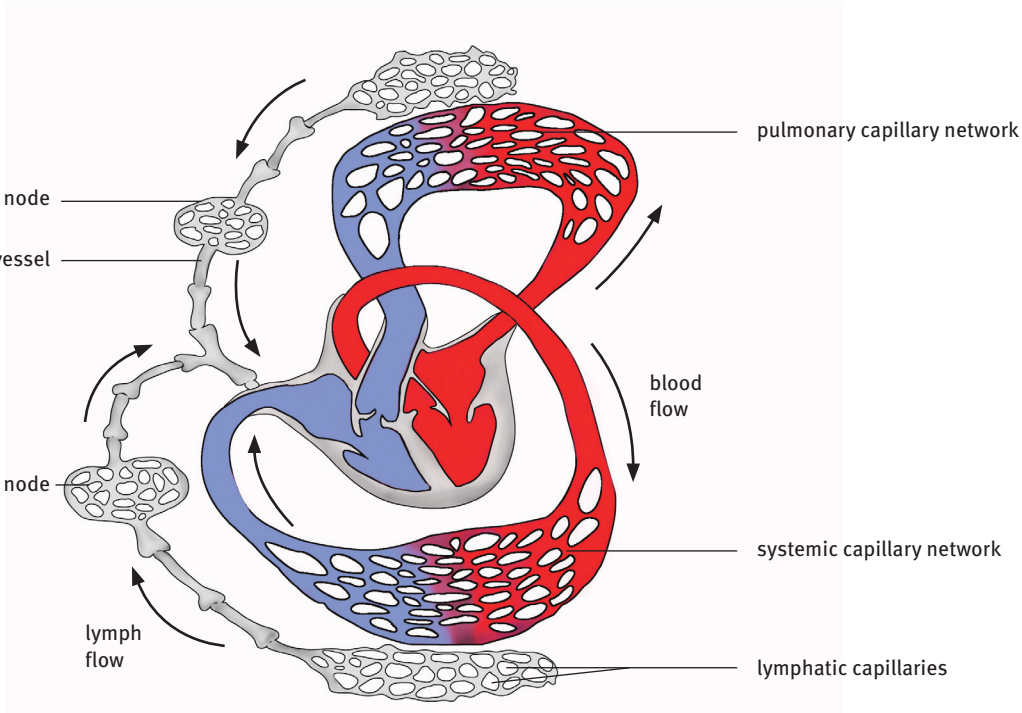


FIGURE 8.10 Relationship between the cardiovascular system and the lymphatic system

Table 8.2 Comparison of the cardiovascular system and the lymphatic system

	Closed cardiovascular system: blood	Open lymphatic circulatory system: lymph
Function	Collecting and distributing oxygen, nutrients and hormones to tissues of entire body	Collecting and removing waste products left in tissues
Pathway	Flows in a closed circuit in a continuous direction throughout the body via arteries, capillaries, veins	Flows in an open circuit from tissues into lymphatic vessels; when in vessels, flows in only one direction
Movement	Pumped by the heart into arteries that carry it to the rest of the body; veins return blood from all parts to the heart	Not pumped; just flows from tissues into lymph capillaries; lymphatic vessel flow is helped by body movements such as deep breathing, action of nearby muscles and blood vessels
Vessels	Arteries, veins and capillaries	Lymph ducts (veins) and capillaries
Fluid	Liquid plasma that transports red and white blood cells and platelets	Filtered lymph ready to return to the cardiovascular system: clear or milky white fluid like blood plasma Unfiltered lymph: plasma, tissue fluid, red and white (lymphocytes) blood cells and chyle (proteins and lipids)

Table 8.2 Comparison of the cardiovascular system and the lymphatic system		
	Closed cardiovascular system: blood	**Open lymphatic circulatory system: lymph**
Damage	Blood is visible, and damage to blood vessels has signs such as bleeding or bruising	Lymph is invisible, and damage to the lymphatic system is difficult to detect until there is swelling
Filtration	All blood flows through the kidneys which remove waste products and excess fluids; needed fluids returned to cardiovascular circulation system	Filtered by lymph nodes throughout the body; remove some fluid and debris, kill pathogens and some cancer cells

7 Cardiovascular diseases and disorders

- Diseases that affect the cardiovascular system can be serious and are a major cause of death. Some are genetic, but often they are due to an unhealthy lifestyle: smoking, eating too much fried, fatty food, being overweight, doing little exercise, plus having high blood pressure and high cholesterol. These last two are also made worse by an unhealthy lifestyle.
- Anaemia: a person has too few red blood cells due to a lack of iron. The haemoglobin level is low and the person is pale and has no energy.
- Leukaemia: a cancer that causes uncontrolled production of some leucocytes. These cells gather in bone marrow, crowding out normal white blood cells, red blood cells and platelets.
- High and low blood pressure: Hypertension is high blood pressure, caused by salt and water being held in tissues. The heart has to work harder and there is increased pressure on the walls of blood vessels. This greatly increases the risk of stroke, heart attack and kidney disease. Obesity increases the risk. Hypotension is low blood pressure. If the pressure drops too much, the person feels dizzy or faints. However, hypotension is often linked to a long life and an old age free of illness.
- Angina, atherosclerosis and strokes: Angina is chest pain caused when too little blood and oxygen gets to the heart muscle, due to a block or spasm of the coronary arteries. It is caused by atherosclerosis of the cardiac arteries. This can lead to a heart attack or a brain-damaging stroke if a clot blocks a blood vessel to the brain.
- Heart attack: When the blood supply to part of the heart muscle (myocardium) is greatly reduced or stopped, the person suffers myocardial infarction. A blood clot or fatty deposit blocks part of a coronary artery. A person can recover if the heart muscle is undamaged and can still pump enough blood to supply the rest of the heart and body.

7.1 Treatment of heart disease

Treatment of heart disease is through non-surgical and surgical procedures.

- Coronary stenting: A catheter with a balloon and mesh tube called a stent is pushed into a blocked vessel. The balloon is blown up to open the vessel, and expand the stent, which stops the vessel narrowing again.
- Heart valve replacement and pacemaker: Damaged valves are replaced with artificial or transplanted valves in open-heart surgery. An artificial pacemaker can be put in

when the body's natural pacemaker – the sino-atrial (SA) node – no longer works properly. It keeps the normal heart beat by sending electrical impulses to the heart.

- Coronary artery bypass graft (CABG) surgery: This restores blood flow to the heart if there are many blockages in several arteries. Vessels from another part of the body are used. The patient's heart is stopped so a heart-lung machine takes over the function of those organs during the operation.
- Heart transplant: This risky operation – pioneered in South Africa – is when an unhealthy heart is cut out and replaced with a healthy heart donated by someone who has died (an organ donor). A transplant is only performed when all other treatments have been tried.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 After a period of vigorous activity you would expect blood leaving a muscle to have:

A less carbon dioxide, less oxygen and less glucose
B more carbon dioxide, more oxygen and less glucose
C more carbon dioxide, more oxygen and more glucose
D more carbon dioxide, less oxygen and less glucose. (2)

1.2 Blood from the digestive tract (alimentary canal) returns to the heart by way of:

A hepatic vein and vena cava
B hepatic artery, hepatic vein and vena cava
C hepatic portal vein and vena cava
D hepatic portal vein, hepatic vein and vena cava. (2)

1.3 The substances produced by lymphocytes to combat bacterial cells are called:

A antigens
B antibodies
C antidotes
D antitoxins. (2)

1.4 A pacemaker inserted into the heart during an operation performs the function of the:

A atrio-ventricular node
B septum
C sino-atrial node
D bicuspid and tricuspid valves. (2)

1.5 You may acquire natural, active immunity to a disease if you:

A are injected with an antibody to the disease
B recover from an attack of the disease
C are inoculated against the disease
D are born with antibodies to the disease. (2)

1.6 Oxygen moves into the tissues as the blood is flowing through the:

A capillaries
B arteries
C veins
D arteries and veins. (2)

1.7 Which row in the table below shows correctly the change in concentrations of oxygen and carbon dioxide in the blood as it passes through the lungs?

	Concentration in blood	
	Oxygen	**Carbon dioxide**
A	increases	decreases
B	increases	increases
C	decreases	decreases
D	decreases	increases

(2)

1.8 The blood groups of 200 students are shown in the table below.

Blood group	Number of students
O	94
A	84
B	16
AB	6

What percentage of the students have blood group A?

A 42%
B 45%
C 84%
D 90% (2)

1.9 Which row in the table below describes correctly a health problem linked to blood pressure?

	Health problem	Blood pressure
A	angina	low
B	heart attack	low
C	fainting	high
D	stroke	high

(2) [18]

Question 2: True/false

Read each of the statements 2.1 to 2.5 provided below.
Decide if each statement is scientifically correct or incorrect.
If correct, write down the word 'true' next to the question number.
If incorrect, write down the word 'false' next to the question number, and rewrite the sentence to show the change made by underlining the changed text.

2.1 The chamber of the heart that collects blood from the lungs is the left atrium. (2)

2.2 The movement of blood through the heart is known as the cardiac cycle. (2)

2.3 Atrial systole is the contraction of the ventricles. (2)

2.4 Pulmonary arteries carry oxygenated blood. (2)

2.5 The pacemaker is known as the atrio-ventricular node. (2) [10]

Question 3: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

3.1 The blood vessels that carry oxygenated blood from the lungs to the heart (1)

3.2 The large vein that carries deoxygenated blood from the head to the heart (1)

3.3 The type of muscle tissue found in the walls of arteries and veins (1)

3.4 The lining that surrounds the heart (1)

3.5 The fluid component of blood (1)

3.6 The fluid found bathing cells (1)

3.7 The major lymph vessel in the human body (1)

3.8 The semilunar structures found in veins (1)

3.9 The valve between the right atrium and right ventricle (1)

3.10 The circulatory system that starts in capillaries and ends in capillaries and carries blood in a single direction (1) [10]

Question 4: Matching columns

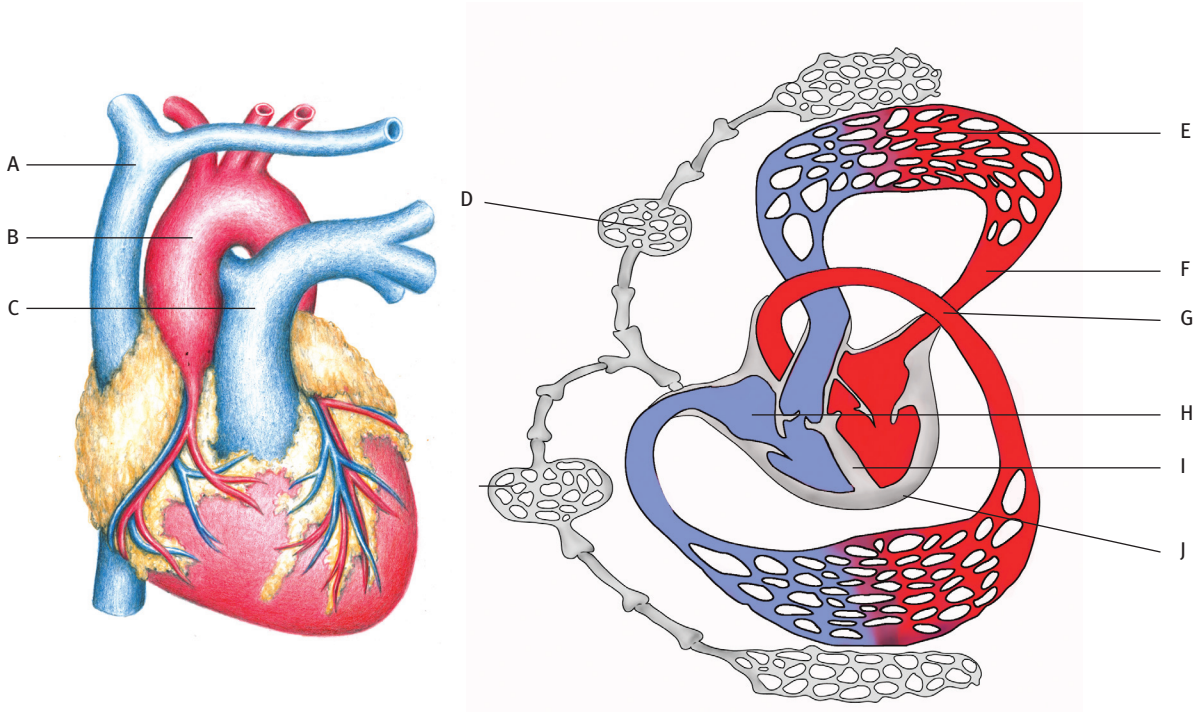
Match the description in COLUMN I with the term in COLUMN II.
Write only the letter (A–L) next to the question number (4.1–4.10).

Column I		Column II	
4.1	Point of the heart	A	lymph
4.2	Fluid found in the thoracic duct	B	diastole
4.3	Relaxation of the heart muscle	C	apex
4.4	Muscle making up the heart	D	accelerans nerve
4.5	Increased heart beat	E	cardiac
4.6	Narrowest blood vessel	F	capillary
4.7	Epithelial tissue lining blood vessels	G	lymphocytes
4.8	Structures that prevent backflow in veins	H	platelets
4.9	Blood cells found in lymph ducts	I	erythrocytes
4.10	Blood cells that carry oxygen	J	endothelium
		K	smooth
		L	valves

[10]

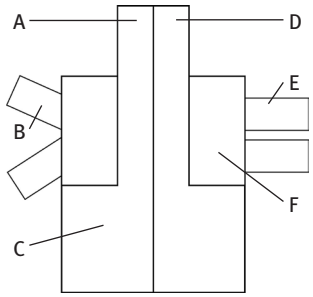
Question 5: Diagrams

5.1 Study the diagrams below and provide labels for the structures A to J.



(10)

5.2 Copy the diagram below. Fill in labels A to G and use arrows to show the direction of blood flow.



(14) [24]

Question 6: Short response

6.1 In each case, give an example of a disease to which immunity can be acquired by injecting:

6.1.1 an activated bacterial toxin (1)

6.1.2 a killed bacterium (1)

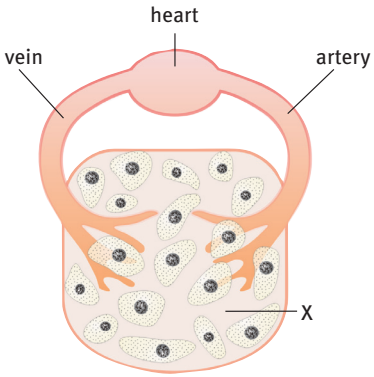
6.1.3 an antibody. (1)

6.2 The table below shows the blood group of a number of students. Calculate the percentage of students with blood group O.

Blood group	Number of students
A	4
B	4
O	11
AB	1

(2)

6.3 The diagram represents part of the circulatory system. Study it and answer the questions that follow.



6.3.1 Name the type of blood vessel labelled X. (1)

6.3.2 Place arrows on the diagram to show the direction of blood flow in the artery and the vein. (2)

6.3.3 What is the function of the heart? (1) [9]

Question 7: Tables

7.1 Tabulate a comparison of a closed cardiovascular system and an open lymphatic system in humans. Compare structure, function and movement of fluids. (10)

7.2 Compare the structure of arteries, veins and capillaries in a table. (16) [26]

Question 8: Data response

8.1 A student, when at rest, measured her heart rate three times using a stethoscope and a stopwatch.

The results are shown in the table.

Measurement	Number of beats in 20 seconds
1	21
2	21
3	24

8.1.1 Calculate the student's:

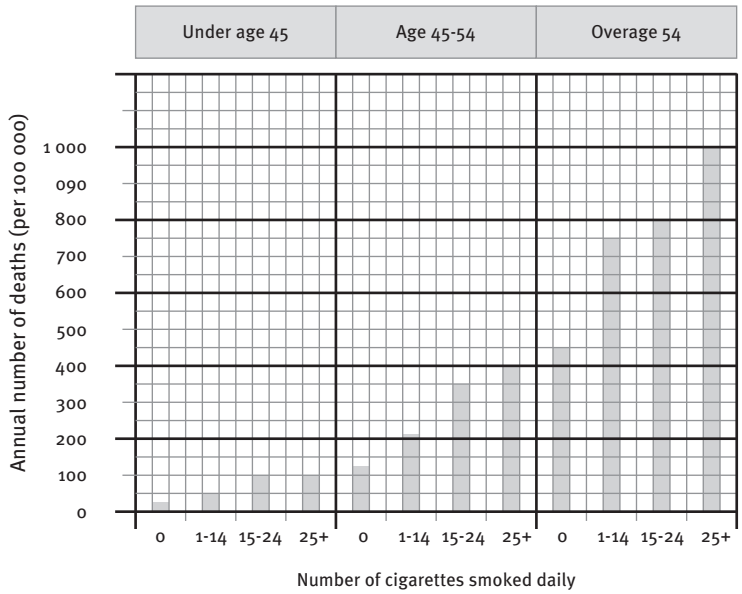
(a) average heart rate in 20 seconds (2)

(b) average heart rate per minute. (2)

8.1.2 What term is used to describe a person's heart rate when the person is inactive or resting? (1)

8.1.3 The student then exercised for 30 minutes. What effect would this have on her heart rate? (1)

8.2 The bar chart shows the relationship between cigarette smoking and annual deaths from heart disease in males.



8.2.1 State the aim of the investigation. (2)

8.2.2 Identify the independent variable used in the investigation. (2)

8.2.3 Identify the dependent variable used in the investigation. (2)

8.2.4 What is the annual number of deaths (per 100 000) for males aged between 45 and 54 who smoked between 15 and 24 cigarettes per day? (2)

8.2.5 Explain the TWO trends seen in the bar chart. (4) [18]

Question 9: Essay

Describe the cardiac cycle and indicate the role of the nerve stimuli and contraction in each part of the cycle. (maximum 25) [25]

TOTAL MARKS: 150

Strand 3

Environmental studies

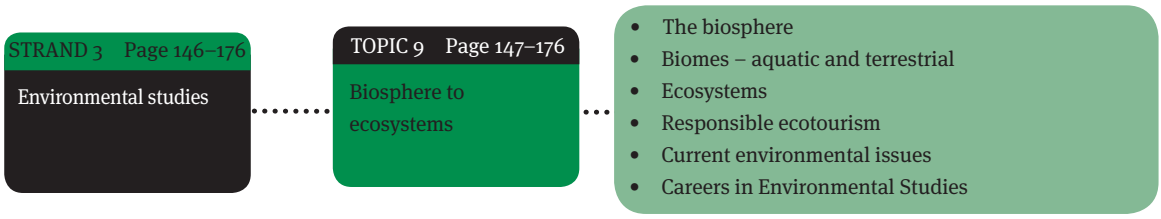
Overview

Environmental Studies is a course of study that focuses on the natural environment. There is a fine balance in nature. Everything is linked to everything else in many ways.

The natural environment provides six main resources: water, air, soil, fossel fuels, plants and animals. All these resources are inter-related. We humans are responsible for managing these resources correctly and for making sure that development is sustainable. This means the need of people living today must be met without harming the ability of future generations to meet their needs.

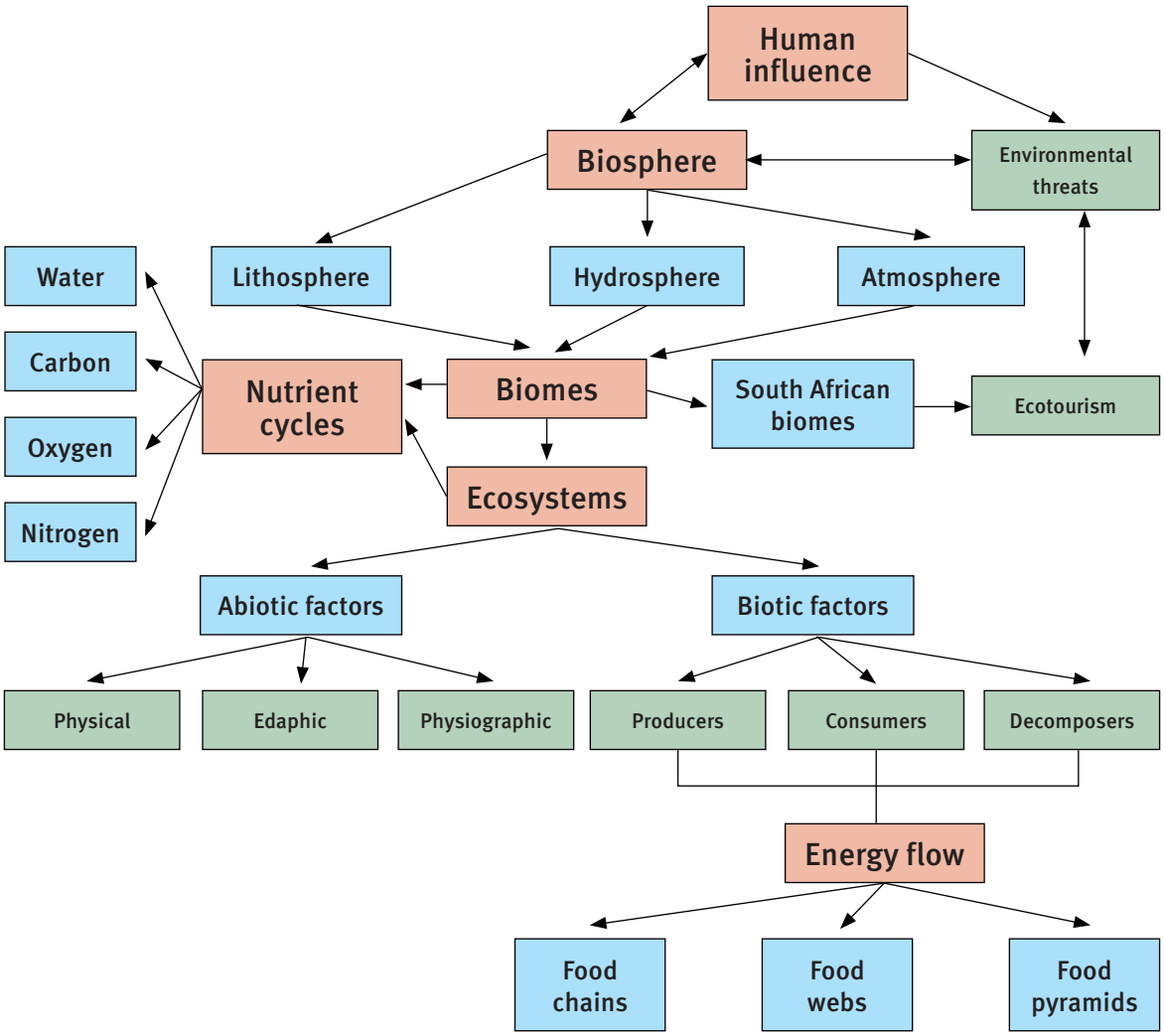
The study of living organisms, their relationship to one another and to the place where they live is called ecology. We need to understand the principles of ecology and how to apply them in our everyday lives so that the balance of nature is not upset.

The topic that you focus on this year is called 'Biosphere to ecosystems'.



Overview

Organisms interact with other organisms and with their environments in which they live, so that they can survive and produce offspring. In this topic you learn about some of the interactions that happen in nature and you learn the words and concepts or ideas that describe them. You also learn about how people have an effect on the environment in which they and other organisms live.



1 The biosphere

The biosphere is the part of the Earth where humans and other organisms are able to live.

1.1 Characteristics of the biosphere

The biosphere consists of the atmosphere, the hydrosphere and the lithosphere.

1.1.1 The atmosphere

- is made up of gases that keep the environment stable
- has the gases oxygen, hydrogen, carbon dioxide, water vapour and nitrogen
- is involved in breathing and cellular respiration, photosynthesis and protection against harmful ultraviolet sun rays.

1.1.2 The hydrosphere

- is the aquatic or water part of the biosphere
- consists of the waters of the oceans (salt water), rivers and lakes (fresh water)
- is the habitat of many aquatic organisms such as fish.

1.1.3 The lithosphere

- is the outside crust of the Earth
- is formed of rocks and soil
- is a source of some of the mineral ions which living organisms need.

1.2 Studying the biosphere

- Biosphere – where life is found on Earth, made up of the atmosphere (air), hydrosphere (water) and the lithosphere (land).
- Biome – a large area with a certain climate and certain species of plants and animals. A biome is made up of smaller areas called ecosystems.
- Ecosystem – different communities of plants and animals interacting with each other and with their physical (non-living) environment.
- Community – a biological community is all the populations of all the different species in a particular place; for example, populations of lions, impala, birds, warthogs, thorn trees and other plants that interact in an area.
- Population – a group of organisms of the same species, living in a specific area at the same time.
- Species – a group of organisms of the same kind, which can breed with one another and produce fertile offspring.
- Niche – the role an organism or species plays where it lives.
- Habitat – a place where an organism lives.
- Organism – a single organism.

2 Biomes – aquatic and terrestrial

- The biosphere is divided into many biomes.
- Biomes can be divided into aquatic (water) and terrestrial (land) types.
- Aquatic biomes are divided into marine (saltwater) and freshwater types.
- A biome:
  - contains specific kinds of plant and animal life that are adapted to the environment
  - is made up of several ecosystems.

2.1 Marine biomes of South Africa

South Africa has a long coastline. It has the following features:

- The east coast where the warm Agulhas Current influences the water temperature.
- The west coast where the cold Benguela Current influences nutrient content.
- The south-western and south coast, where these water masses mix.
- The ocean tides, currents, temperature changes and oxygen and salt content have an effect on the kinds of animal and plant communities that are found along the coastline.
- Thick marine forests of giant kelp and sea bamboo are a major source of food and also give shelter to fish, other marine animals and plants.
- The east coast waters have a greater biotic diversity of plant and animal species than the south-west and south coast waters.
- Marine biomes: sandy beaches, rocky shores, coral reefs, benthic beds (the ocean floor) and the pelagic zone (open, deep ocean).

2.1.1 Sandy beaches

Sandy beaches have:

- a moving layer of sand dunes
- continual wave and current action
- an inter-tidal zone where the ocean meets the land
- cyclical daily wet and dry periods as waves and tides come in and out.

2.1.2 Rocky shores

- Rocky shores are found in many places along our coastline.
- They provide a firm, strong foundation for plants and animals to attach to.
- They are the habitat of a great diversity of marine organisms.

2.1.3 Coral reefs

- Coral reefs are found in the warm subtropical waters off the coast of northern KwaZulu-Natal.
- They are home to many fish species and other marine animals.
- Along with tropical forests, they support the biggest diversity of organisms on the Earth.

2.1.4 The open sea

- The deep sea has no firm base.
- Organisms found are fish, phytoplankton and zooplankton.
- Fish of different sizes, whales and dolphins swim in the open sea.
- Phytoplankton are microscopic plant-like organisms, such as algae, that can photosynthesise.
- Zooplankton are animal-like organisms – some are just visible with the naked eye but most are microscopic.

2.1.5 Estuaries

- Estuaries are the meeting places of the rivers and the sea – where fresh water meets salt water.
- They have features of both marine and freshwater biomes.
- Organisms are specially adapted to tolerate salt and fresh water.
- The fresh water brings rich nutrients from the land.
- Mixing of salt and fresh water allows huge numbers of marine life to exist.

2.2 Freshwater biomes

Freshwater biomes are rivers, streams, ponds, lakes and wetlands. These biomes are affected by changes in climate and weather.

2.2.1 Wetlands

- Wetlands are areas with waterlogged soils, or areas covered with a shallow layer of water.
- They may be permanently or seasonally covered with water.
- They are important because they:
  - are flood controllers because they slow down flood water
  - are filters that improve water quality by trapping sediments
  - hold nutrients such as phosphorus and nitrogen, and even harmful bacteria
  - are wildlife habitats – they provide food and shelter for many animals.

2.3 Terrestrial biomes

There are seven terrestrial biomes in South Africa.

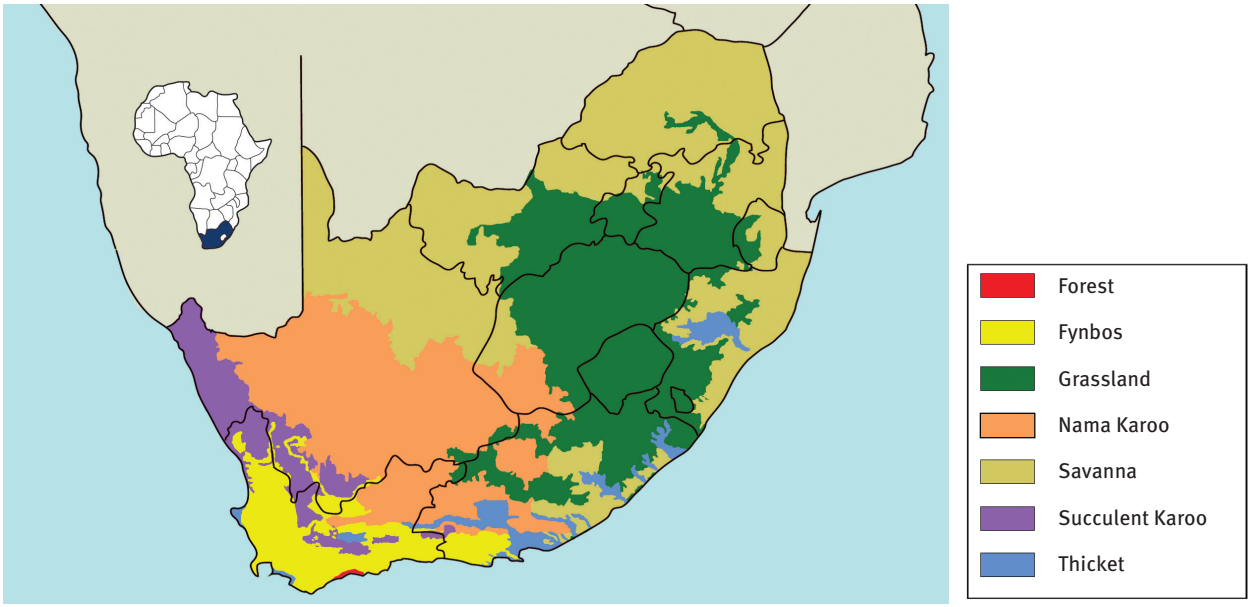


FIGURE 9.1 Biomes of South Africa

2.3.1 The Savanna biome

- 'Savanna' refers to vegetation that is mixed grassland and trees.
- 46% of South Africa is savanna.
- The Savanna biome has the following features:
  - infertile, porous soil, which allows water to drain away quickly
  - summer rainfall; extremely hot temperatures in summer; cold winters with little rain
  - wild animals such as antelope, lion, buffalo, leopard, cheetah, hippo, giraffe, zebra and elephant
  - livestock such as cattle graze the grasses
  - many types of birds such as hornbills, flycatchers, woodpeckers and shrikes
  - baobab, marula, mopane and acacia trees.

2.3.2 The Grassland biome

- Grasses are the main vegetation. Woody plants are either absent or rare.
- This biome covers 24% of South Africa's surface area.
- It has the following features:
  - high rainfall; thunderstorms and hail common in summer; frost common in winter
  - deep and dark soils with fertile upper layers
  - mainly 'sweet' grass for grazers
  - many kinds of antelope – blesbok, black wildebeest, rietbok, grey rhebok, eland, springbok – are common, plus big cats such as lion

- rich variety of birds such as the blue crane, black korhaan and helmeted guinea fowl
- maize farming, dairy farming, beef and wool production
- a number of perennial rivers such as the Orange, Vaal and Pongola.

- The biggest threat to the Grassland biome is commercial forestry. Very large areas have been replaced by plantations of pine trees.

2.3.3 The Nama Karoo biome

- The Nama Karoo is an area of transition between the Cape flora in the south, and the tropical Savanna in the north.
- It has the following features:
  - warm, dry, semi-desert climate
  - sandy soil with little nutrition
  - plants such as sweet-thorn, stone plant and blue Karoo daisy
  - sheep-farming is the main agricultural activity
  - a rich variety of rodents, plus fox, jackal, ostrich and reptiles
  - endemic or near-endemic bird species such as the Sclaters lark.

2.3.4 The Succulent Karoo biome

- The Succulent Karoo is in the western part of South Africa, stretching all the way up the West Coast.
- It has the following features:
  - winter rainfall and very hot and dry summers
  - sandy soil with little nutritional value
  - succulent plants, which have thick fleshy leaves to store water and others with small leaves and thorns to reduce water loss through transpiration
  - annual plants that survive the dry period by germinating, growing, flowering and setting seeds during the moist winter and spring; they evade the dry periods by being stored as seeds
  - animals such as the dassie rat, Namaqua dune mole-rat, barking gecko and the Cape horseshoe bat
  - large areas of colourful Namaqualand daisies that bloom for a short time, and other interesting flowers.

Damage to the Nama Karoo and Succulent Karoo biome is mainly caused by sheep over-grazing. Other problems are over-collection of the endemic plants and badly-managed tourism (e.g. trampling of plants).

2.3.5 The Fynbos biome

- 'Fynbos' refers to the small shrubs with fine leaves found in this biome.
- Fynbos occurs almost only in the south-western and southern parts of the Western Cape Province.

- The biome is a World Heritage Site. With at least 8 570 species of flowering plants, it is one of the most diverse floras in the world.
- It has the following features:
  - cold, wet winters and hot, dry summers with strong winds and regular fires
  - sandy and alkaline coastal soil, further inland it becomes more acidic; in the lowlands the soil is more fertile and neutral
  - evergreen plants
  - low shrubs with fine leaves, such as ericas, and leafless, tufted, grass-like plants such as restios are the main plants; proteas can grow into large bushes
  - trees are rare and grasses are a small part of the vegetation
  - the fynbos plants only reproduce through seeds; they depend on small mammals or birds, such as the Cape sugarbird, for pollination
  - it has 68% endemic plants, many found only in very small areas
  - fauna includes the leopard, grysbok, Cape mountain zebra and geometric tortoise.
- Fynbos vegetation is used for grazing small stock and for collecting and selling wild flowers, proteas, rooibos tea, buchu, veld flowers and thatching-reed, and for growing table and wine grapes, wheat, fruit and olives.
- Threats to the Fynbos biome include: development and agriculture; plantations of alien trees; uncontrolled fires; take-over of alien plants; draining of wetlands; collecting firewood; picking too many wild flowers.

2.3.6 The Forest biome

- Indigenous evergreen and semi-deciduous closed forests are found in coastal lowlands and escarpment slopes.
- With a few exceptions, forests are small (usually taking up less than 1 000 hectares).
- The biome's features are:
  - high rainfall areas
  - small area but relatively high number of different organisms
  - trees of different heights, so reduced light beneath the canopy
  - species such as tree ferns and vines common in the shade
  - animals such as bushbuck, bush pig and blue duiker
  - birds include the Knysna lourie, woodpecker and rameron pigeon.
- Forests are threatened by the felling of trees for wood, collecting firewood, and collecting bark, roots and bulbs for traditional medicines.

2.3.7 The Thicket biome

- Most Thicket is found in river valleys where there is water and a thick layer of rich soil.
- Its features include:
  - dune sands, sandy and clay soils
  - different types of vegetation: from shrubs, evergreen forests to succulents

- many plants with spines to protect them from grazers, for example the Euphorbia
- small animals like monkeys and squirrels are common, and large animals such as black rhino, elephant and kudu occur.

3 Ecosystems

- An ecosystem is a community of living and non-living factors in an area that interact with each other.
- An ecosystem can be as large as a mountain or a lake, or as small as a tree or a pond.
- A terrarium and an aquarium are artificial ecosystems.
- An ecosystem consists of two parts:
  - biotic factors – living organisms; examples are plants, animals and micro-organisms
  - abiotic factors – non-living factors; examples are soil factors, water, temperature and sunlight.
- The biotic factors interact amongst themselves, and with the biotic factors. The abiotic factors also interact in a similar way. These interactions help to balance the energy flow of the ecosystem.
- Biotic factors interact with each other in different ways. Symbiosis is living together. Examples of these interactions are:
  - mutualism – both organisms benefit; example: flower and bee
  - commensalism – one organism benefits, the other is not affected; example: orchid and tree
  - parasitism – one organism benefits (parasite) and the other is harmed (host); example: humans and tapeworms (endoparasite) or mosquitoes (ectoparasite).

3.1 Living organisms – biotic factors

- Living organisms can be grouped according to how they get their food.
- The groups are the producers, consumers and decomposers.

3.1.1 Producers

- Organisms that make their own food from substances they get from the environment are called producers or autotrophs.
- Plants and algae are producers. The substances from the environment that they use are sunlight, carbon dioxide (CO_2) and water (H_2O). They turn these into food in the form of glucose during photosynthesis.
- Plants can be classified according to their dependence on water and where they grow:
  - Hydrophytes are plants that grow in water. Examples are Elodea and water lilies.
  - Mesophytes are plants that need a moderate supply of water, light and temperature. Examples are marula, fig and mango trees.
  - Xerophytes are plants that grow in very dry regions. Examples are cacti and aloes.

3.1.2 Consumers

- Organisms that cannot make their own food and have to eat other organisms are classified as consumers or heterotrophs.
- Consumers are divided into three groups:
  - Primary consumers are animals that feed only on plants. They are called herbivores. Examples are antelope, zebra, wildebeest, buffalo, rhino and sheep.
  - Secondary consumers are animals that feed on primary consumers. They are called carnivores. Examples are dogs, leopards and snakes.
  - Tertiary consumers are animals that feed on secondary consumers. They are also carnivores. Examples are lion, hawks and eagles.
- Omnivores are animals that eat animals and plants. This makes them primary and secondary consumers. Examples are humans, pigs and baboons.
- Predators catch live prey, kill and eat them. Examples are lion and snakes.
- Prey are the animals hunted and fed on by predators.
- Scavengers eat what is left over by predators. Examples are hyenas, crayfish and vultures.

3.1.3 Decomposers

- Organisms that break down dead plant and animal bodies, as well as animal wastes, are called decomposers (saprophytes/saprovores). Examples are fungi (mushrooms) and bacteria.
- Decomposers play a very important role in ecosystems because they return nutrients to the soil, which are then absorbed by plant roots.
- Decomposers are essential in the nutrient cycles.

3.2 Non-living factors – abiotic factors

The abiotic factors in ecosystems can be classified into physiographic factors, edaphic (soil) factors, and physical factors.

3.2.1 Physiographic factors

Physiographic factors in ecosystems have to do with the position and shape of the area. They include slope, aspect and altitude.

- Slope – a slope (inclination) refers to how steep or how flat an area is. A steep slope results in fast run-off of water, so soil erosion may take place. Steep slopes usually have shallow and infertile soil. Few plants grow there and there are few animals.
- Aspect – the aspect of a slope is the direction it faces: north, east, south or west. The slope of one side of a hill may get more heat than the other side. A north-facing slope receives more direct sun rays than a south-facing slope. A north-facing slope is warmer and drier, and evaporation is higher. Xerophytes are found on the warmer and drier north-facing slope. Shade-loving plants are likely to be found on the cool and moist south-facing slopes.

- Altitude – altitude (elevation) is the height of the land above sea level. The height of a mountain will determine the amount of precipitation, solar radiation (sun), wind and shade that the organisms receive. At higher altitudes the temperature is lower, wind speed is greater, and the rainfall is higher. Fewer plant and animal species are found at higher altitudes than at lower altitudes. Areas at sea level on the coast are warmer than mountainous and inland areas that are at higher altitudes.

3.2.2 Edaphic (soil) factors

Soils are not all the same because they are affected by different factors. The size of the soil particles influences the factors found in the soil. Edaphic factors are:

- pH level – this means how acidic or alkaline the soil is.
  - Acid soil – a pH of less than 7; sand is acidic.
  - Alkaline soil – a pH of greater than 7; clay is alkaline.
  - Neutral soil – a pH of 7; loam is neutral to alkaline.
- Humus content – this means how much humus there is in the soil. Humus is dead and decaying plant and animal material.
  Humus:
  - makes the soil fertile
  - provides plants with nutrients
  - keeps oxygen in the soil
  - holds water
  - allows excess water to drain away.
- Soil texture – refers to the different types of soils. There are three main types of soil:
  - Sand – low water retention; particles are large.
  - Clay – high water retention; particles are very small.
  - Loam – holds adequate amount of water; mixture of sand and clay; lots of humus.
- Soil air – soil air is the air found in spaces between soil particles that are not filled with water. The more air, the more oxygen there is for the plants. The amount of air depends on the size of soil particles and the spaces between them.
  - Loosely packed soil particles such as sand have large air spaces and much air.
  - Clay has small air spaces and little or no air.
  - Loamy soils hold a moderate amount of air as humus provides the air spaces.

3.2.3 Physical factors

Factors such as sunlight, temperature and water that affect ecosystems are called physical factors.

- Sunlight – the main source of light in the ecosystem
  - Plants need sunlight for the process of photosynthesis.
  - Light intensity means how bright the light is. Most plants grow well in bright light; others do better in shady conditions.
    - Photoperiodism means an organism's response to day length (photoperiod).

  - It affects plant growth and flowering; for example, there are short-day plants (plants that only flower when days are shorter than nights) and long-day plants (plants that only flower when days are longer than nights).
  - It also controls the activity of some animals; for example: there are nocturnal animals (active at night) and diurnal animals (active during the day).
- Temperature – influences behaviour
  - Cold-blooded animals – cannot regulate their own body temperature; are inactive in extreme temperatures. Examples: fish, amphibians and reptiles.
  - Warm-blooded animals – can regulate their own body temperature; maintain a constant body temperature; can survive hot and cold conditions. Examples: mammals and birds.
  - Migration – movement from one area to another, caused by seasonal changes. Example: swallows.
  - Hibernation – reduced winter activity and winter 'sleep'. Examples: snakes and rodents.
  - Aestivation – summer inactivity and summer 'sleep'. Examples: snails and insects.
  - Dormancy – some plant species survive cold seasons by becoming dormant. Examples:
    - Some plants die and leave their seeds.
    - The aerial parts of some plants die down and the plant survives in an underground storage organ such as a bulb or tuber.
    - Other plants survive by reducing their metabolic activity – for example, some trees and shrubs shed their leaves.
- Water availability – the amount of freely available water in the environment
  - Water is an important limiting factor in a terrestrial ecosystem or biome.
  - The amount of rainfall determines the type of plants and animals that can live in the biome or ecosystem.
  - Animals get water through drinking and eating. They lose water mainly through sweating, excretion and breathing.
  - Plants get water through their roots. They lose water through transpiration.

3.2.4 Plant adaptations to conserve water

- Xerophytes are plants that are adapted to very dry conditions (e.g. aloe and acacia). Adaptations to reduce water loss include:
  - thick waxy cuticle, cork on the stems, or dead leaves that protect living leaves below them
  - reduced leaf area – thorns, small leaves
  - shallow, widely-branched root system that can absorb surface water quickly over a large area
  - thick roots, stems and leaves that store water.

- Hydrophytes are plants that are adapted for aquatic or semi-aquatic conditions (e.g. water lily and water hyacinth).
  Adaptations to a water environment include:
  - large, flat leaf blades help plants to float on water
  - many stomata on the top surface of the leaf help excess water escape through transpiration
  - thin or no waxy cuticle on the upper leaf surface so that water runs off
  - little or no xylem because plants are supported by water
  - larger air spaces between cells enable plants to float.

3.2.5 Animal adaptations to conserve water

Examples are:

- dry, scaly skin to reduce water loss
- water in urine is reabsorbed
- burrowing into the ground
- nocturnal behaviour.

3.2.6 Atmospheric gases in ecosystems

Table 9.1 Origins and uses of atmospheric gases in ecosystems

Gas	Origin and/or use
Oxygen (21% of atmosphere)	• Used for cellular respiration in animals • Produced by plants during photosynthesis
Carbon dioxide (0,035%)	• Produced during cellular respiration • Used by plants during photosynthesis
Nitrogen (78%)	• Converted into nitrites and nitrates by bacteria • Plants and animals convert the nitrogen into proteins
Water vapour (0–4%)	• Released into the atmosphere when plants transpire • Enters atmosphere from the soil, rivers, lakes and oceans through the process of evaporation • Returns to the ground as precipitation

3.2.7 Winds in ecosystems

- Moving air currents are called wind.
- Wind influences rainfall, which in turn affects the types of plants and animals living in an ecosystem.
- Wind increases transpiration.
- Winds disperse pollen and seeds.

3.3 Energy flow through ecosystems

- Energy is needed for growth, movement and reproduction.
- The energy in ecosystems comes from one source and flows in one direction only: from the sun to producers (green plants) to consumers and to decomposers.

Table 9.2 Trophic (feeding) levels and energy transformations	
Trophic (feeding) level	**Energy transformation**
Producers (photosynthetic organisms)	• Producers change the sun's solar energy into chemical energy – they capture the sunlight and produce food through the process of photosynthesis. • Most of this energy is used to carry out the plant's life activities. • The rest of the energy is passed on as food to primary consumers.
Primary consumers (herbivores)	• Primary consumers consume the producers. • They use the food energy in the producers to carry out life activities. • The rest of the energy is passed on as food to secondary consumers.
Secondary consumers	• Secondary consumers consume primary consumers. • They use the food energy in the primary consumers to carry out life activities. • The rest of the energy is passed on as food to tertiary consumers.
Tertiary consumers	• Tertiary consumers consume secondary consumers. • They use the food energy in the secondary consumers to carry out life activities. • The rest of the energy is passed into the environment.
Decomposers / Saprophytes (fungi and bacteria)	• Fungi and bacteria get their energy from the bodies and wastes of dead producers and consumers. • They return energy to the environment as nutrients for the cycles.

3.3.1 Food chains

- A food chain is the energy flow through feeding (trophic) levels from one organism to the next.
- Food chains can be shown for terrestrial and for water ecosystems.

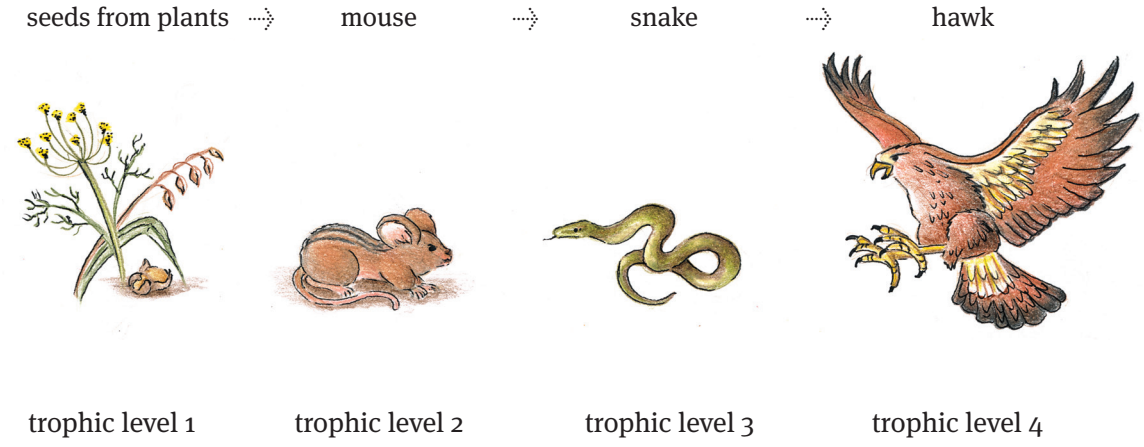


FIGURE 9.2 An example of a terrestrial food chain

- The food chain above shows:
  - Energy stored in seeds is transferred to the mouse when it eats the seeds.
  - Energy in the mouse is transferred to the snake when it eats the mouse.
  - Energy is transferred to the hawk when it eats the snake.

3.3.2 Food webs

A food web is made of several interlocking food chains in an ecosystem.

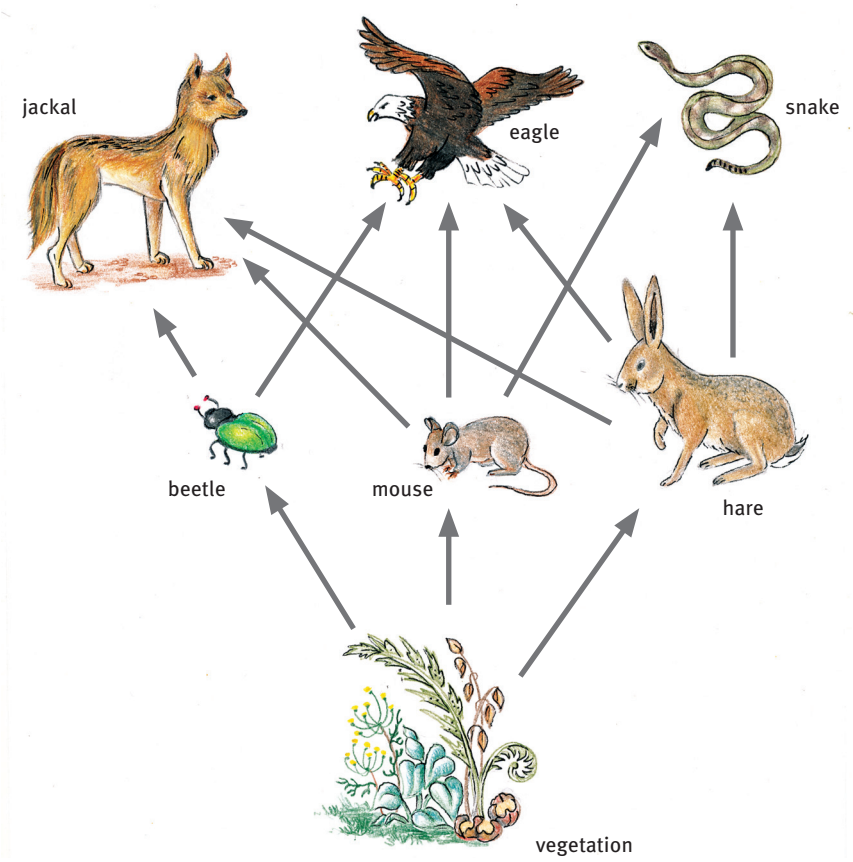


FIGURE 9.3 An example of a food web

3.3.3 Food pyramids

- Food chains and food webs do not show how much is eaten.
- Food pyramids show how much is eaten at each trophic level.
- There are three types of food pyramids: energy pyramid, biomass pyramid and number pyramid.

The pyramid of energy

- At each trophic level, about 90% of the energy is lost in the form of heat.
- The total energy passed from one level to the next is only about one-tenth of the energy received from the previous level.

The pyramid of biomass

- A total count of the population, multiplied by the weight of an average individual in it, gives an estimate of the weight of the population, called the biomass.
- It is the total mass of living organisms at one trophic level.

The pyramid of numbers

- There are many more small animals than larger ones.
- If the size of the individuals is small, their numbers are large.
- The figures represent the number of individuals counted at each trophic level.

3.4 Nutrient cycles in ecosystems

- Energy flows through ecosystems and is continually replaced by the sun.
- Nutrients don't flow through ecosystems like energy, but are cycled. There is a fixed amount of nutrients needed for living in the biosphere, which is cycled over and over again.
- Nutrient cycles in the ecosystem that support life are the carbon, nitrogen, oxygen and water cycles.

3.4.1 The water cycle

- Evaporation – water changes from liquid to water vapour through the energy of the sun.
- Condensation – water vapour cools down and forms droplets in the atmosphere that form clouds.
- Precipitation – water droplets or ice crystals gather and then fall from the sky as rain, hail or snow.
- Run-off – water runs over the land towards the water bodies.

3.4.2 The carbon cycle

- Earth's atmosphere contains 0,035% carbon dioxide.
- During photosynthesis, plants use sunlight to bind carbon to glucose, releasing oxygen in the process.
- Plants change glucose to other sugars, proteins, or fats.
- Animals get their carbon by eating and digesting plants and other animals.
- Both plants and animals respire, and release carbon dioxide during cellular respiration and breathing.
- Decomposition also releases carbon back to the environment.
- Fossilisation captures carbon in the soil as coal and oil.
- Weathering and mineralisation of soils and rocks also releases carbon into the environment.

3.4.3 The nitrogen cycle

- Earth's atmosphere contains about 79% nitrogen gas.
- Nitrogen-fixing bacteria are found in the soil and in root nodules of leguminous plants such as peas, beans and clover. They absorb nitrogen gas from the air spaces in the soil and convert them to nitrates. Plants use the nitrates to form organic molecules which are needed to form proteins.

- Lightning flashes create high temperatures which cause some nitrogen and oxygen in the atmosphere to form oxides of nitrogen. The oxides dissolve in rain and enter the soil where they form nitrates. Plants use these nitrates to form proteins.
- Proteins are passed from one organism to another in food chains.
- When plants and animals die, their bodies decompose and the proteins are released into the soil. Animal wastes such as urine and sweat have nitrogen in compounds such as ammonia, urea and uric acid. Nitrifying bacteria in the soil break down the proteins from the dead animals and convert nitrogen in animal wastes back to nitrates, which are again available to plants.
- Denitrifying bacteria in the soil convert some of the nitrates back into nitrogen gas, which goes into the atmosphere.

3.4.4 The oxygen cycle

- Earth's atmosphere contains 21% oxygen gas.
- Green plants produce oxygen during photosynthesis and release it into the atmosphere.
- Animals and plants use oxygen during cellular respiration and produce carbon dioxide.
- The oxygen cycle is part of the carbon and water cycles.
- In the lithosphere, oxygen is naturally bound as carbonates, silicates, sulphates, and other oxides.
- In the atmosphere, oxygen produces ozone. The ozone layer around our atmosphere protects the biosphere from harmful rays of the sun.

4 Responsible ecotourism

Ecotourism refers to visitors travelling into natural areas and behaving in a caring and responsible way that conserves the environment and improves the well-being of local people.

4.1 The economic benefits of ecotourism

- Responsible ecotourism creates opportunities for local communities to earn money in a way that benefits them, without harming the natural or social environment.
- It also provides an income for a country.

4.2 Ethics and ecotourism

- Doing things ethically means doing them in a moral, thoughtful, acceptable and correct way.
- Ethical ecotourism allows as many of the local people as possible in a conservation area to be part of the decisions that are made.

4.3 Opportunities of ecotourism

Ecotourism leads to many benefits and opportunities. These include:

- educational opportunities for local communities
- job opportunities for local communities
- infrastructure development in local communities.

5 Current environmental issues

Some of the issues associated with environmental interactions are: air pollution, global warming, acid rain, monoculture and overpopulation.

5.1 The Greenhouse effect

- Heat caused by infrared radiation is absorbed by 'greenhouse gases' such as water vapour, carbon dioxide, ozone and methane.
- This slows down the rate at which heat escapes from the atmosphere.
- Greenhouse gases make up only about 1% of the Earth's atmosphere and regulate our climate by trapping heat and holding it in a kind of warm air-blanket that surrounds the planet.
- Too much heat is now being trapped, and the Earth is warming up.

5.2 Global warming

- Over the decades, human activities of burning natural gas, coal and oil (fossil fuels) in our industries and driving cars and so on have created more greenhouse gases in the atmosphere than the ecosystem needs. This has caused air pollution, which affects the health of all organisms – including humans.
- Currently, carbon dioxide accounts for more than 60% of the increased greenhouse effect. The level of carbon dioxide in the atmosphere is increasing by over 10% every 20 years.
- More greenhouse gases mean more infrared radiation is trapped. This leads to a slow increase in the temperature of the Earth's surface and the air in the atmosphere. This process is named 'global warming'.
- Why is global warming an issue? As global temperatures increase, they affect biomes and the animals and plants living there. The weather will change, and places like South Africa become even drier. The polar ice caps are melting, and so the sea level is very slowly rising. This is beginning to affect humans living in coastal areas.

5.3 Acid rain

- Factories and vehicle exhausts release pollutant gases into the air such as, for example, carbon dioxide and sulphur dioxide. These compounds dissolve in atmospheric water (water vapour) and form sulphuric acids and carbonic acids.
- The product is acidic water, which is returned to Earth as acid rain.

- Acid rain corrodes buildings; it burns plant leaves, affecting their ability to photosynthesise; it increases the acidity of the soil; it affects human and animal life; and it acidifies water bodies, and so damages the plants and animals in the water.

5.4 Monoculture

- Monoculture means growing one single crop, year after year, over a wide area. It causes farmers to use large amounts of fertilisers to support growth and yield production.
- Monoculture attracts many pests and diseases – this causes farmers to use large amounts of pesticides.
- Pesticides and fertilisers run off during rains and can pollute the environment and harm other organisms.

5.5 Overpopulation

- Carrying capacity means the number of organisms that an environment's resources can support.
- When the number of organisms exceeds the carrying capacity of its habitat it means that there is overpopulation.
- Human numbers have increased to such an extent that overpopulation is causing many environmental problems.
- The Earth's resources, such as food, clean water, clean air and living space, are limited and are running out.
- Huge human population numbers are also creating a huge amount of waste that is not biodegradable.

5 Careers in Environmental Studies

- There are two main career paths:
  - socio-environmental careers, e.g. ecotourism specialist, environmental journalist, environmental lawyer, cultural resource specialist
  - environmental science careers, e.g. nature conservation officer, marine biologist, ecologist, landscape architect, environmental impact assessor
- Good environmental management combines both these types of work.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

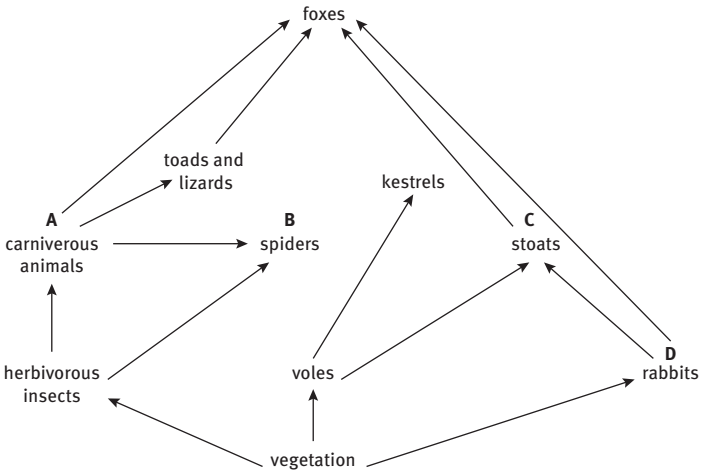
1.1 In the ecosystem of a tropical rainforest, the producers obtain energy from the:

A consumers
B decomposers
C rotting leaves
D sunlight. (2)

1.2 A generalised food chain may be shown as follows:

producer ⇢ primary consumer ⇢ secondary consumer ⇢ tertiary consumer

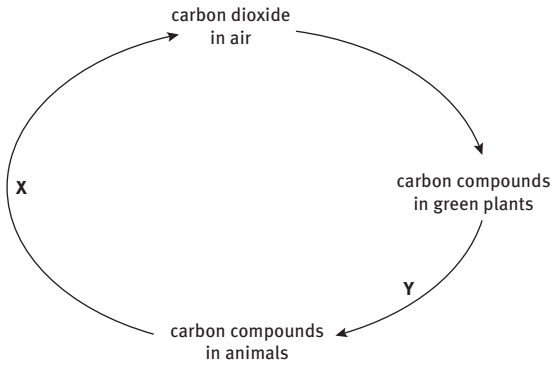
Which labelled organisms in the food web below are both secondary and tertiary consumers? (2)



1.3 The activity of decomposers returns substances to the atmosphere. Which products of decomposition enter the atmosphere?

A carbon dioxide and nitrogen
B carbon dioxide and water
C oxygen and nitrogen
D oxygen and water (2)

1.4 The diagram represents part of the carbon cycle.



What processes are represented by X and Y?

	X	Y
A	combustion	photosynthesis
B	photosynthesis	respiration
C	respiration	excretion
D	excretion	nutrition

(2)

1.5 Which process is part of both the carbon cycle and the water cycle?

A evaporation
B photosynthesis
C translocation
D transpiration (2)

1.6 Which is a food chain made up of a producer, herbivore and carnivore?

A bee ⇢ bee-eater ⇢ hawk
B hen ⇢ rat ⇢ owl
C maize ⇢ mouse ⇢ eagle
D sun ⇢ grass ⇢ sheep (2)

1.7 Which organisms remove carbon dioxide from the atmosphere?

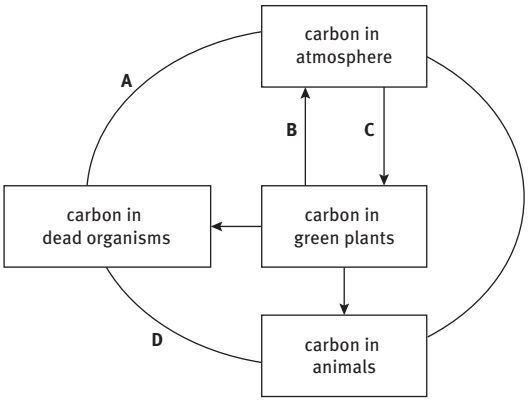
A carnivores
B decomposers
C herbivores
D producers (2)

1.8 What are the effects of sewage pollution on the oxygen concentration and the number of bacteria in a river?

	oxygen concentration	number of bacteria
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

(2)

1.9 The diagram shows part of the carbon cycle.
Which arrow shows respiration in decomposers?



(2)

1.10 The table shows the numbers of fish in a river downstream of a factory that started to release waste hot water into the river in 1990.

Number of fish in	Species								
	L	M	N	O	P	Q	R	S	T
1990	20	100	5 000	1 100	2	3	85	0	0
1992	150	2	100	65	0	0	560	30	26

What effect did the hot water have on the fish?

A a decrease in the number of species
B a decrease in the total number of fish
C an increase in the number of species
D an increase in the total number of fish (2)

1.11 Which set of words correctly shows the organisation of living things from the largest to the smallest?

A species ⇢ biosphere ⇢ community
B biosphere ⇢ community ⇢ species
C individual ⇢ biosphere ⇢ community
D species ⇢ individual ⇢ community (2) [22]

Question 2: True/false

Read each of the statements 2.1 to 2.5 provided below.
Decide if each statement is scientifically correct or incorrect.
If correct, write down the word 'true' next to the question number.
If incorrect, write down the word 'false' next to the question number, and rewrite the sentence to show the change made by underlining the changed text.

2.1 The Fynbos biome is found in South Africa and nowhere else in the world.

2.2 Sandy soils have a poor water retention capacity.

2.3 A community is a collection of organisms of the same kind living in the same area at the same time.

2.4 Xerophytes have leaves with a large surface area.

2.5 Monoculture is the growth of a single crop in a large area. (5 × 2) [10]

Question 3: Scientific terminology

Give the scientific term for each of the following descriptions.
Write the term next to each question number.

3.1 Animals that eat plants (1)

3.2 Organisms that break down dead organisms in the environment (1)

3.3 The loss of water vapour from the leaves of plants through stomata (1)

3.4 The number of organisms that an environment can support (1)

3.5 The biome that is a mixture of grass and trees (1)

3.6 A group of similar organisms that are able to breed with each other and produce fertile offspring (1)

3.7 Non-living factors found in the environment (1)

3.8 Soil factors (1)

3.9 Type of soil that contains humus, sand and clay (1)

3.10 The region on Earth that supports life (1) [10]

Question 4: Matching columns

4.1 Match the description in COLUMN I with the term in COLUMN II. Write only the letter (A–L) next to the question number (4.1.1–4.1.10).

Column I		Column II	
4.1.1	Animals that hunt their food	A	Food chain
4.1.2	Formation of clouds from water vapour	B	Producers
4.1.3	Flow of food energy in an ecosystem	C	Monoculture
4.1.4	Excessive pollution of a water body	D	Condensation
4.1.5	Organisms that eat others	E	Denitrification
4.1.6	Plants that photosynthesise	F	Eutrophication
4.1.7	Organisms that break down dead matter	G	Nitrification
4.1.8	Water droplets falling to Earth as rain	H	Saprophytes
4.1.9	Growing crops of one kind	I	Predators
4.1.10	Conversion of nitrates to nitrogen gas	J	Precipitation
		K	Consumers
		L	Prey

(10)

4.2 State whether each of the phrases in COLUMN I applies to A only, B only, both A and B, or none in COLUMN II. Write down A only, B only, both A and B or none next to the question number. For example, 4.2.1 None

Column I	Column II
4.2.1 Animals that eat plants	A primary consumers B herbivores
4.2.2 Living factors	A biotic B abiotic
4.2.3 Soil factors	A altitude B edaphic
4.2.4 Consumers	A autotrophs B heterotrophs
4.2.5 Physiographic factors	A slope B altitude
4.2.6 Inactivity during winter	A hibernation B aestivation
4.2.7 Water bodies	A lithosphere B hydrosphere
4.2.8 Zone of life on Earth	A biosphere B lithosphere

(8) [18]

Question 5: Missing words

Select the most appropriate words from the lists given in questions 5.1 and 5.2 below, to complete each of the given paragraphs.
Write the words chosen next to their corresponding numbers.

5.1 *habitat, community, biotic, abiotic, ecosystem, population*

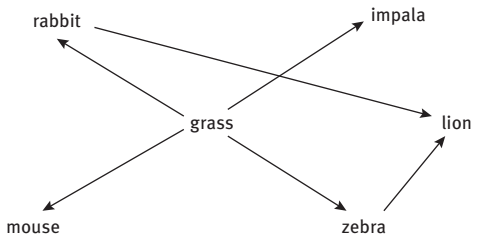
The place in which animals and plants live is called a __5.1.1__. Many different organisms in a __5.1.2__ share a habitat. Animals and plants in an environment are known as __5.1.3__ factors. The __5.1.4__ factors determine the type of vegetation and animal life found and distributed in an __5.1.5__. (5)

5.2 *sun, food chain, plants, lost, consumers, herbivores*

Energy from the __5.2.1___ is transferred to living organisms through a __5.2.2__. __5.2.3__ photosynthesise and provide food energy for __5.2.4__. Energy is __5.2.5__ at each trophic level as heat, respiration and excretion. (5) [10]

Question 6: Short response

Study the diagram and answer the questions that are associated with it.



6.1 Name a secondary consumer. (1)

6.2 Name an herbivore. (1)

6.3 Name a predator and its prey. (2)

6.4 Without which organism will the others not survive? (1) [5]

Question 7: Tables

Complete the following table by writing only the numbers provided and the associated answers.

Organism	Type of feeder	Ecological status	Grouping
Shark	7.1	7.2	Single
Snail	Herbivore	7.3	7.4
Wild dog	7.5	Secondary consumer	7.6
Mushroom	7.7	7.8	Groups/colonies
Eagle	Carnivore	7.9	7.10

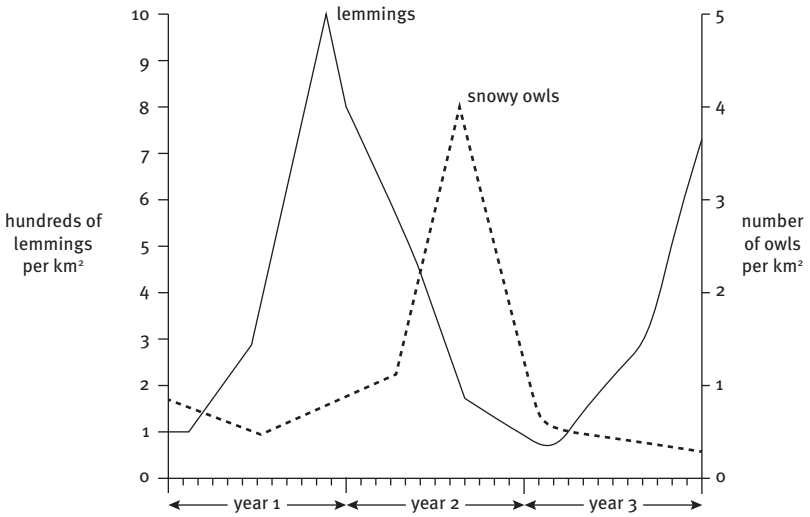
[10]

Question 8: Graphs

In the Arctic, snowy owls are predators of lemmings. The lemmings eat arctic plants.

8.1 Draw the food chain for this arctic ecosystem. (3)

8.2 The graph below shows the changes in the populations of snowy owls and lemmings over a three-year period.



8.2.1 During the first 10 months of year 1, the lemming population increases slowly at first and then more rapidly. Suggest why the rate of increase becomes greater. (1)

8.2.2 Using information in the graph, suggest why the lemming population falls during year 2. (1)

8.2.3 Using information in the graph, describe and explain how changes in the lemming population affect the snowy owl population. (3)

8.2.4 If all the snowy owls were removed from the arctic ecosystem, suggest and explain what effect this would have on the lemming population in the following years. (3)

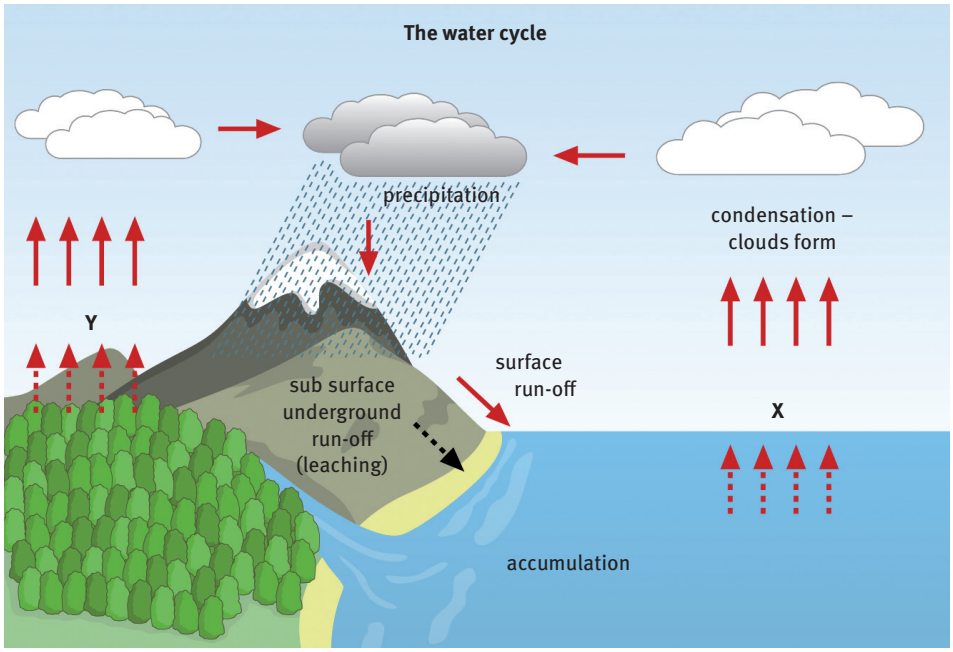
8.2.5 Lemmings and snowy owls get their energy from the food they eat.

(a) What is the original source of all the energy in this ecosystem? (1)

(b) Name the process that first traps this energy. (1) [13]

Question 9: Contextual

9.1 Study the diagram below and answer the questions that follow.



9.1.1 (a) For water to circulate in this cycle a supply of energy is needed. What is the source of this energy? (1)

(b) State which process is represented by X. (1)

(c) State which process is represented by Y. (1)

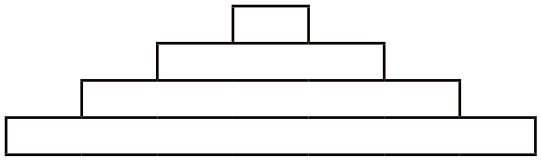
(d) Suggest what causes cloud formation. (2)

9.1.2 Water is needed by plants. State TWO ways in which plants use water. (2)

9.1.3 (a) Explain how water is absorbed by the root hairs of a plant. (3)

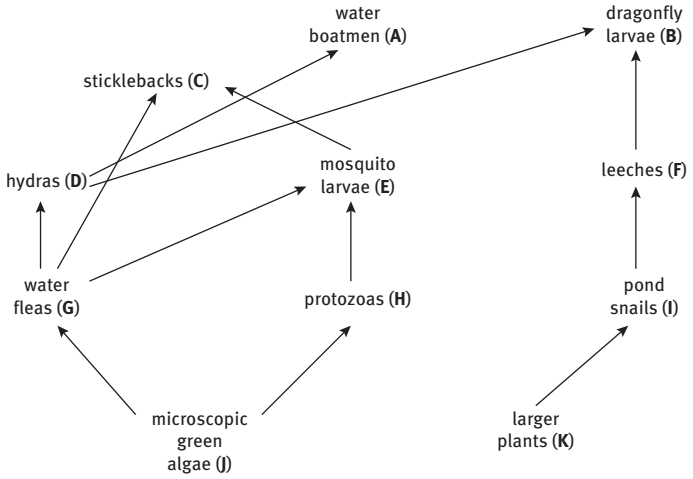
(b) Cereal plants were growing in a field. The field was then flooded with sea water. Suggest why the sea water causes the plants to die. (3) [13]

9.2 Study the diagram below of an ecological pyramid of biomass and answer the questions that follow.



9.2.1 Alongside the appropriate level, name trophic levels 1 and 3. (2)

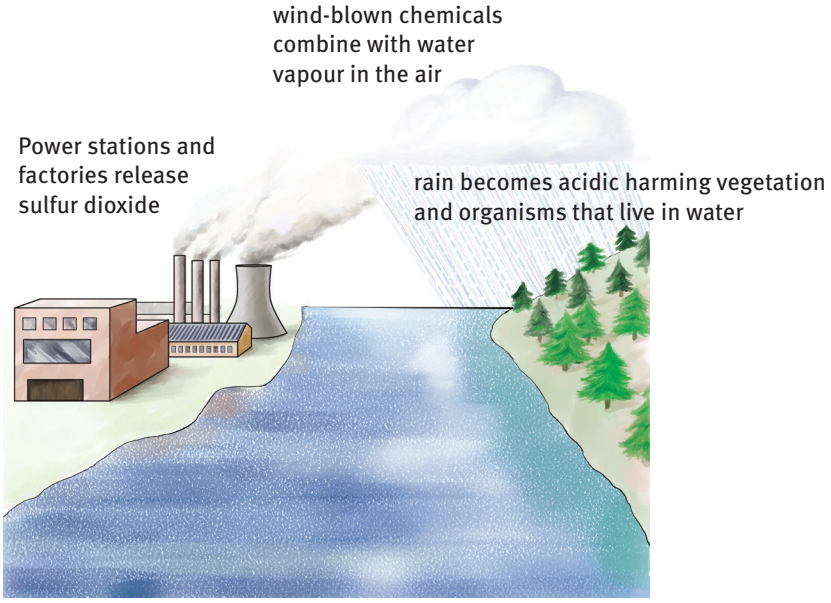
9.2.2 The food web of a freshwater pond given below is associated with the ecological pyramid of biomass in question 9.2.1.



Write the letters of the organisms (A to K) that are found at trophic levels 2 and 4 in the ecological pyramid of biomass. (6)

9.2.3 An outbreak of a bacterial disease that affects only mosquito larvae occurred in the pond. Predict and explain TWO of the effects this might have on the hydra population. (4) [12]

9.3 Acid rain is a serious environmental problem in some areas of the world. Lakes in Canada, Norway and Scotland are highly acidic as a result of acid rain. The figure below shows a cause of acid rain.



9.3.1 State ONE cause of acid rain other than that shown in the figure. (1)

9.3.2 Describe TWO effects of acid rain on forest ecosystems. (2)

9.3.3 Describe TWO different ways to reduce pollution so that there is less acid rain. (2)

The table below shows the pH ranges that some animals that live in lakes can tolerate.

animals		pH							
group	examples	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5
fish	trout	■	■	■	■	■			
	bass	■	■	■	■				
	perch	■	■	■	■	■	■		
amphibians	frogs	■	■	■	■	■	■	■	
	slamanders	■	■	■	■	■			
molluscs	clams	■	■	■					
	snails	■	■	■					
crustacean	crayfish	■	■	■	■				
insects	mayfly larvae	■	■	■	■				
	blackfly larvae	■	■	■	■	■	■	■	■

9.3.4 State ONE feature of molluscs that is not a feature of crustaceans. (1)

9.3.5 Use the information in the table.

(a) Name an animal that could be found in a lake with a pH of 4,0. (1)

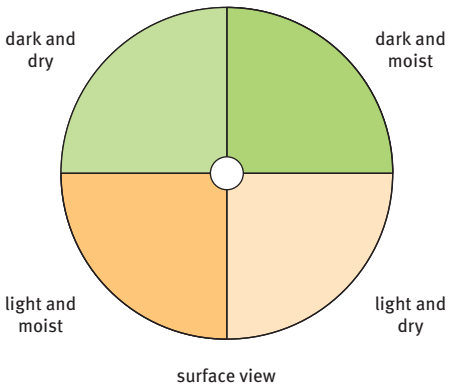
(b) Name the animals that are most sensitive to a decrease in pH. (1)

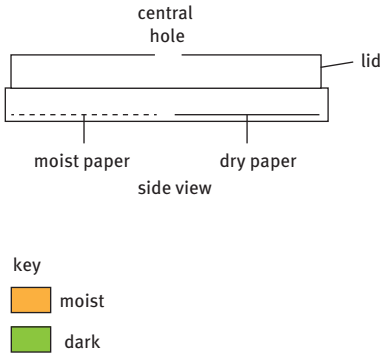
(c) Suggest why some animals cannot tolerate living in water with a pH as low as 4,0. (1) [9]

Question 10: Data response

The figure below shows a choice chamber.

- This apparatus can be used to study the behaviour of small invertebrates, such as woodlice, in different conditions.
- 60 woodlice were introduced through the central hole.
- The four sections of the choice chamber had different conditions as shown in the figure:
  - dark and dry
  - dark and moist
  - light and dry
  - light and moist.



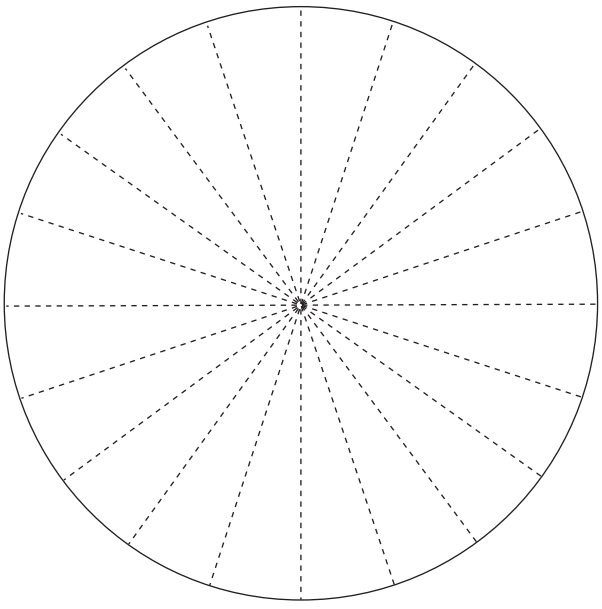


- The choice chamber was left undisturbed for 10 minutes.
  - The numbers of woodlice in each section were counted.
  - The numbers were recorded in the table below.
  - These woodlice were released into their natural environment.
  - The investigation was repeated with three more samples of woodlice.

10.1 Complete the information missing in the table below by writing the calculations required for 10.1.1 to 10.1.4. (4)

Sample of woodlice	Conditions			
	dark and dry	dark and moist	light and dry	light and moist
1st	8	47	1	4
2nd	4	56	0	0
3rd	5	52	1	2
4th	7	49	2	2
Total	10.1.1	204	10.1.3	8
Average	10.1.2	51	10.1.4	2

10.2 Plot the average number of woodlice in each condition onto the pie chart.



(8)

10.3 (a) State which conditions the woodlice prefer. (1)

(b) Suggest how this behaviour might help the woodlice to survive in their natural habitat. (2)

10.4 Suggest how you could improve this investigation to make the results more reliable. (3) [18]

Question 11: Essay

Use the words provided below in a paragraph to show how they are related to each other in a sensible scientific way.

ecology	ecosystem	plant	herbivore
species	community	animal	carnivore
autotroph	heterotroph	food chain	food web
producer	consumer	nutrient	biotic
abiotic	adapt	symbiosis	saprophyte

[20]

TOTAL MARKS: 170

Strand 4

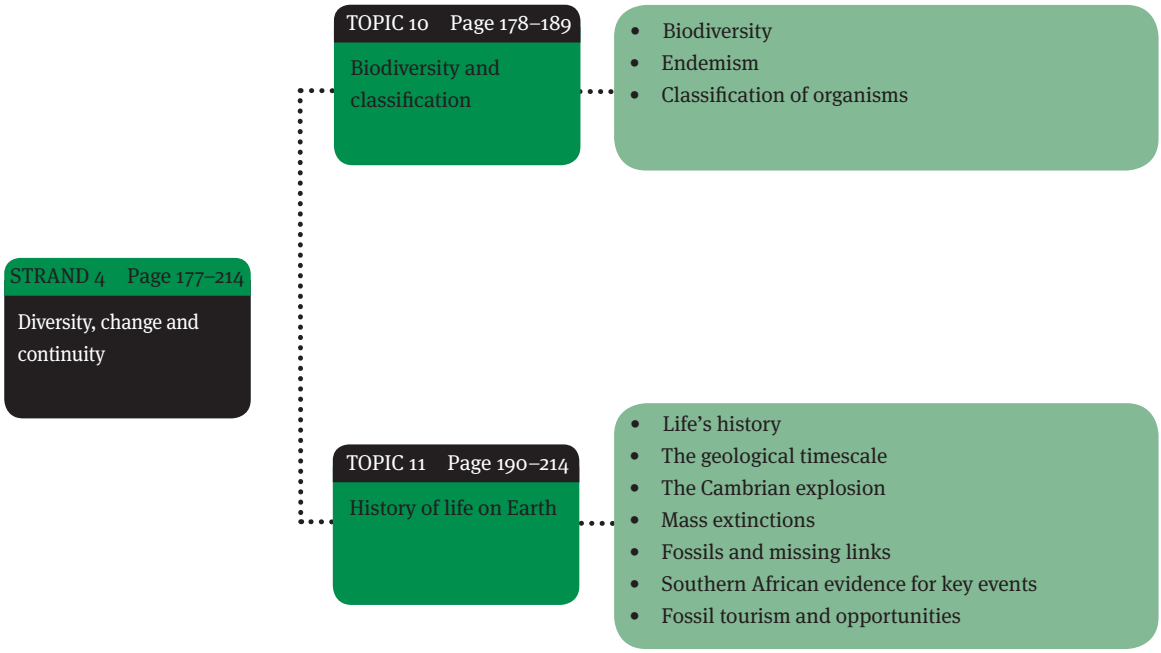
Diversity, change and continuity

Overview

The first living organisms arose about 3,5 billion years ago. Many have died out are are found today only as fossils. Changes in the life forms have been caused by climate change and the movement of continents over millions of years.

The number of life forms on Earth today is astounding – over 5 million – and more are being discovered all the time. We find organisms everywhere – in deserts, fresh water and salty water, in the icy Antarctic and in boiling hot springs. Each environment is governed by a variety of different physical factors, and only organisms that have features that suit their environment can survive.

South Africa has a rich biodiversity of both living and fossilised organisms. It is placed third in the world in terms of biodiversity.

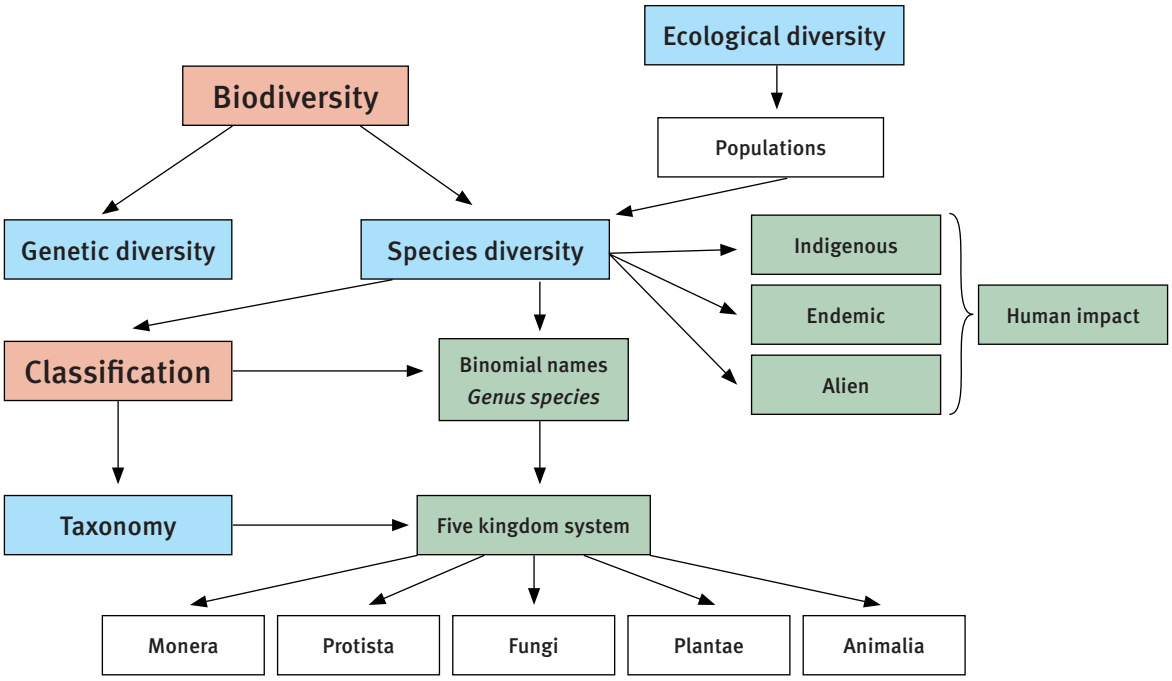


Topic 10

Biodiversity and classification

Overview

Biodiversity is the word used to describe the variety of organisms found on Earth. Organisms adapt to survive in their environment and so differences in genes and environments are what create this variation between individuals. Scientists organise all known life forms into human-made classification systems.



1 Biodiversity

Biodiversity is the variety of living organisms on Earth. Biodiversity can be looked at in three ways:

- species diversity is the number of species in any given area
- genetic diversity is the range of genetic differences within a species
- ecological biodiversity is the number of different ecosystems in a given environment.

1.1 Species diversity

- Species diversity describes the variety of species that exist on Earth.
- A species is a group of organisms that look similar and can interbreed to produce fertile offspring. Fertile means that the offspring are able to breed themselves.
- A species shares genes for common features (gene pool).

1.2 Genetic diversity

- Genetic diversity describes the genetic variation within one species.
- The characteristic features that make each organism are carried in the genes.
- Genes are inherited from parents.
- Genes allow a species to adapt to changing environmental conditions.

1.3 Ecological diversity

- Ecological diversity is the variety of ecosystems in a geological area.
- Ecosystems are named according to the landscape and climate in the area.
- In South Africa there are seven biomes: Savanna, Grassland, Nama Karoo, Succulent Karoo, Fynbos, Forest, and Thicket.

Indigenous

2 Endemism

- Indigenous species – living organisms that come from and occur naturally within a country or region.
- Endemic species – living organisms that occur in one area only.
- Alien or exotic species – living organisms that were brought into (imported into) an area or country from another.

2.1 Biodiversity and endemism in South Africa

- South Africa has a rich biodiversity of both living and fossilised organisms.
- It is placed third in the world in terms of biodiversity.
- There are eleven types of biome in the world and South Africa has seven of them.
- South Africa has three world biodiversity 'hot spots' – these are areas with especially high numbers of endemic plant species.

2.2 Biodiversity of international importance in South Africa

- The Cape Floral Kingdom – it is the smallest of the six plant kingdoms in the world, but has the largest number of plant species per square kilometre; almost 80% of the species are endemic
- World-renowned wildlife that attracts millions of tourists – the Kruger National Park; the Big Five (leopard, lion, buffalo, rhino and elephant); coastal wildlife parks (these parks now include the great white sharks and southern right whales to form the so-called 'Big Seven')
- Seventeen wetland sites that support a great diversity of organisms
- A large and varied fossil record – almost 75% of all hominid fossils found in Africa come from South Africa; layers of rock from the Karoo hold the world's richest collection of Therapsid (mammal-like reptile) fossils
- A number of natural or cultural-natural sites have been declared World Heritage Sites.

2.3 Biodiversity is under threat

- Threats to South Africa's biodiversity include:
  - alien species – they can push out indigenous and endemic flora and fauna
  - development –human activities, such as developing new suburbs and clearing land for use by farmers, cause a loss in biodiversity.
- If biodiversity is threatened there are several knock-on effects, for example:
  - Loss in species can cause food chains and food webs to collapse.
  - Loss of natural heritage makes South Africa a less interesting place. This affects tourism and national income negatively, can lead to job losses, cause unemployment, an increase in stress and more crime.
  - Loss of fauna and flora could mean a loss of possible cures to diseases.
  - Some food and energy sources for people will be lost.
  - The number of endangered species on Red Data lists will increase.

3 Classification of organisms

- Sorting and grouping organisms according to similar features is called classification or taxonomy.
  - Classification – identifying organisms
  - Taxonomy – classifying organisms into large groups or taxa according to similar and different characteristic features

- Taxonomy has two branches: nomenclature and systematics.
  - Nomenclature – naming organisms
  - Systematics – classifying organisms and species based on related characteristics and features.

3.1 History of classification

- Aristotle classified all living organisms into the Two Kingdom System: the plants and animals. (Microscopic organisms had not been discovered.)
- Carolus Linnaeus introduced a hierarchical system to classify living things from simple to complex. He also gave each organism a two-part Latin name – this is known as binomial nomenclature. The first part of the name indicates the genus and the second part the species to which the organism belongs.
- Robert Whittaker developed the Five Kingdom System:
  1 Kingdom: Monera – prokaryotic organisms such as bacteria
  2 Kingdom: Protista – primitive eukaryotic organisms such as algae
  3 Kingdom: Mycota – only fungi, like mushrooms
  4 Kingdom: Metaphyta or Plantae – advanced eukaryotic plants
  5 Kingdom: Metazoa or Animalia – all multicellular animals.
- Dr Carl Woese developed a Three Domain System, which contains kingdoms in each domain.
  1 Eubacteria: prokaryotic bacteria
  2 Archaea: prokaryotic bacteria that live in extreme environments such as icy cold, and hot thermal vents in the oceans
  3 Eukarya: make up the other kingdoms Monera (Protista), Fungi, Plantae and Animalia.

3.2 Organisms are classified into prokaryotes and eukaryotes

All cells fall into one of the two major classifications: prokaryotes or eukaryotes.

- Prokaryotes – unicellular or multicellular organisms with cells that do not contain a membrane-bound nucleus. DNA is found in the cytoplasm.
- Eukaryotes – unicellular or multicellular organisms with cells that have a true membrane-bound nucleus.

Table 9.1 Differences between prokaryotic and eukaryotic cells

Prokaryotic cells	Eukaryotic cells
Most primitive: earliest form of life	More modern: later forms of life
Do not have a pre-defined nucleus	Have a well-defined, membrane-bound nucleus
DNA spread around in the cytoplasm	True nuclei in which DNA is compacted as chromatin
Have circular chromosomes (plasmids)	Have linear DNA
Contain no membrane-bound organelles	Contain membrane-bound organelles
Most metabolically diverse	Metabolically similar
Very small	Larger
No or primitive cytoskeleton structures	Have a complex cytoskeleton
Small ribosomes	Larger ribosomes
Don't undergo meiosis but reproduce sexually by the transfer of DNA fragments through conjugation	Reproduce sexually using meiosis

3.3 The Five Kingdom System of classification

The Five Kingdom classification system uses prokaryotic and eukaryotic features to organise organisms and features associated with feeding and nutrition:

- Autotrophic – the organism is able to make its own food by using light energy or the energy released from chemical reactions.
- Heterotrophic – the organism is not able to make its own food; gets its food by eating other organisms or by-products.
- Saprotrophic (saprophytic) – the organism feeds on dead organic material.

Table 9.2 The Five Kingdom System of classification

Domain	Kingdom	Major characteristics	Example(s)
Archaea	Monera	• Microscopic unicellular prokaryotes • Can be autotrophic or heterotrophic • Known as the 'living fossils' • Live in extreme environments like salty lakes and boiling hot springs	Pyrolobus fumarii lives in temperatures over 100 °C
Bacteria		• Microscopic unicellular prokaryotes • Can be autotrophic or heterotrophic • Some useful, e.g. for fermentation and decomposition of dead material • Some harmful, e.g. cause diseases	Vibrio cholerae causes cholera
Eukarya	Protista	• Protozoa are unicellular or multicellular eukaryotes • Algae are autotrophic – produce own food through photosynthesis • Most are heterotrophic – cannot make own food by photosynthesis	Algae and protozoa
	Mycota (Fungi)	• Multicellular eukaryotes • Heterotrophic – absorb nutrients from dead or living organisms • Some parasitic, e.g. fungus that causes the disease athlete's foot • Cannot produce own food	Yeast, mushrooms and moulds
	Plantae	• Plants are multicellular, eukaryotic organisms • Green plants have cells with walls of cellulose, and nuclei • Green plants are autotrophic – have chlorophyll and photosynthesise	Mosses (bryophytes), ferns (seedless vascular plants) and all plants that produce seeds, either from flowers (angiosperms) or from cones (gymnosperms)
	Animalia	• Animals are eukaryotic, multicellular organisms • Cells have nuclei but no cell walls and no chlorophyll for photosynthesis • Heterotrophic and feed on other organisms • Can live in water (aquatic) or on land (terrestrial)	Insects, tapeworms, roundworms, birds, fish and mammals

3.4 Naming things in Science using the binomial system

- The binomial system of naming uses:
  - a generic or genus name – begins with a capital letter
  - a specific or species name – begins with a small letter.
- Scientific names of organisms must be printed in italic or underlined if you are writing by hand.

Table 9.3 Taxonomic classification of living organisms using common examples

Classification levels	Organisms				
	Pea	**Fruit fly**	**Dog**	**Domestic**	**Human**
Domain	Eukarya	Eukarya	Eukarya	Eukarya	Eukarya
Kingdom	Plantae	Animalia	Animalia	Animalia	Animalia
Phylum	Magnoliophyta	Arthropoda	Chordata	Chordata	Chordata
Class	Magnoliopsida	Insecta	Mammalia	Mammalia	Mammalia
Order	Fabales	Diptera	Carnivora	Carnivora	Carnivora
Family	Fabaceae	Drosophilidae	Canidae	Felidae	Hominidae
Genus	*Pisum*	*Drosophila*	*Canes*	*Felis*	*Homo*
Species	*P. sativum*	*D. melanogaster*	*C. familiaris*	*F. domesticus*	*H. sapiens*

3.4.1 Using Latin to name organisms

- Latin was the language of the international scientific world when taxonomy was developed. Today, the classical binomial system is still used all over the world and is part of all scientific literature.
- The International Congress of Botanists and Zoologists regulates the naming system and continues the tradition for newly discovered organisms.

3.4.2 Classification keys

- We use a classification key to name and identify unknown plants and animals.
- A classification key is a list of an organism's visible features that can be seen and compared to the unknown organism you want to identify.
- Scientists use a dichotomous key which consists of pairs of statements about visible characteristics of an organism.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 The scientist responsible for introducing the system of naming organisms using a two-part scientific name is:

A Linnaeus
B Whittaker
C Woese
D Aristotle. (2)

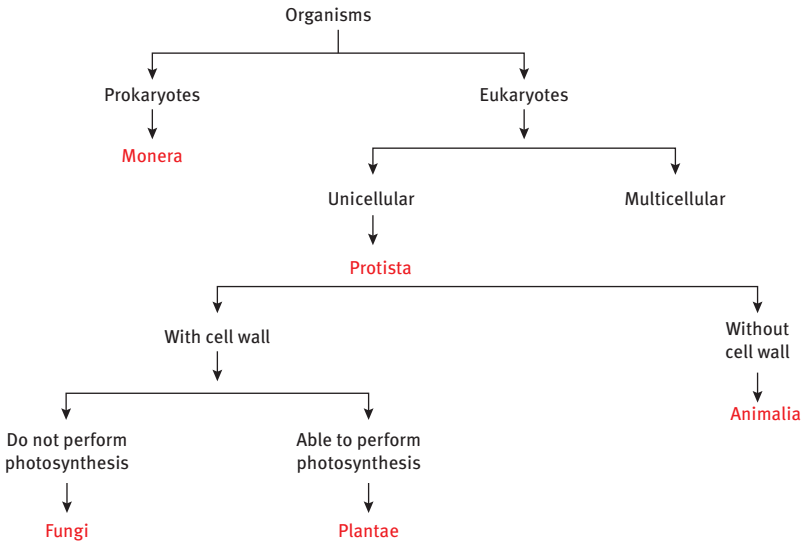
1.2 The Two Kingdom classification system was developed by:

A Linnaeus
B Whittaker
C Woese
D Aristotle. (2)

1.3 The Five Kingdom classification system was developed by:

A Linnaeus
B Whittaker
C Woese
D Aristotle. (2)

1.4 Which classification system does the diagram below represent?



A The Two Kingdom classification system
B The Three Kingdom classification system
C The Four Kingdom classification system
D The Five Kingdom classification system (2)

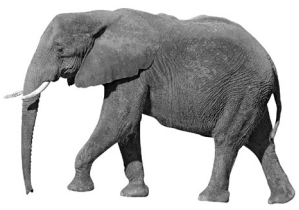
1.5 A dichotomous key:
A provides two choices per characteristic
B is used to identify and name unknown organisms
C uses visible features to organise organisms
D makes use of all of the above. (2)

1.6 The diagram shows a flowering plant. Using the key, identify this plant.

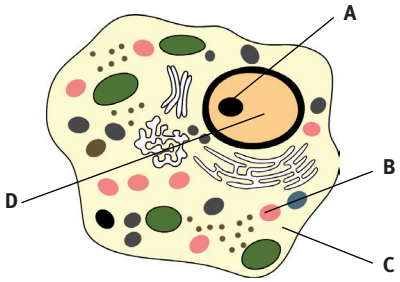
1	three petals ..... more than three petals	go to 2 go to 3
2	leaves longer than they are wide ..... leaves wider than they are long	A B
3	leaves parallel-veined ..... leaves not parallel-veined	C D

(2)

1.7 The diagram shows an animal whose scientific name is *Loxodonta africana*.
To which species does it belong?
A *africana*
B *Loxodonta*
C mammal
D vertebrate (2)

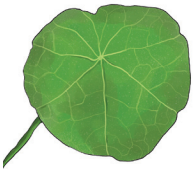


1.8 The diagram shows a eukaryotic cell.
Which part contains chromosomes?



(2)

1.9 The diagram shows a leaf.
Use the key to identify the leaf.



1	Leaf with several small leaflets ..... Leaf with one large leaf blade	go to 2 go to 3
2	Leaflets broad and flat ..... Leaflets narrow and hair-like	A B
3	Leaf with smooth edge ..... Leaf with toothed edge	C D

(2)

1.10 Which of the information about prokaryotic and eukaryotic cells is incorrect?

	Prokaryotic cell	Eukaryotic cell
A	Earliest form of life	Later form of life
B	Have a well-defined, membrane-bound nucleus	No pre-defined nucleus
C	DNA spread around in the cytoplasm	True nucleus in which DNA is compacted as chromatin
D	Circular chromosomes (plasmids)	Linear DNA

(2) [20]

Question 2: True/false

Read each of the statements 2.1 to 2.5 provided below.
Decide if each statement is scientifically correct or incorrect.
If correct, write down the word 'true' next to the question number.
If incorrect, write down the word 'false' next to the question number, and rewrite the sentence to show the change made by underlining the changed text.

2.1 Nomenclature is identifying organisms.
2.2 The Two Kingdom System only logically organises animals and plants.
2.3 The domain Eubacteria are bacteria that live in extreme environments.
2.4 Endemic species are organisms that live within a certain country only.
2.5 The kingdom Mycota contains mushrooms. [10]

Question 3: Scientific terminology

Define each of the following terms. Write the definitions next to each question number.

3.1 prokaryotic (1)
3.2 classification (1)
3.3 eukaryotic (1)
3.4 nomenclature (1)
3.5 systematics (1)
3.6 binomial (1)
3.7 Eubacteria (1)
3.8 Mycota (1)
3.9 Monera (1)
3.10 Archaea (1) [10]

Question 4: Matching columns

Match the description in COLUMN I with the term in COLUMN II.
Write only the letter (A–L) next to the question number (4.1–4.10).

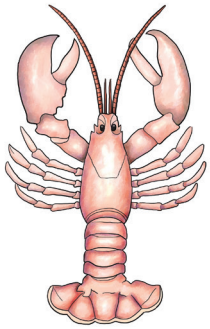
COLUMN I		COLUMN II	
4.1	Metaphyta	A	Aristotle
4.2	Monera	B	Bacteria that live in extreme conditions
4.3	Two Kingdom system	C	Eukaryotic plants
4.4	Archaea	D	Linnaeus
4.5	Metazoa	E	Fungi, plants and animals
4.6	Eukarya	F	Prokaryotic bacteria
4.7	Protista	G	Whittaker
4.8	Mycota	H	Eukaryotic animals
4.9	Five Kingdom system	I	Eukaryotic fungi
4.10	Genus and species	J	Eukaryotic algae

[10]

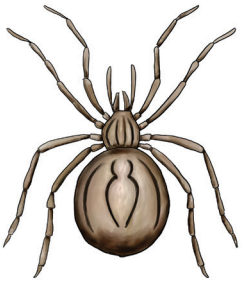
Question 5: Short response

5.1 Study specimens A to D below.

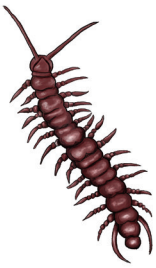
5.1.1 Use the following key to identify each of the animals. They are not drawn to scale.



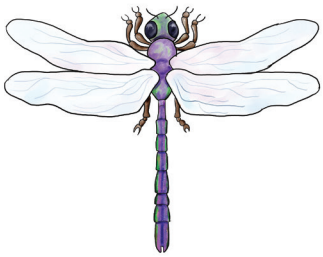
Specimen A



Specimen B



Specimen C



Specimen D

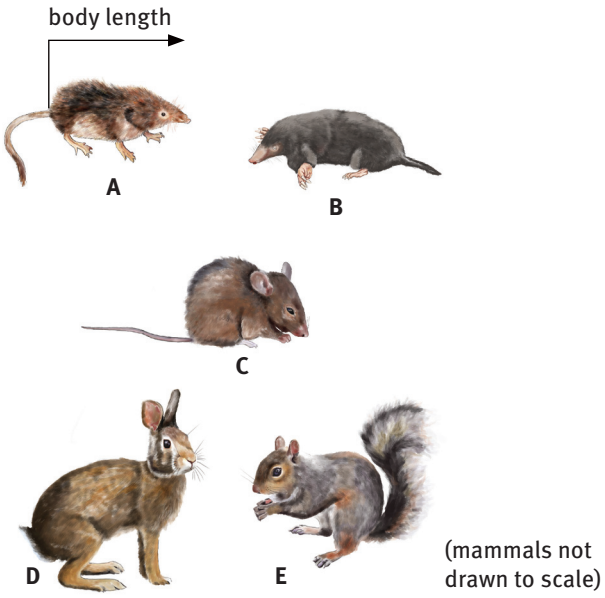
1	More than 4 pairs of legs..... 4 pairs of legs or less.....	Lithobiomorpha go to 2
2	4 pairs of legs..... 3 pairs of legs.....	go to 3 go to 4
3	2 pairs of jointed antennae..... No jointed antenna.....	Decapoda Araneae
4	1 pair of wings..... 2 pairs of wings.....	Diptera Odonata

(8)

5.1.2 State TWO common visible characteristics that these organisms share which can be used to classify them into a common group. (4)

5.2 Study the diagrams of mammals A to E below.

Use the key to identify each of the mammals A to E.
Write down the letter for each mammal and their classification.



(mammals not drawn to scale)

1	Tail more than half that of body length..... Tail less than half that of body length.....	go to 2 go to 4
2	Ears at top of head, with thick tail..... Ears at side of head, with thin tail.....	Sciurus caroliniensis go to 3
3	Nose pointed, nose length longer than its dep th..... Nose blunt, nose length shorter than its dep th.....	Sorex araneus Clethrionomys glareolus
4	Front legs as wide or wider than long..... Front legs longer than wide.....	Talpa europaea Oryctolagus cuniculus

(10) [22]

Question 6: Tables

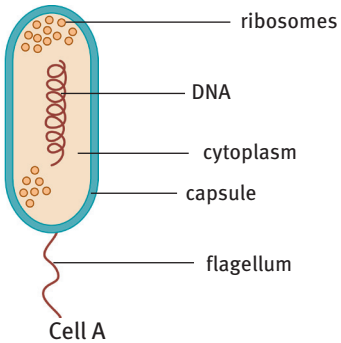
Complete the following table by classifying each organism into its correct kingdom. Place a cross (×) in the correct column.

	Kingdom				
Organism	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Earthworm					
Bread mould					
Fern					
Seaweed					
Eagle					
Cockroach					
Lily					
Mushroom					
B. cholera					
Snail					

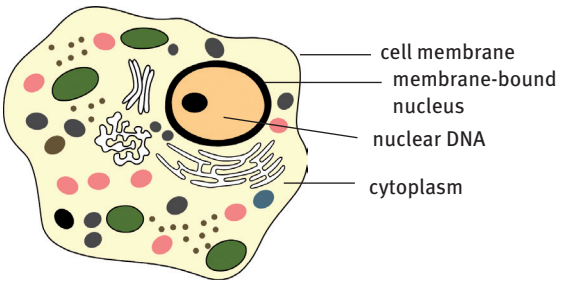
[10]

Question 7: Contextual

Study the diagrams of cells A and B below and answer the questions.
The cells are not drawn to scale.



Cell A



Cell B

7.1 Classify cells A and B into a suitable kingdom. (4)

7.2 Identify each of these cells as a prokaryote or a eukaryote. Provide reasons for your decision. (4) [8]

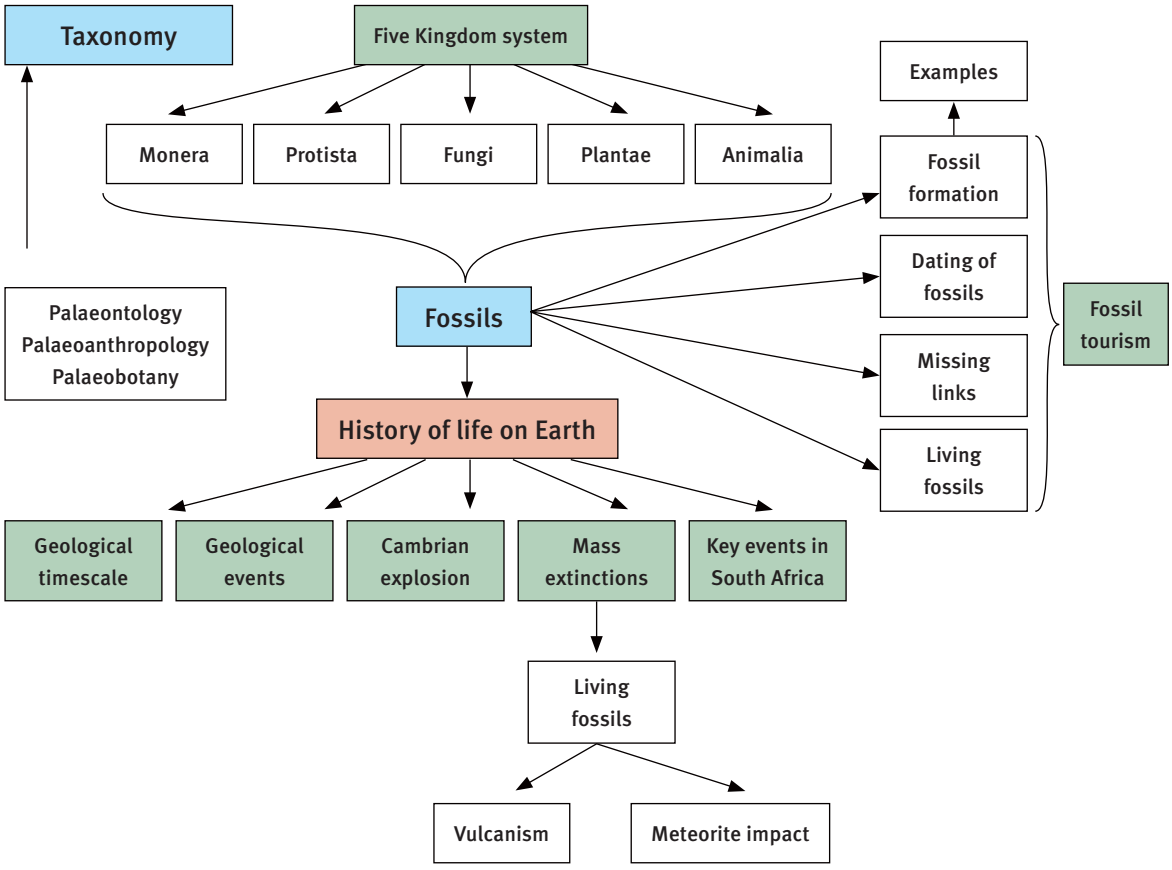
TOTAL MARKS: 90

Topic 11

History of life on Earth

Overview

The first living organisms arose about 3,5 billion years ago. Many have died out and are found today only as fossils. South Africa has a rich fossil record providing evidence of some key events in the history of life on Earth. Changes in the life forms have been caused by climate changes and the movement of continents over millions of years.



1 Life's history

The history of the Earth shows how living and fossil organisms evolved, and stretches about 3,5 billion years from the origin of life on Earth up to today. Common characteristics in all present-day organisms show that they all share ancestor organisms. Over billions of years, all known species diverged and developed through the process of evolution.

The process of divergence of life on Earth occurred as follows:

- The first forms of life were bacteria (single-celled micro-organisms): the Archaea.
- Photosynthesis using oxygen evolved about 3,5 million years ago. It led to the atmosphere being oxygenated.
- Oxygen in the air led to more organisms evolving about 1,9 million years ago: eukaryotes.
- Around 1,7 million years ago, multi-cellular organisms began to appear.
- Algae were the first kind of plant on Earth – they appeared around 1 200 million years ago.
- Land-based plants with veins for carrying nutrients evolved around 450 million years ago.
- Invertebrate animals arose around 600 million years ago.
- A sudden increase in animal life including vertebrates occurred about 525 million years ago.

2 The geological timescale

By dating fossils and their surrounding rock strata palaeontologists have made a 'calendar' of events in the Earth's history, called the geological timescale.

The geological timescale subdivides all time since the end of the Earth's formation (nearly 4 billion years ago) until modern times into units of descending order as aeons, eras, periods and epochs.

The process of evolution is not smooth, and is affected by changing conditions on Earth. The changes fall into two kinds:

- Climate changes – Ice Ages, increases in oxygen and global warming
- Geological events – movement of the continents, volcanic eruptions and meteorite impacts.

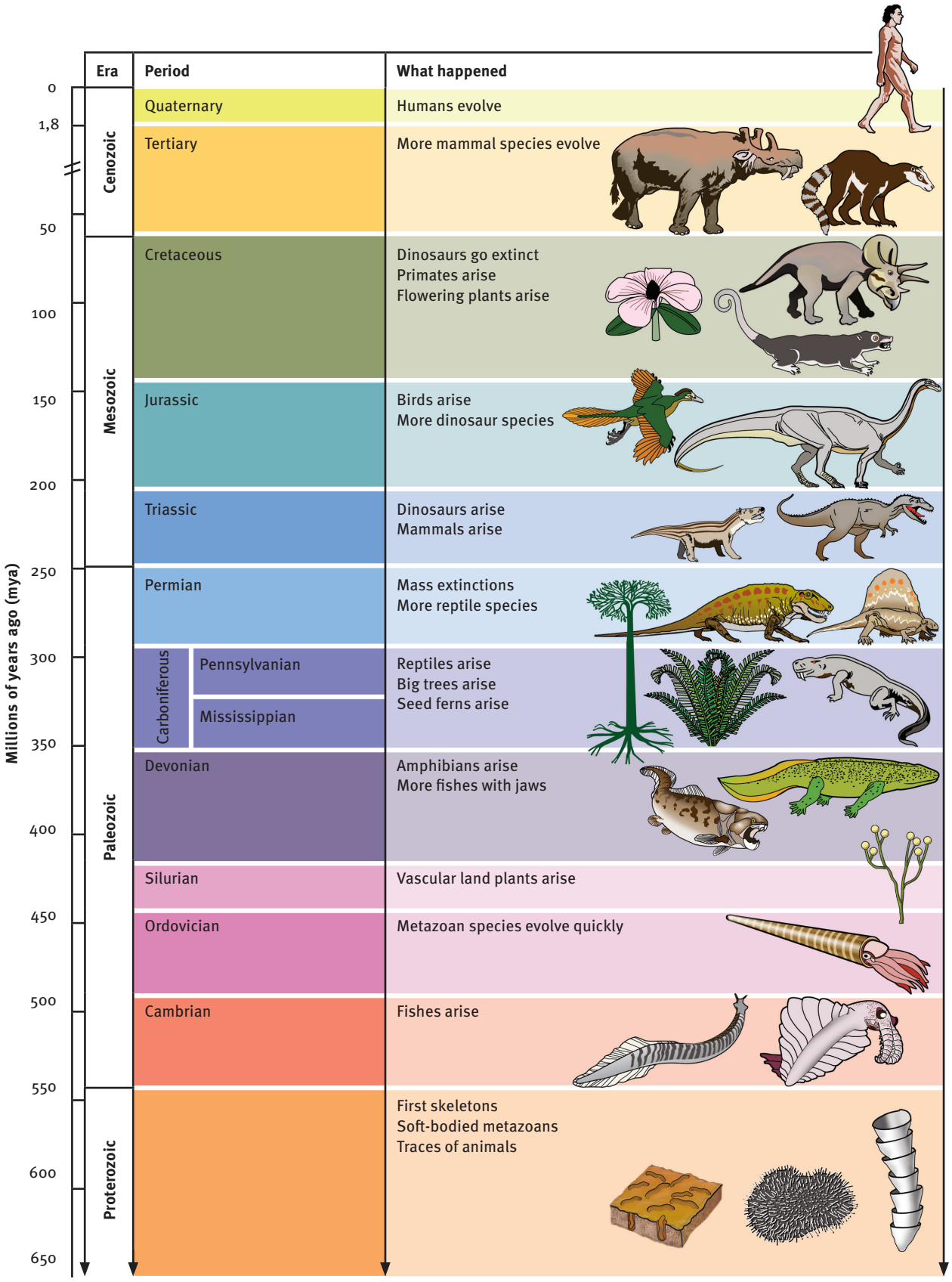


FIGURE 11.1 Geological timescale on Earth with associated life forms

2.1 Using inductive and deductive reasoning

To come up with an explanation of the history of life, scientists use both inductive and deductive reasoning.

2.1.1 Inductive reasoning

- Inductive reasoning – when specific examples are used to make more general rules, ideas or theories.
- Scientists used inductive reasoning to make two important generalisations:
  - The atmosphere of primitive Earth was made up of mainly hydrogen, methane, ammonia, nitrogen and water vapour.
  - Ultraviolet light and lightning changed these gases into organic molecules which were the building blocks of life.
- In the 1920s, the scientists A.I. Oparin in Russia and J.B.S. Haldane in England each came up with an hypothesis that the ultraviolet light and lightning changed the gases into organic molecules such as proteins and fatty acids. These then were the 'building blocks' of life.

2.1.2 Deductive reasoning

- Deductive reasoning – the use of scientific facts, general laws and principles to formulate an idea or hypothesis.
- S.L. Miller's test of the Oparin–Haldane hypothesis – by recreating primitive environmental conditions in a laboratory Miller found that organic molecules were produced from the gases hydrogen, methane, ammonia, nitrogen and water vapour.

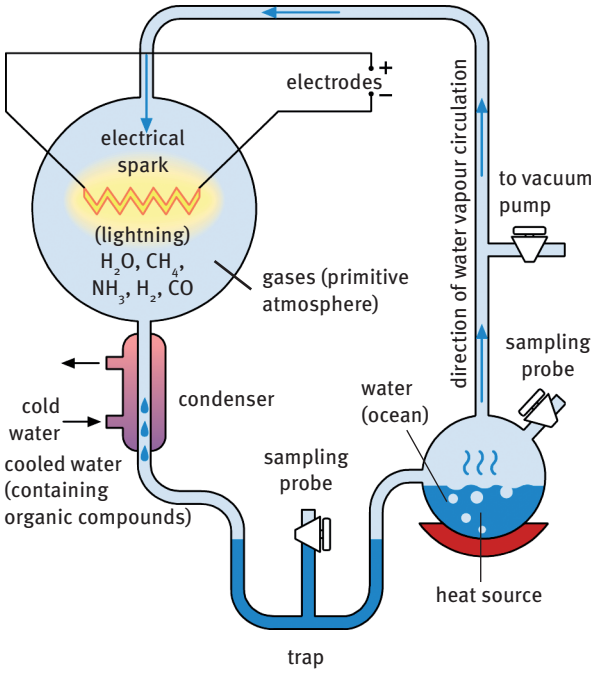


Figure 11.2 Miller's apparatus used to test the Oparin–Haldane hypothesis

3 The Cambrian explosion

- The Cambrian period began 543 million years ago and ended 505 million years ago. It lasted for 38 million years.
- In the first 5–20 million years of the Cambrian period, the major groups of animals appeared.
- These are classified as: Platyhelminthes (flatworms), Nematoda (worms), Annelida (segmented worms), Mollusca (slugs, snails and creatures with shells), Arthropoda (invertebrates with external skeleton and joined limbs), Echinodermata (marine invertebrates) and Chordata (vertebrates – with skeleton).
- From the end of the Cambrian period into the Holocene epoch of the Quaternary period (in which we now live) the fossil record shows that different groups of animals evolved out of those primitive Cambrian forms in this order:
  - fish: about 438 million years ago
  - amphibians: about 380 million years ago
  - reptiles: about 225 million years ago
  - birds: about 180 million years ago
  - mammals: about 150 million years ago
  - humans: about 250 000 to 300 000 thousand years ago.

4 Mass extinctions

- Mass extinctions – periods in the Earth's history when biodiversity suffered a crash, with the number of species enormously reduced.
- There have been five major mass extinctions:
  - First extinction: end of the Ordovician period, 450 million years ago
  - Second extinction: end of the Devonian period, 375 million years ago
  - Third extinction: end of the Permian period, 251 million years ago
  - Fourth extinction: end of the Triassic period, 205 million years ago
  - Fifth extinction: end of the Cretaceous period, 65 million years ago.

4.1 The causes of mass extinctions

There are two types of theory on what caused the mass extinctions:

- Environmental disasters: meteor or asteroid impacts, severe vulcanism, radiation from exploding stars or killer diseases
- Organisms failing to adapt to habitat or environmental changes: changing temperatures of ice and warm ages, global sea level changes and continental drift.

4.1.1 Earth-bound theories of mass extinctions

- Ice Ages:
  - cooling atmosphere
  - formation of large glaciers
  - ocean levels drop due to water trapped in glaciers as ice

- decrease in O_2 levels
- increase in salt (mineral) content of the oceans
- change in natural environments
- extinction of life forms.

Four Ice Ages have been identified in the Earth's history – at 700, 320, 286 and 3 million years ago.

- Continental drift:
  - The Earth's crust is made of continental plates.
  - Continental drift refers to the movement of continental plates apart or together over a period of time.
  - All continents used to be one big land mass (super-continent) called Pangaea.
  - Pangaea broke up into two large masses (225–200 million years ago):
    - Laurasia in the northern hemisphere
    - Gondwanaland in the southern hemisphere.
  - Gondwanaland broke up to form South America, Africa, Madagascar, Australia, India and Antarctica.
  - Laurasia broke up to form North America, Europe, the Middle East, Asia and China.
  - It is the main theory used to explain the formation of glaciers during the Ice Ages.
  - It explains similar geological structures and identical plant and animal fossils found in South America and Africa.

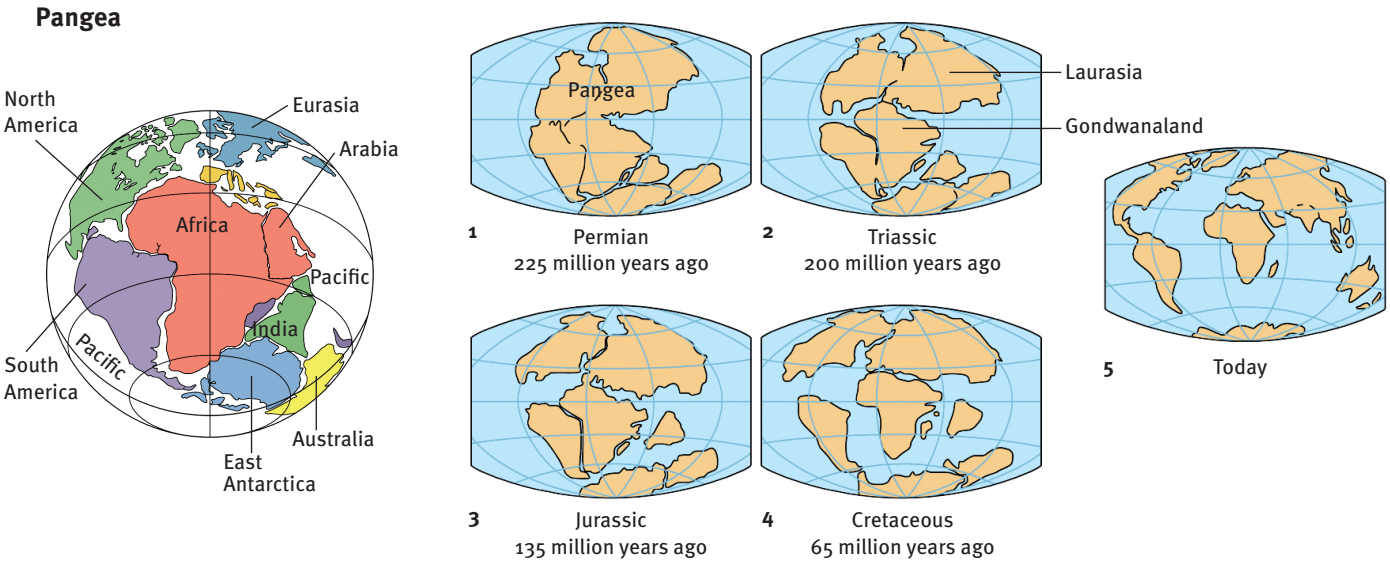


Figure 11.3 Continental drift

- Plate tectonics:
  - movement in the Earth's crust
  - 14 major plates in the Earth's crust
  - plates lie on top of hotter, molten material, allowing plates to move apart
  - plate movement can cause large sections of the lithosphere to be forced upward into the atmosphere and so experience cooler temperatures
  - may have led to climate changes
  - may have caused the Ice Ages.

Bivalve and ammonite fossils have been found on the Makhatini flats in northern KwaZulu-Natal and whale fossils in the Sahara desert – this indicates that these places were once under the sea.

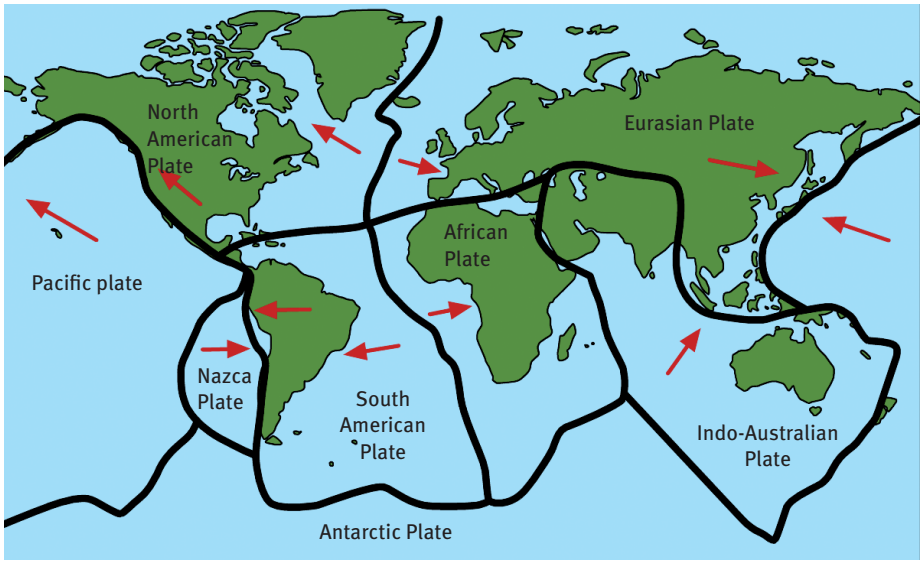


FIGURE 11.4 Tectonic plates

- Volcanic activity:
  - Massive volcanic eruptions have occurred in the Earth's history.
  - Scientists believe that vulcanism was the main cause of three of the known mass extinctions.
  - Huge clouds of volcanic matter and dust in the atmosphere blocked out the sun's rays.
  - This reduced solar radiation and led to the rapid cooling of the Earth and to the spread of glaciers.

- Killer diseases:
  - A change in climate can influence the presence and spread of deadly diseases.
  - A viral and bacterial invasion could kill off huge numbers of organisms.
  - This would have an effect on the survival of other organisms.

4.1.2 Extraterrestrial theories

- Extraterrestrial means from beyond the Earth.
- Meteorites and asteroids have hit Earth during its history.
- Weather patterns and tectonic movement have been affected.
- Examples:
  - The crater in the Gulf of Mexico (caused by an asteroid) – the crater is about 65million years old (time of dinosaur extinction)
  - The Vredefort Dome in the Free State (meteorite impact) – the crater is 100 km in diameter; the meteorite blasted about 16 km into the Earth's crust.
- Dinosaur extinction theory:
  - An asteroid impact melted rocks and caused a 180–300 km-diameter crater, 300 to 1 000 metres deep, in the Gulf of Mexico.
  - Enormous killer tsunamis occurred along coastlines.
  - Sediments were deposited by the tsunamis.
  - The impact caused acid rain and an ash cloud that blocked out the sun for months. This led to severe global cooling known as the 'nuclear winter' which killed off many species.
  - It also increased atmospheric CO_2 which resulted in a period of global warming after the cooling.

4.1.3 The sixth mass extinction

- The rate of extinction of organisms on the Earth at present is higher than at any time in the past.
- 30 000 species per year are becoming extinct.
- Extinction is mainly caused by humans.
- The human population is growing at a fast rate, and humans are each having more of an impact on Earth.
- Industrial activity causes:
  - increased greenhouse gases resulting in global warming
  - air, land and water pollution which causes acid rain
  - ozone depletion which affects climate
  - deforestation and desertification which cause reduced biodiversity.
- Increased urbanisation and agriculture cause:
  - widespread habitat destruction
  - reduced habitats for huge numbers of organisms
  - soil degradation through monoculture, over-farming and fertiliser application
  - deforestation, desertification and pollution.

5 Fossils and missing links

- Fossils – the remains, impressions or traces of ancient life forms, which have been preserved in the Earth's crust for thousands of years
- Most creatures found as fossils are extinct; however, some still live on Earth today.
- Organisms that are found as fossils and as living specimens on Earth today are known as living fossils.
- The study of fossils is called palaeontology, and the process by which dead organisms or their parts are changed into fossils is called fossilisation.
- Fossils can form in different ways: covered by sediment, volcanic ash or resin (amber).
- Fossils may be:
  - macrofossils – large bodies and parts
  - microfossils – microscopic organisms and parts.
- Fossils types:
  - full body fossils – dead organisms preserved in their complete form; replacement; permineralisation; mould/cast
  - compression fossils – full body skeletons and soft-bodied organisms
  - trace fossils – organism traces such as a footprint; teeth; eggs.

5.1 How fossils form

- The process of fossil formation in sedimentary rock usually happens as follows:
  1. A freshly dead carcass of an animal or body part of a plant
  2. is covered with mud
  3. decomposes or is broken down by scavengers
  4. gets buried under more layers of mud and sand over time
  5. the buried skeleton or full body is exposed to high pressures and temperatures
  6. the compounds in the bones of the animal are replaced by molecules of silica or carbonate
  7. the skeleton or body turns into rock and becomes a fossil.
- Eventually the fossil might be lifted up to the surface by movement of the Earth's crust, or exposed by erosion so that it is discovered by a palaeontologist.
- The chances of an organism becoming a fossil are very small.
- Soft-bodied organisms decay and disappear very quickly, so the right conditions must be present.
- Organisms may be preserved as fossils in their original form or they may change as they become fossilised.

5.1.1 Fossils preserved in their original form

- The soft parts of animals or plants are very rarely preserved.
- Examples of fossils preserved in their original form are:
  - whole insects that got stuck and were preserved in amber (ancient resin from trees)
  - whole mammoths that have been preserved, frozen, in deep ice in very cold regions.

5.1.2 Fossils preserved in changed form

- Such fossils are no longer the actual organisms but have solid parts filled with a different substance.
- Organisms with a solid and resistant skeleton are easily preserved, so most fossils are made of the remaining bones, teeth and shells of ancient animals once their soft parts are decayed.
- They are found in sedimentary rocks.

Petrified or replacement body fossils

- In this process an organism becomes buried under layers of sand and mud.
- The remains become soaked in water that contains silica or calcium carbonate.
- Slowly the silica or calcium carbonate replaces the tissue of the dead organism, and then becomes hard.
- The organism has become petrified.

Permineralisation body fossils

- The hard parts of an organism, such as bone, gradually decay.
- Mineral salts move into the pores.
- Crystals harden and form a rock-like copy of the hard parts.
- See the process of fossil formation – 5.1 above.

Mould or cast fossils

- The remains of an organism are preserved in rock, but later get dissolved.
- Acid groundwater dissolves the crystallised remains, forming a mould.
- This also happens when bodies are caught under volcanic larva and ash.
- A hole in the shape of the organism's remains is left behind –this is called a fossil mould.
- If the mould is filled up with sediment it hardens in the shape of the original organism, forming a cast.

Compression fossils

- A compression fossil is formed when the shape of an organism is preserved in rock; for example, a leaf or a fish.
- Under high pressures and temperatures the organism is heated, compressed and solidified.

Trace fossils

- A trace fossil is formed when some trace or evidence of an organism is fossilised.
- Examples: a footprint, an animal's burrow, a tooth, an egg
- The actual remains of the organism are not preserved.

5.2 The incomplete fossil record

- There are still large gaps in our knowledge about fossils and in the fossil record.
- Only a few of the ancient organisms are preserved as fossils. This is because they had to be covered soon after death, or they were decomposed by bacteria.
- Only organisms with a solid and resistant skeleton are easily preserved.
- We have not found all the fossils that exist in the Earth.

5.2.1 Missing links in the fossil record

- A missing link is an organism that is thought to be an intermediate between old and new groups in the fossil record.
- Some known missing links are:
  - the coelacanth – living and fossilised link between the fishes and amphibians
  - *Archaeopteryx* – fossilised link between the dinosaurs and birds
  - *Thrinaxodon* – fossilised link between reptiles and mammals.

***Latimeria chalumnae* (the coelacanth) – a living fossil in South Africa**

- Scientists discovered coelacanth fossils and thought that the ancient fish had become extinct about 65 million years ago.
- Then a living specimen – a living fossil – was caught in the mouth of the Chalumna River near East London, in 1938.
- Coelacanth is the common name.
- *Latimeria chalumnae* is the coelacanth's taxonomic name.
- It is a transition fossil between the fish and reptiles.

***Archaeopteryx* – the link between reptiles and birds**

- *Archaeopteryx* is the first known bird.
- Its fossilised remains were found in the nineteenth century in limestone in Solnhofen, Germany.
- *Archaeopteryx* had well-developed wings; teeth; well-developed hind limbs and a long tail; it had feathers growing from each vertebra; the whole body was covered with feathers.
- It is an intermediate between birds and small carnivorous lizard dinosaurs.
- *Archaeopteryx* lived during the late Jurassic period, about 147 million years ago and is one of the best examples of evolution.

***Thrinaxodon* – the link between reptiles and mammals**

- This animal lived during the Triassic period, 248–245 million years ago.
- Fossilised remains have been found in South Africa and Antarctica – showing that the two continents were once joined together as Gondwanaland.
- *Thrinaxodon* was cat-sized, had sharp teeth and claws, and was a carnivore. It is believed to be the link between reptiles and mammals. Why? Little holes in the skull suggest that *Thrinaxodon* had whiskers, and it can be deduced that it had a protective covering of fur. It was probably also warm-blooded, like mammals, but it laid eggs, and its skeleton had other reptilian features. It had developed better lungs than its ancestors. *Thrinaxodon* probably dug and lived in shallow burrows in hillsides or riverbanks. It probably ate creatures like insects, and smaller reptiles like lizards.

5.3 Methods used to date fossils

- Two methods are used to date fossils:
  - relative dating
  - radiometric dating.
- Fossil dating means the date when the fossil was formed.

5.3.1 Relative dating

- Relative dating – determines the age of the fossil relative to the age of another fossil, or a geological event such as a volcanic eruption.
- Relative dating can only tell us whether a particular fossil was formed before or after another fossil or geological event.
- In rock strata where the original layers are still intact, fossils in the lower layer are older than fossils in the upper layer.
- Natural events like earthquakes, volcanic eruptions and weathering processes can upset the layers and relative dating becomes difficult.
- Scientist then use what are called 'index fossils'. These are fossils that are unique to a particular time period. They help to date the strata and the associated fossils.
- A typical index fossil is the trilobite that lived in the oceans during the Palaeozoic era; trilobites became extinct at the end of the era, and are specific to that period of time.
- Ammonites are another example of index fossils.
- Figure 11.5 shows how relative dating works.
  - Layers 6 and 19 are the same age because the same fossils are found in them.
  - Layers 12 and 23 are the same age because the same fossils are found in them.

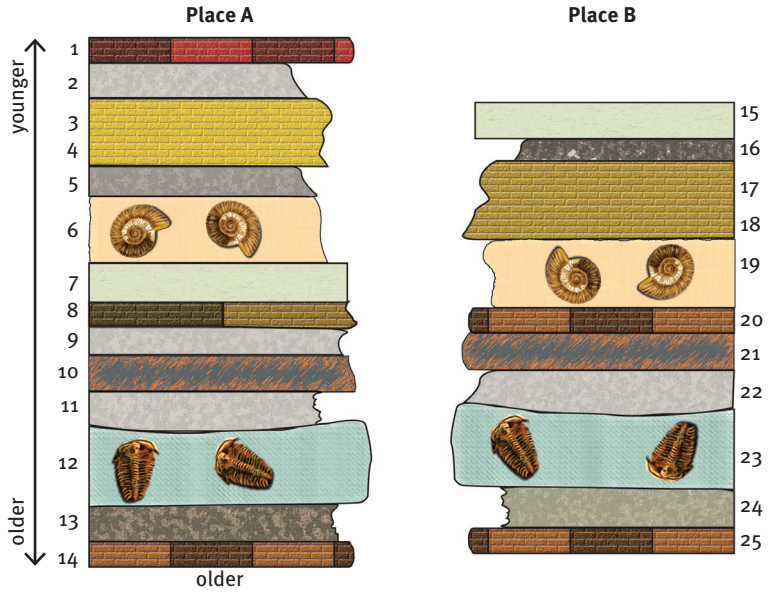
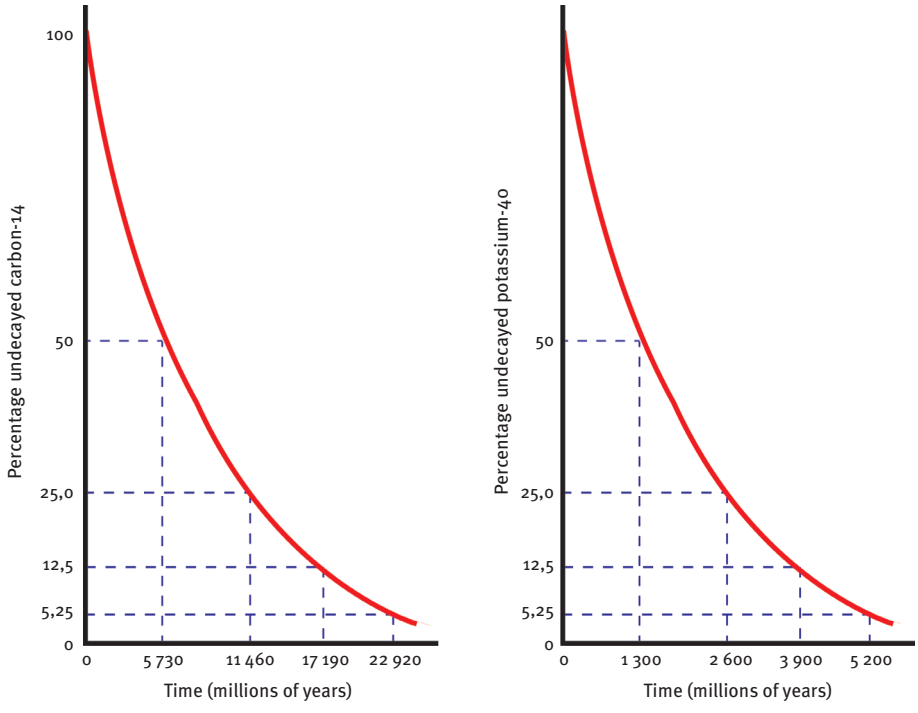


FIGURE 11.5 Relative dating of fossils

5.3.2 Radiometric dating

- Radiometric dating (absolute dating) – gives a more accurate age to a fossil.
- Radioactive isotopes of certain mineral elements are used.
- Isotopes of certain elements break down (decay) over time to form other elements.
- The rate (time taken) at which they decay is known as the isotope's half-life.
- Radiometric dating can date both fossils and the surrounding strata.
- Dating occurs by calculating the ratio between the original amount of radioactive isotopes present and the amount now remaining.
- Isotopes of carbon, uranium, potassium and others are used.



A Decay of carbon-14 **B Decay of potassium-40**

FIGURE 11.6 Radiometric dating of fossils

6 Southern African evidence for key events

Southern Africa has a rich source of fossil evidence for the history of life on Earth. Fossils are found at unique places that are associated with the development of the Earth and the history of Gondwanaland.

6.1 Soft-bodied animal fossils in Namibia

- Ediacaran fossils, preserved in sandstone beds, were first found in Namibia.
- They are about 600–543 million years old.
- They are now found world-wide and are thought to be the first evidence of complex, multi-cellular life on the planet. They were filled with body fluid. They had no skeletons or hard parts to their bodies.
- Palaeontologists think they are the remains of large lichens.

6.2 Early plants near Grahamstown

- Lycophytes were simple land plants that had developed simple conducting tissues (tubes) for carrying nutrients.
- They are called primitive vascular plants because of this.
- Later they also developed downward-growing roots and upward-growing stems.
- Fossils of Lycophytes are found in the Grahamstown district.

6.3 Forests of trees near Mooi River and Estcourt

- Many fossilised plants from Permian times are found.
- The genus *Glossopteris* bore seeds in cones, was found in forests and had long straight leaves.
- Fossils have been found in the coal fields of South Africa.
- The genus is also found in Australia, Antarctica and South America and so is evidence for the theory of continental drift.
- *Glossopteris* forests died out about 251 million years ago during the Permian mass extinction.

6.4 Mammal-like reptiles in the Karoo

- The Karoo has fossils of more primitive reptiles, amphibians, fish, molluscs, insects and simpler organisms.
- Many *Therapsid* fossils and footprints of are found in the Karoo. *Therapsid* was a mammal-like animal, about 45 cm long and lived about 225 million years ago.
- *Thrinaxodon* and *Lystrosaurus* are other well-known fossils.
- *Lystrosaurus* was the size of a pig and had powerful front legs to dig burrows.
- Silica has replaced the original bones to form perfect fossil copies.

6.5 The coelacanth in East London

- The coelacanth had been known in fossilised form.
- On 23 December 1938, a live coelacanth was fished out of the sea.
- It is a living fossil.

6.6 Dinosaurs and first mammals – Eastern Cape and Lesotho

- The Maluti Mountains in Lesotho have fossils of dinosaurs and examples of first mammals.
- The Melkhoutboom cave in the Eastern Cape shows origins of early human existence.

6.7 Dinosaurs – South Africa, Lesotho and Zimbabwe

- The Drakensberg and Maluti mountains are fossil sites of the dinosaur *Euskelosaurus*.
- This was a semi-bipedal dinosaur from the late Triassic period.
- *Euskelosaurus* was about 9 m long and 3 m high.

6.8 The first humans at various South African sites

- The Cradle of Humankind is a World Heritage Site in Gauteng and includes the region around the Sterkfontein caves, Swartkrans and Kromdraai.
- It is rich in hominid fossils – giving evidence of human evolution over the past 3,5 million years.
- 'Mrs Ples' is the nickname of a hominid skull that was discovered at Sterkfontein in 1947 by Dr Robert Broom.
- Mrs Ples is the world's most complete skull of the species *Australopithecus africanus*.
- The skull of a 3-year-old *Australopithecus*, named the Taung child, was found at Taung in the North West Province.
- Makapansgat Valley in Limpopo is another famous fossil site.
- *Australopithecus sediba* is a recently discovered hominid species, found by Mathew Berger at Sterkfontein in 2010. It was given the short name Karabo ('answer' in Setswana).
- The 'Out of Africa Hypothesis' is a modern theory of human origin. It is based on fossil evidence and suggests that modern man (*Homo sapiens*) evolved in Africa, migrated out of Africa and replaced all other human populations.

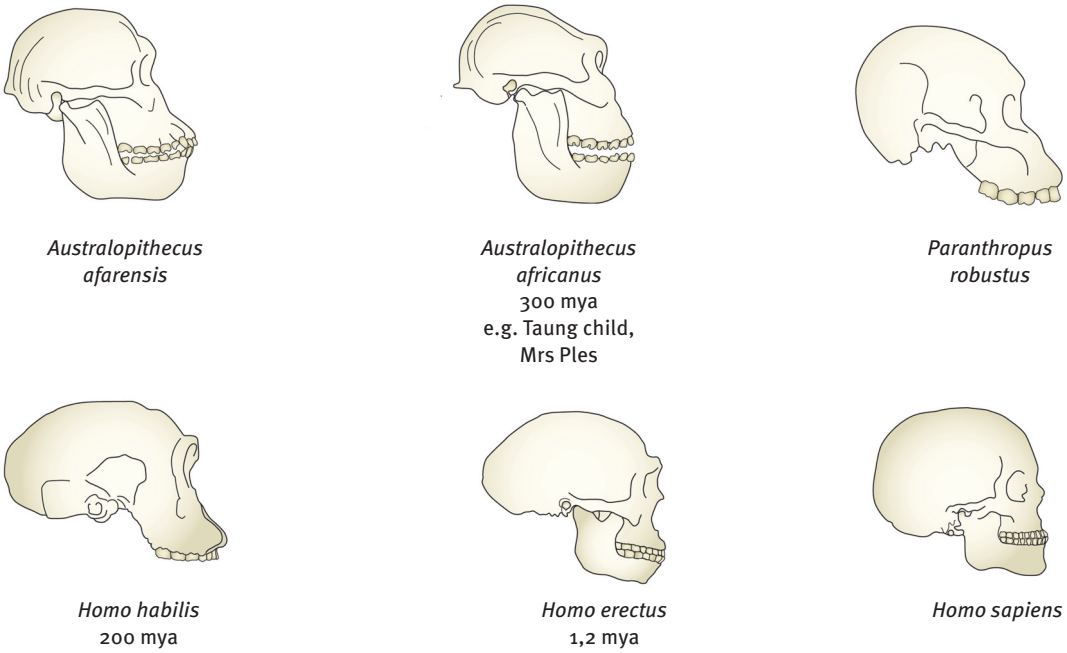


Figure 11.7 Hominid skulls

6.9 Fossilised bacteria from Barberton

- The oldest forms of life are the fossils of simple bacteria, over 3,5 billion years old.
- Well-preserved fossil remains of primitive fossil Archaea bacteria have been found in the Barberton Greenstone Belt in Mpumalanga.

7 Fossil tourism and opportunities

Many of the places where fossils are found have been developed for tourism. This creates jobs for people, and so helps communities and the country.

Below are three examples of important fossil tourism sites.

7.1 The Karoo National Park in the Western Cape

- The Karoo National Park near Beaufort West has a fossil trail (including a Braille trail for blind visitors) where tourists can see fossils and learn about the interesting geology of the area.
- The wider Karoo area has fossils of pre-dinosaurs, dinosaurs, early reptiles and Therapsid species.

7.2 The Cradle of Humankind in Gauteng

- The Cradle of Humankind World Heritage Site in Gauteng has been developed into a modern educational and tourism centre.
- Inside are interactive, hands-on exhibits such as an adventure boat ride 'through time'.

- At the Sterkfontein Centre, about 10 kilometres away, visitors can go on informative guided tours into the caves where famous hominid fossils were – and still are being – discovered.

7.3 West Coast Fossil Park at Langebaan, Western Cape

- Fossils were discovered at Langebaanweg in the late 1950s.
- The site is one of the richest fossil sites in the world – not only because there are so many different kinds of fossils, but also because the fossils are so well preserved.
- One important discovery was that of Agriotherium africanum, the first bear fossil ever found in Africa south of the Sahara.
- Fossils of extinct seals and penguins have also been found here.

Questions

Question 1: Multiple choice

Various answers are provided to each question. Choose the correct answer. Only write the letter of the answer you select next to the question number.

1.1 Scientists define evolution as:

A an explanation of the origin of life
B just a controversial theory
C how species have changed over time
D a form of intelligent design. (2)

1.2 What are the remains of living organisms called?

A strata
B fossils
C evolution
D minerals (2)

1.3 According to the fossil record, 99% of organisms that lived on Earth are:

A endangered
B surviving
C mutating
D extinct. (2)

1.4 Evidence for past events that have occurred during Earth's ancient history is recorded in:

A history books
B written timelines
C fossils within rocks
D clothes people wore. (2)

1.5 The fossil record supports Darwin's theory of evolution by demonstrating that plants and animals:

A have changed over time
B existed for only a few thousands of years
C are the same in various environments
D remain unchanged until extinction. (2)

1.6 Scientists have discovered fossils of whale ancestors that have well developed hip and thigh bones, which are typically used for walking by mammals. Modern whales most likely evolved from ancestors who:

A lived in the sea, then became better adapted for land
B lived on land, then became better adapted for the sea
C evolved in the sea and remained in the sea
D evolved on land and remained on land. (2)

1.7 Fossils of shellfish and snails are commonly found in the Las Vegas valley. What can you infer about the environmental conditions in the Las Vegas valley millions of years ago? The Las Vegas valley:

A was always a desert
B was once a forest
C once contained a glacier
D once contained a shallow sea. (2)

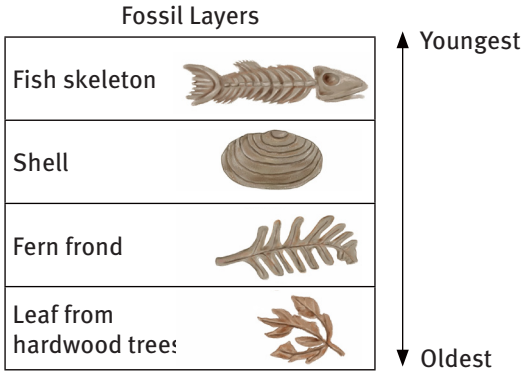
1.8 In order to determine the relative age of fossils, scientists may use a type of fossil known as a(n):

A index fossil
B radioactive fossil
C relative fossil
D absolute fossil. (2)

1.9 In order to be considered a useful index fossil, an organism must have lived for a:

A short period of time in a wide geographical region
B short period of time in a narrow geographical region
C long period of time in a wide geographical region
D long period of time in a narrow geographical region. (2)

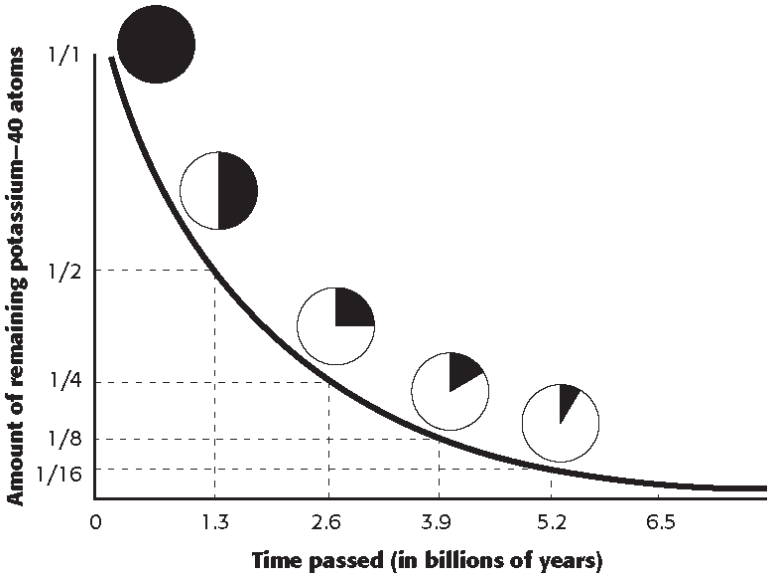
1.10 Several fossils were uncovered in different layers of rock in a desert area. The following diagram indicates the age of the layers of rock and the fossils found in each.



Based on the fossils found, this area was most likely once a:

A lake that was replaced by a forest
B forest that was replaced by a sea
C rainforest that was replaced by a forest
D forest that was replaced by grassland. (2)

1.11 The following graph shows the half-life of potassium-40 over time.



© Holt

After three half-lives have passed, how much of the original element is present in the specimen?

A ½
B ¼
C ⅛
D 1/16 (2)

1.12 Fossils are most commonly preserved in which type of rock?

A igneous rock
B metamorphic rock
C sedimentary rock
D transitional rock (2)

1.13 Which of the following is an example of a trace fossil?

A footprint from a dinosaur
B insect preserved in amber
C mammoth frozen in the ground
D piece of petrified wood (2)

1.14 Which statement is NOT a weakness of the fossil record?

A Since only animals fossilise, the evolutionary history of plants cannot be studied using fossils.
B Large numbers of species may have died under conditions where their bodies were not fossilised.
C The fossil record is biased because most preserved organisms contain hard body structures.
D The fossil record is biased because it favours organisms that were widespread and abundant. (2)

1.15 The body of an animal is more likely to become fossilised if it:

A remains on the surface after death
B does not contain hard body parts
C dies in a moist environment
D is buried before it decomposes. (2)

1.16 Why are fossils of hard-bodied organisms more common than soft-bodied organisms?

A The fossils of soft-bodied organisms preserve better than hard structures.
B The fossils of hard-bodied organisms preserve better than soft structures.
C There are more organisms with hard structures in aquatic environments.
D There are more organisms with soft structures in land environments. (2)

[32]

Question 2: True/false

Read each of the statements 2.1–2.5 provided below.
Decide if each statement is scientifically *correct* or *incorrect*.
If *correct*, write down the word 'true' next to the question number.
If *incorrect*, write down the word 'false' next to the question number, and *rewrite the sentence* to show the change made by underlining the changed text.

2.1 Radiometric dating occurs by calculating the ratio between the original amount of radioactive isotopes present and the amount now remaining.
2.2 The shortest time interval on the geological timescale is called an epoch.
2.3 Preserved hardened tree sap is called a trace fossil.
2.4 The oldest stratum of the earth is found near the surface.
2.5 The Archean aeon contained the Archaea bacteria. [10]

Question 3: Scientific terminology

Define each of the following terms. Write the definitions next to each question number.
3.1 sedimentary rock (1)
3.2 trace fossil (1)
3.3 strata (1)
3.4 index fossil (1)
3.5 transition fossil (1)
3.6 living fossil (1)
3.7 relative dating (1)
3.8 radiometric dating (1)
3.9 microfossils (1)
3.10 tectonic plates (1) [10]

Question 4: Matching columns

Match the description in COLUMN I with the term in COLUMN II.
Write only the letter (A–L) next to the question number (4.1–4.10).

COLUMN I		COLUMN II	
4.1	Rock in which fossils are most commonly found	A	Laurasia
4.2	Layers of rock in which fossils are found	B	Sedimentary rock
4.3	Transition fossil between reptiles and birds	C	Coelacanth
4.4	Location of many hominid fossils	D	Cradle of Humankind
4.5	Europe and Asia	E	Trilobite
4.6	Living fossil	F	Strata
4.7	Index fossil	G	Gondwanaland
4.8	Study of fossils	H	Archaeopteryx
4.9	Fossilised plant	I	Palaeontology
4.10	Geological time interval subdivided into periods	J	Glossopteris
		K	Thrinaxodon
		L	Era

[10]

Question 5: Short response

5.1 Study the diagrams that show part of the Earth's history and answer the questions that follow.

Diagram A

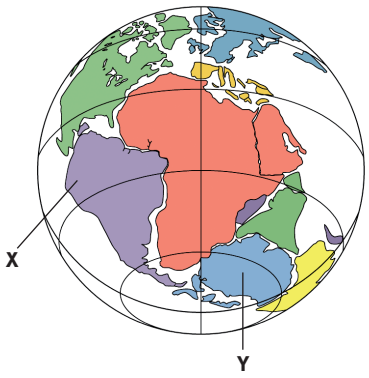
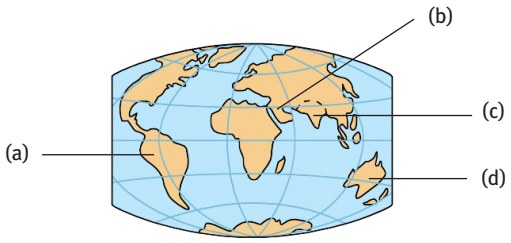


Diagram B

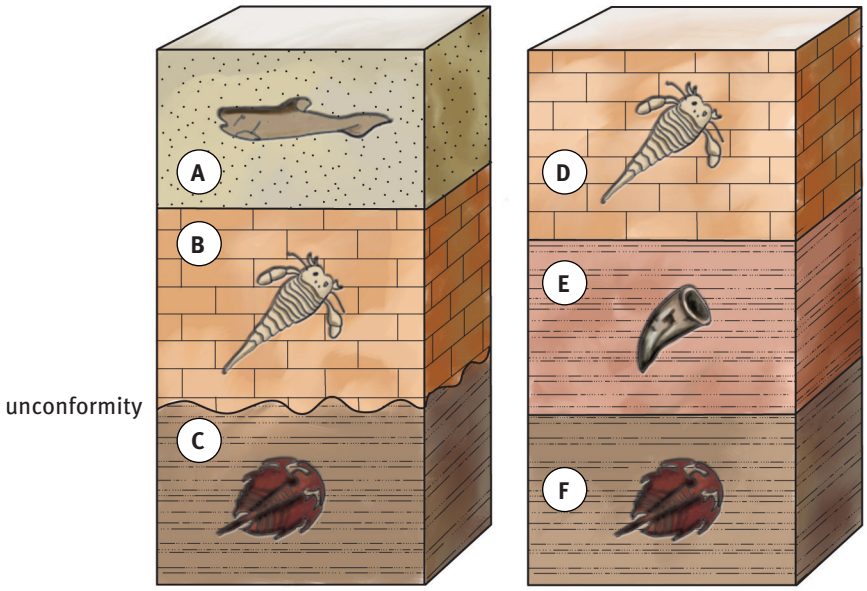


5.1.1 Identify diagram A. (1)

5.1.2 Match parts X and Y with the continents in diagram B. Use the letters in diagram B. (2)

5.1.3 Name the modern continents that made up Laurasia. (3) [6]

5.2 Base your answer on the diagrams below, which represent two bedrock outcrops, I and II, found several kilometres apart from each other. Rock layers are lettered A through F. Drawings represent specific index fossils.



5.2.1 What characteristics must a fossil have in order to be considered a good index fossil? (2)

5.2.2 During which geological time period was rock layer C deposited? (2)

5.2.3 Which layer in outcrop II may be considered missing from outcrop I where the region labelled 'unconformity' is found? (2)

5.2.4 State which TWO weathering processes could have caused the unconformity if rock layer E is sedimentary rock. (2)

5.2.5 Which rock layer in outcrop I is most likely the same relative age as rock layer D in outcrop II? (2) [10]

Question 6: Tables

6.1 The table lists commonly used radioactive isotopes and their half-lives. Study the table and answer the questions that follow.

Half-lives of selected radioactive isotopes		
Radioactive isotope	**Approximate half-life**	**Decay product**
Rubidium-87	48,6 billion years	Strontium-87
Thorium-232	14,0 billion years	Lead-208
Potassium-40	8,4 billion years	Argon-40
Uranium-238	4,5 billion years	Lead-206
Uranium-235	0,7 billion years	Lead-207
Carbon-14	5 730 years	Nitrogen-14

6.1.1 Which isotope has the longest half-life? (2)

6.1.2 Which stable element does uranium-238 decay into? (2)

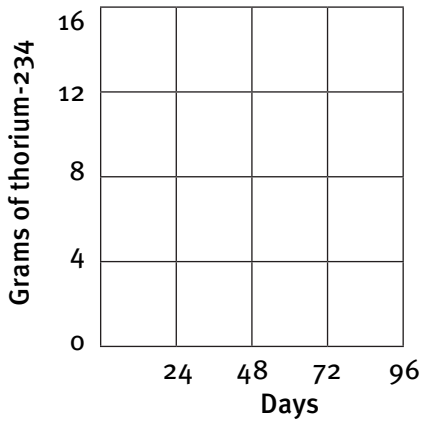
6.1.3 Which isotope will be most helpful in dating bones that are 6 000 years old? (2) [6]

Question 7: Graphs

In a laboratory a quantity of the radioactive isotope thorium-234 was produced. Over the course of several weeks, the unstable isotope decays, and the amount of thorium remaining in the sample over 36 days was measured. The following data was obtained.

Days elapsed	Grams of thorium-234 remaining
0	16
12	11
24	8
36	6

7.1 Redraw the grid below on graph paper / grid paper and plot an appropriate graph for the data in the table.



(4)

7.2 From the graph, determine how long it took the thorium in the original sample to decay to an amount of 15 grams. (2) [6]

Question 8: Essay

Palaeontologists study fossils to obtain information about the history of life on Earth. One of the limitations of the fossil record is that it is 'incomplete'.

In your response, answer the following questions to justify why fossils give palaeontologists useful information of the life that once existed on Earth.

- What type of information can scientists observe directly from fossils? (4)
- What type of information must be inferred from fossils? (4)
- How do palaeontologists explain the 'gaps' in the fossil record? Support your response with evidence. (4)

3 bonus marks [15]

TOTAL MARKS: 107

Topic 1

Answers to questions

Question 1: Multiple choice

1.1 B✓✓ (2)
1.2 A✓✓ (2)
1.3 C✓✓ (2)
1.4 B✓✓ (2)
1.5 A✓✓ (2)
1.6 B✓✓ (2)
1.7 B✓✓ (2) [14]

Question 2: Scientific terminology

2.1 C✓, H✓, O✓, N✓, S✓ (5)
2.2 amino acids✓ (1)
2.3 glycerol✓, fatty acids✓ (2)
2.4 C✓, H✓, O✓ (3)
2.5 starch✓, glycogen✓, fructose✓, glucose✓ (4)
2.6 C✓, H✓, O✓ (3)
2.7 C_6✓H_{12}✓O_6✓ (3)
2.8 2.8.1 eutrophication✓ (1)
2.8.2 leaching✓ (1)
2.8.3 micro nutrients✓ (1) [24]

Question 3: Diagrams

3.1 lock and key✓
3.2 iodine✓
3.3 rickets✓
3.4 starch test✓ [4]

Question 4: Missing words

4.1 4.1.1 enzymes✓
4.1.2 proteins✓
4.1.3 catalysts✓
4.1.4 speed up✓
4.1.5 use up✓
4.1.6 substances✓ (6)

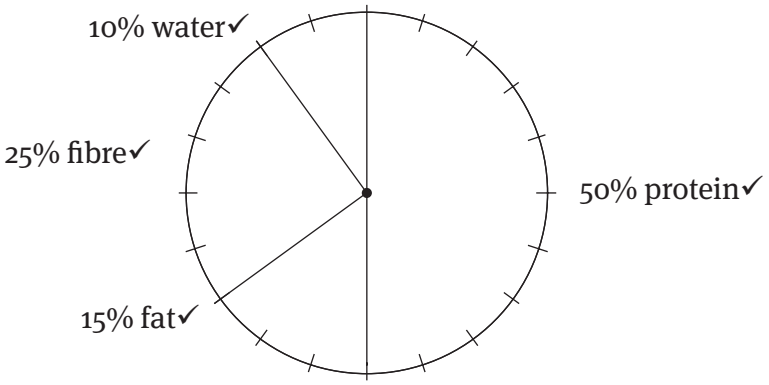
4.2 4.2.1 cells✓
4.2.2 extra-cellular✓
4.2.3 intra-cellular✓
4.2.4 digestive✓ (4) [10]

Question 5: Short response

5.1 water✓and oxygen✓ (2)
5.2 organic substance✓
elements: C, H, O✓
fats and oils✓
glycerol and fatty acids✓
saturated or unsaturated✓ (any 4) (4)
5.3 cell membrane✓✓ and membrane organelles✓✓ (4)
5.4 R✓ (2)
5.5 5.5.1 slow down✓ as enzymes are inactive✓ (2)
5.5.2 slow down✓ but still effective✓ as close to optimum✓ (3)
5.5.3 stop✓ as protein structure / enzyme structure✓ has been denatured✓ by heat✓ (4)
5.6 Its secondary amino acid structure has changed✓ and the overall shape, tertiary structure, has been irreversibly altered✓. (2) [23]

Question 6: Tables

6.1 6.1.1 detergent/soap that contains enzymes✓
enzymes break down the stains / clean the washing✓ (2)
6.1.2 biological detergent✓ (1)
6.1.3 100 °C temperature for both detergents✓ (1)
6.2 6.2.1 Percentage composition of a veggie burger



(4)

6.2.2 The veggie burger weighs 50 grams
Protein present in the veggie burger is 50%
Mass of protein is 25✓ g✓ (2)

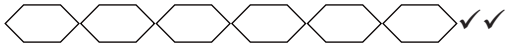
6.2.3 Fat in veggie burger is 15%
Fat in beef burger is 35%
Beef burger fat : veggie burger fat = 2✓: 1✓ (2)

6.2.4 carbohydrates✓ (1)

6.2.5 No✓, as carbohydrates are missing✓ (2) [15]

Question 7: Drawings

7.1  ✓✓ (2)

7.2  ✓✓ (2) [4]

Question 8: Comprehension

8.1 Lather control agents✓ (1)

8.2 To produce a pleasant smell✓ (1)

8.3 As they are very powerful in their action✓ (1)

8.4 proteases✓ – proteins✓
amylases✓ – sugars✓
lipases✓ – lipids / fats and oils✓ (6) [9]

Question 9: Data response

9.1 carbohydrates/monosaccharides✓✓ (2)

9.2 87✓ cm^3✓ (2)

9.3 60 °C✓ (1)

9.4

Test tube	Volume of bubbles produced (cm^3)
A	65 - 50 = 15✓
B	95 - 50 = 45✓
C	50 - 50 = 0✓
D	60 - 50 = 10✓
E	55 - 50 = 5✓
F	88 - 50 = 38✓

(6)

9.5 E✓D✓A✓F✓B✓C✓ (6) [17]

TOTAL MARKS: 120

Topic 2

Answers to questions

Question 1: Multiple choice

1.1 B✓✓ (2)
1.2 A✓✓ (2)
1.3 C✓✓ (2)
1.4 D✓✓ (2)
1.5 A✓✓ (2)
1.6 B✓✓ (2)
1.7 D✓✓ (2)
1.8 B✓✓ (2)
1.9 A✓✓ (2)
1.10 C✓✓ (2)
1.11 C✓✓ (2)
1.12 B✓✓ (2) [24]

Question 2: True/false

2.1 True✓✓ (2)
2.2 False✓
The movement of water into a cell is known as endosmosis.✓
OR
The movement of water out of a cell is known as exosmosis.✓ (2)
2.3 True✓✓ (2)
2.4 False✓
Organelles with double membranes are the nucleus, mitochondrion and chloroplast. ✓ (2)
2.5 False✓
Proteins that are found across the cell membrane are integral proteins.✓
OR
Proteins that are found on the outside of the cell membrane are peripheral proteins.✓ (2) [10]

Question 3: Scientific terms

3.1 3.1.1 osmosis✓
3.1.2 magnification✓
3.1.3 fluid mosaic✓ (3)
3.2 3.2.1 osmosis✓ (1)
3.2.2 active transport✓ (1)

3.2.3 irrigation method✓ (1)
3.2.4 plastids/chloroplasts✓ (1)
3.2.5 (rough) endoplasmic reticulum✓ (1)
3.2.6 mitochondrion✓ (1)
3.2.7 centrosome/centriole✓ (1)
3.2.8 differentiation✓ (1) [11]

Question 4: Diagram

Using the irrigation method✓

A specimen is placed on a microscope slide in a drop of water.✓ It is then covered with a cover slip.✓ A drop of stain is placed on the side of the cover slip✓and drawn through to the other side using paper towel / filter paper.✓ [5]

Question 5: Short response

5.1 5.1.1Selectively permeable – a membrane that allows substances of a certain size✓ to pass though and prevents others✓.

5.1.2Photosynthesis – a process that produces carbohydrates/sugars in plants✓ using sunlight, chlorophyll, carbon dioxide and water✓ (4)

5.2 plant cells – chloroplast ✓
animal cells – centriole✓ (2) [6]

Question 6: Tables

Parts of the microscope and their function✓

Part of the microscope	Function
Objective lens✓	Magnifies the image of the specimen✓
Stage✓	Supports the specimen / microscope slide✓
Course adjustment screw✓	Fine focus adjustment movements✓

[7]

Question 7: Drawings

7.1 actual size = $\frac{\text{size on diagram} \times \text{number on scale bar}}{\text{measured length of scale bar}}$ ✓

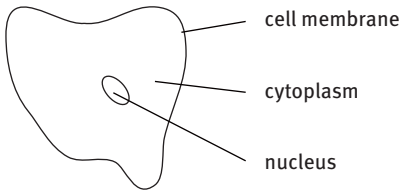
actual size = $\frac{15\text{ mm} \times 15\ \mu\text{m}}{10\text{ mm}}$ ✓

15 mm = 15 000 µm
10 mm = 10 000 µm
15 µm = 0,015 mm

actual size = $\frac{15\text{ mm} \times 0{,}015\text{ mm}}{10\text{ mm}}$ ✓

actual size = 0,0225✓ mm✓ OR ≈ 0,023✓ mm✓ OR 23✓ µm✓ (5)

7.2 Drawing of a cheek cell taken from a micrograph



Mark:
heading✓; 3 labels✓✓✓; clear, solid line✓;
printed labels ✓; ruled label lines✓;
shape and proportion✓

(8) [13]

Question 8: Contextual

8.1 8.1.1 A – mitochondrion✓
B – nucleoplasm / chromatin network / DNA✓
C – vacuole✓
F – cell sap / vacuole✓ (4)

8.1.2 D – photosynthesis✓
E – control of cell metabolism✓
G –support and structure (shape)✓ (3)

8.1.3 chlorophyll✓✓ (2)

8.2 8.2.1 plant / parenchyma cell✓ (1)

8.2.2 C – vacuole / cell sap✓
D – cell wall✓ (2)

8.2.3 A – photosynthesis✓
B – control of the cell / heredity✓ (2)

8.2.4 (a) A✓– chloroplast✓ (2)
(b) B✓– nucleus✓ (2)
(c) D✓– cell wall✓ (2)
(d) E✓– cell membrane✓ (2)

8.2.5 (a) $\text{magnification} = \frac{\text{length of scale bar}}{\text{size on scale bar}}$ ✓

$\text{magnification} = \frac{11\text{ mm}}{0{,}3\text{ mm}}$ ✓✓

magnification = 366,67 ×✓ (4)

(b) $\text{actual size} = \frac{\text{size on diagram} \times \text{number on scale bar}}{\text{measured length of scale bar}}$ ✓

$\text{actual size} = \frac{35\text{ mm} \times 0{,}3\text{ mm}}{11\text{ mm}}$

actual size = 0,955✓ mm✓ OR 955✓ µm✓ (5)

8.3 Exosmosis✓
Water will move from the cell into the salt solution✓ through a semi-permeable✓ membrane along a concentration gradient✓ causing plasmolysis✓. (5) [36]

TOTAL MARKS: 112

Topic 3

Answers to questions

Question 1: Multiple choice

1.1 D✓✓ (2)
1.2 B✓✓ (2)
1.3 D✓✓ (2)
1.4 A✓✓ (2) [8]

Question 2: Scientific terminology

2.1 anaphase✓ (1)
2.2 prophase✓ (1)
2.3 meristematic tissue / meristems✓ (1)
2.4 prophase✓ (1)
2.5 metaphase plate / cell plate✓ (1)
2.6 centrioles✓ (1) [6]

Question 3: Matching columns

3.1 3.1.1 G✓
3.1.2 C✓
3.1.3 F✓
3.1.4 I✓
3.1.5 H✓
3.1.6 A✓
3.1.7 N✓
3.1.8 E✓
3.1.9 B✓
3.1.10 M✓ (10)
3.2 3.2.1 both A and B✓
3.2.2 A✓
3.2.3 both A and B✓
3.2.4 both A and B✓
3.2.5 none✓
3.2.6 B✓
3.2.7 B✓
3.2.8 both A and B✓ (8) [18]

Question 4: Diagrams

4.1 cytokinesis / telophase✓✓
4.2 tumour / cancer✓✓ [4]

Question 5: Short response

5.1 chromatids✓
centromere✓ (2)

5.2 interphase✓
mitosis✓ (2)

5.3 centrioles in animal cells✓
cell plate in plant cells✓ (2)

5.4 benign✓
malignant✓ (2)

5.5 surgery✓
chemotherapy✓
radiotherapy✓ (3) [11]

Question 6: Tables

Mark table format✓

Differences between mitosis in plant and animal cells✓

Animal cell✓	**Plant cell**✓
Centrioles/centrosome present✓	Centrioles/centrosome absent✓
Cell membrane constriction during cytokinesis✓	Cell plate formed during cytokinesis✓

[8]

Question 7: Drawings

7.1 Marks:
heading✓
cell twice the size of original image✓
no erasures✓
thin, solid, continuous line✓
large drawing✓
no shading✓
shape✓
proportion of parts✓ (8)

7.2 Mark correct labelling of:
cell wall✓
chromatid✓
cytoplasm✓ (3)

7.3 total magnification = $\frac{\text{size on diagram}}{\text{actual size}}$
actual size = $\frac{15\text{ mm}}{1\,500}$✓
actual size = 0,01✓ mm✓ (5) [16]

Question 8: Graphs

Marks:

Heading – Percentage cancer occurrence in men✓

Type of graph✓

Equal spaces between the bars✓

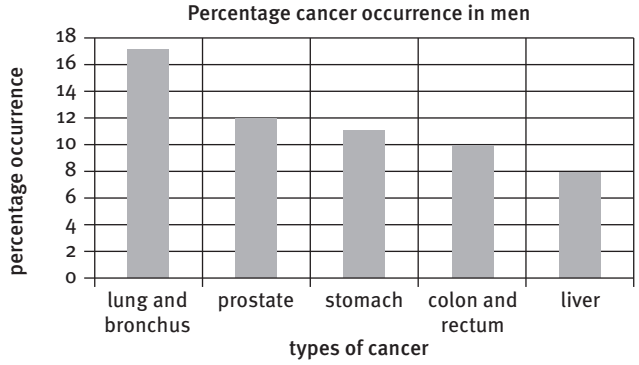
Title of x-axis✓

Types of cancer clearly marked✓

Title of y-axis✓

Suitable scale on y-axis✓

Plotting of point: 1 to 2 bars correct✓; 3 to 4 bars correct✓✓; all bars correct✓✓✓ [10]



Question 9: Contextual

9.1 C✓, B✓, E✓, A✓, D✓ (5)

9.2 Spindle formed between centrioles in animal cells✓

Cell plate develops in plant cells during cytokinesis✓ (2)

9.3 Diagram A – chromatids are pulled apar✓

Diagram E – chromosomes made of chromatids are found at the equator✓ (2) [9]

Question 10: Essay

Cell cycle is made up of interphase✓ and mitosis✓

During interphase cell growth✓ and DNA replication occurs in the nucleus✓

Mitosis involves karyokinesis✓

Prophase✓ – DNA becomes visible as chromosomes✓

Nuclear membrane and organelles disintegrate✓

Chromosomes are made of two chromatids✓ joined by a centromere✓

Metaphase✓ – chromosomes are found on equator of the cell✓,
attached to spindle fibres✓

Anaphase✓ – chromatids are pulled to opposite poles of the cell✓

Telophase✓ – nucleus reappears✓ in the daughter cells

Chromosomes become chromatin✓

Cytoplasm is divided during cytokinesis✓

Two identical daughter cells are produced✓ [20]

TOTAL MARKS: 110

Topic 4

Answers to questions

Question 1: Multiple choice

1.1 A✓✓ (2)
1.2 C✓✓ (2)
1.3 D✓✓ (2)
1.4 A✓✓ (2)
1.5 D✓✓ (2)
1.6 B✓✓ (2)
1.7 B✓✓ (2)
1.8 C✓✓ (2)
1.9 C✓✓ (2)
1.10 A✓✓ (2) [20]

Question 2: Scientific terminology

2.1 epidermal✓ (1)
2.2 meristematic✓ (1)
2.3 tendons✓ (1)
2.4 (striated) skeletal muscle✓ (1)
2.5 sensory✓ (1)
2.6 (hyaline) cartilage✓ (1) [6]

Question 3: Diagrams

3.1 1 – terminal fibres / terminal branches✓
2 – cell body / soma✓
3 – Schwann cell / dendron✓
4 – node of Ranvier✓
5 – pressure sensor / Pacinian corpuscle✓ (5)
3.2 (a) parenchyma✓✓
(b) bone✓✓
(c) xylem✓✓
(d) (hyaline) cartilage✓✓ (8) [13]

Question 4: Missing words

4.1 striated/voluntary/skeletal✓
4.2 tendons✓
4.3 striated/involuntary/cardiac✓
4.4 involuntary✓
4.5 involuntary/smooth✓ [5]

Question 5: Short response

5.1 5.1.5 vaccination – injecting an infectious agent✓ into the blood to stimulate immunity✓ (2)

5.1.2 blood transfusion – transferring blood of a matching blood type✓ from a donor to a recipient patient✓ (2)

5.1.3 antibiotic – a chemical compound✓ taken to fight infections✓ (2)

5.1.4 stem cells – animal embryonic cells✓ that can develop into other tissues✓ (2)

5.1.5 cloning – producing identical molecules, cells or tissues✓ from pre-existing ones✓ (2)

5.2 5.2.1 collagen✓, elastic/elastin✓ (2)

5.2.2 guard cells✓, stoma/pore✓ (2)

5.2.3 xylem, phloem✓ (2)

5.2.4 erythrocytes / red blood cells✓, leucocytes / white blood cells✓ (2)

5.3 5.3.1 cardiac✓, skeletal✓, smooth✓ (3)

5.3.2 vessel✓, tracheid✓, fibre✓ (3)

5.3.3 xylem✓, sclerenchyma✓, collenchyma✓ (3)

5.3.4 squamous✓, cuboidal✓, columnar✓ (3)

5.4 5.4.1plasma✓, erythrocytes / red blood cells✓, leucocytes / white blood cells✓, thrombocytes / platelets✓ (4) [34]

Question 6: Tables

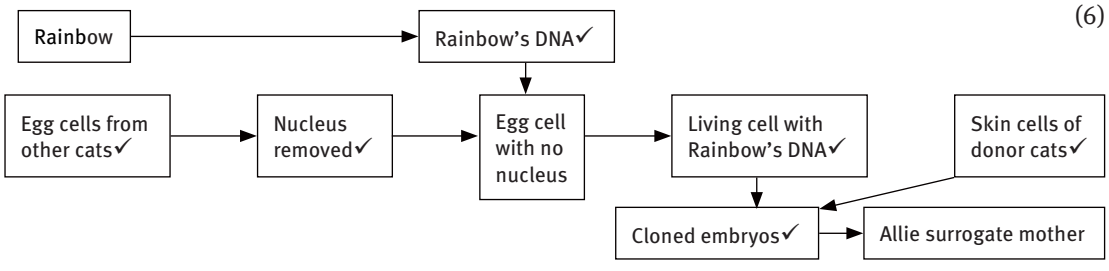
Differences between structure and function of parenchyma, chlorenchyma and xylem

	Parenchyma	Chlorenchyma	Xylem
Structure	Thin cellulose cell walls✓ Intercellular spaces✓ Large vacuole✓	Thin cellulose cell walls ✓ Intercellular spaces✓ Chloroplasts✓	Thin cellulose cell walls ✓ Thick secondary lignin thickening✓ No intercellular spaces / Tightly packed✓
Function	Storage✓ Packing✓	Photosynthesis✓	Transport of water✓ and mineral salts, strengthening and protection✓

[14]

Question 7: Comprehension

7.1 (6)



7.2 Clone – Identical copies✓ of cells or an organism✓
Donor – Animal that provides cells or tissues✓ for the cloning process✓
Surrogate mother – Live female animal✓ used to carry another organism's baby✓ (6) [12]

Question 8: Case study

8.1 8.1.1 Keep Peter at home✓ (1)
8.1.2 Not scratch open the blisters✓ (1)
8.1.3 No✓, as even those children who have had chickenpox can catch it again✓. (2)
8.1.4 Chickenpox is a virus and cannot be cured by antibiotics✓.
Vaccines help in the fighting of chickenpox✓. (2) [6]

8.2 8.2.1 Cloning is a name given to a biotechnological process that makes identical copies of cells✓ and tissues from pre-existing cells and tissues✓. (2)
8.2.2 Tissue culture – Production of exact copies of cells and tissues that have desirable traits✓
Therapeutic cloning – Producing tissues that can be used in transplants✓
Reproductive cloning – Reproducing identical organisms / regeneration of body parts in lower animals✓
Molecular cloning – Producing chemical compounds that are vital in sustaining life, e.g. insulin✓ (4) [6]

8.3 8.3.1 To increase the yield of bean plants for all year round cultivation✓✓ (2)
8.3.2 Many plants will be produced from a tissue sample / cutting✓✓ (2)
8.3.3 A sample of tissue is taken from a plant.✓
It is grown into a callus on a growth medium.✓
Cells can be removed from the tissue and grown on a tissue culture medium.✓
Plantlets are transferred to potting soil when a root and shoot are visible.✓(4)
8.3.4 Growth of cells taken from a plant in a growth medium✓ to form a callus or plantlets. (1)
8.3.5 Asexual/vegetative reproduction✓ (1) [10]

Question 9: Contextual

9.1 9.1.1 A – meristematic✓
B – epidermal✓
C – parenchyma✓
D – collenchyma✓
E – sclerenchyma / sclereids / stone cells✓
F – xylem✓
G – phloem✓ (7)

9.1.2 They are undergoing DNA replication during mitosis✓. (1)

9.1.3 Cells in a tissue change structure and become specialised for a particular function.✓✓ (2)

9.1.4 (a) meristematic – growth and production of new cells/tissues✓
(b) epidermal – protection✓
(c) parenchyma – storage and packing✓
(d) xylem – transport of water and mineral elements, and strength and support✓
(e) phloem – transport of organic sugars✓ (5)

9.1.5 Secondary thickening of lignin✓✓ (2)

9.1.6 Companion cells✓✓ (2)

9.1.7 Differences between structure and function of parenchyma, chlorenchyma and collenchyma

	Parenchyma	Chlorenchyma	Collenchyma
Structure	Thin cellulose cell walls✓ Intercellular spaces✓	Thin cellulose cell walls✓ Intercellular spaces✓ Chloroplasts✓	Thin cellulose cell walls✓ No intercellular spaces /Intercellular thickening✓
Function	Storage and packing✓	Photosynthesis✓	Strengthening✓

(10) [29]

9.2 9.2.1 A – blood✓
B – bone✓
C – cardiac muscle✓
D – smooth muscle✓
E – skeletal muscle✓
F – cartilage✓
G – stem cells✓ (7)

9.2.2 They are undergoing DNA replication / mitosis✓ (2)

9.2.3 Cells in a tissue change structure and become specialised for a particular function.✓✓ (2)

9.2.4 (a) stem cells – growth and production of new cells/tissues✓
(b) epithelial – protection✓
(c) tendon – attaches muscle to bone✓
(d) blood – transport of food and waste around body✓
(e) cartilage – reduces friction and provides protection✓ (5)

9.2.5 solid layers of bone✓
crystalised salts that solidify the matrix✓ (2)

9.2.6 By Schwann cells✓✓ (2)

9.2.7 Structure and location of cardiac, skeletal and smooth muscles

	Cardiac muscle	Skeletal muscle	Smooth muscle

Structure	Striated✓ Intercalated discs✓ Branched / bridges✓	Striated✓ Fibres✓	No striations✓ Spindle shaped✓
Function	Keep heart pumping✓	Movement of skeleton✓	Movement in alimentary canal and bladder✓

(10) [30]

9.3 9.3.1 xylem✓✓ (2)

9.3.2 A – perforation plate✓

B – secondary thickening / annular thickening✓ (2)

9.3.3 Strength and support✓

Transport of water and mineral salts✓ (2)

9.3.4 Dead✓, hollow cells✓ to allow for the flow of water✓

Form long✓ tubes✓ for a continuous pathway of water movement✓

Secondary thickening✓ of lignin✓ for strength and support against gravity✓ (9) [15]

TOTAL MARKS: 200

Topic 5

Answers to questions

Question 1: True/false

1.1 True✓✓ (2)

1.2 True✓✓ (2)

1.3 True✓✓ (2)

1.4 False✓

The dorsal and ventral leaf surfaces of isobilateral leaves look the same.

OR

The dorsal and ventral leaf surfaces of dorsiventral leaves look different. (2)

1.5 True✓✓ (2) [10]

Question 2: Scientific terminology

2.1 monocotyledon✓ (1)

2.2 axillary / lateral bud✓ (1)

2.3 cuticle✓ (1)

2.4 guard cells✓ (1)

2.5 mesophyll✓ (1)

2.6 transpiration✓ (1)

2.7 photosynthesis✓ (1)

2.8 chlorenchyma✓ (1)

2.9 guard cells✓ (1)

2.10 transpiration✓ (1)

2.11 mesophyll✓ (1)

2.12 magnesium✓ (1) [12]

Question 3: Matching columns

3.1 G✓ (1)

3.2 B✓ (1)

3.3 E✓ (1)

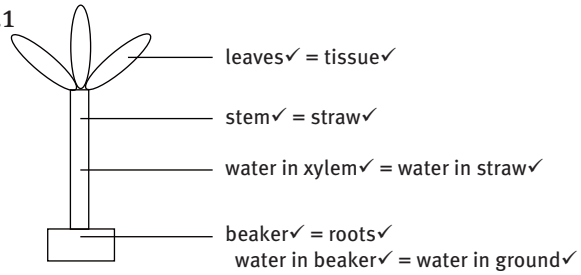
3.4 A✓ (1)

3.5 F✓ (1)

3.6 D✓ (1) [6]

Question 4: Diagrams

4.1



(any 4 pairs) (8)

[8]

Question 5: Short response

5.1 5.1.1 photosynthesis✓✓ (2)

5.1.2 photosynthesis✓✓
gaseous exchange✓✓ (4)

5.1.3 xylem✓ – transports water and mineral salts (ions) ✓
phloem✓ – transports manufactured sugars/carbohydrates/sucrose✓ (4)

5.2 5.2.1 palisade parenchyma✓
spongy parenchyma✓ (2)

5.2.2 guard cells✓
(stomatal) pore✓ (2)

5.2.3 photosynthesis✓
transpiration✓ (2)

5.3 5.3.1 epidermis✓
mesophyll✓
vascular bundle / vein✓ (3)

5.3.2 carbon dioxide✓, water vapour✓, oxygen✓ (3)

5.3.3 cuticle✓, stomata✓, leaf hairs✓ (3)

5.4 gaseous exchange✓✓ (2)

5.5 5.5.1 Diffusion – the movement of a substance from a high concentration✓ to a low concentration / along a concentration gradient✓ until equilibrium✓ (3)

5.5.2 Osmosis – the movement of water✓ from a high concentration✓ to a low concentration / along a concentration gradient✓ through a semi-permeable membrane✓ (4)

5.5.3 Transpiration – diffusion/evaporation✓ of water✓ through the stomata✓ and from the surface of a leaf✓ during the day✓ (5)

5.6 5.6.1 Concentration gradient of a substance✓; environmental conditions✓ (2)

5.6.2 Concentration of water✓; concentration of solute (sugar/salt) (2)

5.6.3 Root pressure✓; capillarity✓; transpiration✓ (3) [46]

Question 6: Graph

7.1 A✓✓ (2)

7.2 leaves are dying / changing colour✓ in preparation for autumn and winter✓ (2)

7.3 plastids✓ (1)

7.4 the change of pigments in leaf cells✓ during the seasons of a year✓ (2)

7.5 cell division / mitosis✓ (1) [8]

Question 7: Paragraph

Water, absorbed by root hairs✓ through osmosis✓ is transported by the capillary action✓ in xylem vessels✓ up the stem to the leaves✓. Water diffuses osmotically from the xylem tubes to the surrounding mesophyll cells✓ to the intercellular air spaces✓ (as vapour)✓, to the substomatal air chambers✓ behind the stomata✓. Here the concentration of water vapour is higher than the air (atmosphere) outside✓ the plant and transpiration takes place✓.
This causes a lower concentration of water vapour in the air spaces of the leaf✓ and the cycle is repeated✓: xylem tubes ⇢ mesophyll cells ⇢ intercellular spaces ⇢ substomatal spaces ⇢ stomata ⇢ atmosphere✓. Transpiration✓ mainly takes place as a result of differences in water concentration of: (a) the cells from the root hairs to the leaves✓, and (b) the intercellular spaces and the atmosphere✓.

(maximum 15) [15]

TOTAL MARKS: 105

Topic 6

Answers to questions

Question 1: Multiple choice

1.1 C✓✓ (2)
1.2 A✓✓ (2)
1.3 C✓✓ (2)
1.4 B✓✓ (2)
1.5 A✓✓ (2)
1.6 A✓✓ (2)
1.7 C✓✓ (2) [14]

Question 2: True/false

2.1 True✓✓ (2)
2.2 False✓

The main function of xylem in a stem is to translocate water and mineral salts (ions).✓

OR

The main function of phloem in a stem is to translocate manufactured sugars / sucrose.✓ (2)

2.3 True✓✓ (2)
2.4 False✓

The epidermis secretes a waxy layer to protect the plant against water loss.✓ (2)

2.5 True✓✓ (2)
2.6 True✓✓ (2)
2.7 False✓

In a dicotyledonous stem vascular bundle, the primary phloem is found on the outside and the primary xylem towards the inside.✓

OR

In a dicotyledonous stem vascular bundle, the primary xylem is found on the inside and the primary phloem towards the outside.✓ (2)

2.8 True✓✓ (2)
2.9 False✓

The pericycle is made of sclerenchyma tissue.✓ (2)

2.10 True✓✓ (2) [20]

Question 3: Scientific terminology

3.1 water✓ (1)
3.2 phloem✓ (1)
3.3 xylem✓ (1)
3.4 epidermis✓ (1)
3.5 adhesion✓ (1)
3.6 strength/support✓ (1)
3.7 cambium✓ (1)
3.8 (dicotyledonous) root✓ (1)
3.9 Casparian strip✓ (1)
3.10 xylem✓ (1)
3.11 transpiration✓ (1)
3.12 translocation✓ (1)
3.13 guttation✓ (1)
3.14 Casparian strip✓ (1)
3.15 annual rings✓ (1) [15]

Question 4: Matching columns

4.1 F✓ (1)
4.2 C✓ (1)
4.3 I✓ (1)
4.4 E✓ (1)
4.5 H✓ (1)
4.6 A✓ (1)
4.7 J✓ (1)
4.8 B✓ (1)
4.9 D✓ (1)
4.10 G✓ (1) [10]

Question 5: Short response

5.1 Differences between the internal anatomies of a dicotyledonous root and stem

Dicotyledonous root (TS)	Dicotyledonous stem (TS)
1 No cuticle✓	1 Cuticle✓
2 Epidermis contains root hairs✓	2 Epidermis contains stomata✓
3 Stele in centre of root✓	3 Vascular bundles in ring✓
4 Xylem in X-shape✓	4 Xylem towards centre of vascular bundle✓
5 Phloem between arms of xylem✓	5 Phloem towards outside of vascular bundle✓
6 Cambium between xylem and phloem✓	6 Cambium in ring✓

7 Pericycle in ring around xylem✓	7 Pericycle cap on outside of vascular bundle✓

(14)

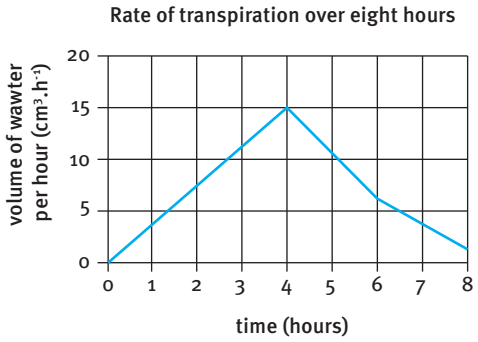
5.2 root pressure✓✓
capillarity✓✓
transpiraton✓✓ (6)

5.3 Water will move out of the plant✓ into the soil✓ by exosmosis✓ causing the plant to wilt✓. (4)

5.4 cuticle✓ – prevents water loss through the epidermis✓
stomata✓ – open and close through the action of guard cells✓; close at night and at midday✓; few stomata on top surface of leaf✓; more stomata on shaded underside of leaf✓
leaf hairs / trichomes✓ – reduce wind movement to prevent evaporation from leaf surface✓
leaf arrangement✓ – shades leaves✓
small leaf surface area – reduces evaporation✓ (any 10) (10) [34]

Question 6: Data response

6.1



Mark:
Heading✓
Line graph✓
Independent variable time on *x*-axis✓
Suitable scale on *x*-axis✓
Title and units on *x*-axis✓
Dependent variable volume of water per hour on y-axis✓
Suitable scale on *y*-axis✓
Title and units on *y*-axis✓
Correct plotting of points✓ (9)

6.2 Rate of transpiration increased✓ from zero✓ for four✓ hours to 15 $cm^3.h^{-1}$✓ and decreased✓ over the next four hours to 1 $cm^3.h^{-1}$✓. (6)

6.3 It was midday✓ and transpiration was at its greatest✓. (2)

6.4 The chloroplasts✓ in the guard cells✓ were photosynthesising✓, producing sugars. Water moved into the guard cells✓ by osmosis✓ causing them to expand✓ and the stomata to open✓. More water vapour was able to pass out into the environment✓, causing an increase in water loss / transpiration. (8)

6.5 They would increase✓ as wind would remove more water vapour✓ from the surface of the leaf causing increased evaporation✓. (3) [28]

Question 7: Contextual

7.1 potometer✓ (1)

7.2 increased temperature✓
decreased humidity / dry air✓
wind✓ (3)

7.3 Plant cut under water to prevent air bubbles in xylem.✓
Apparatus assembled under water to prevent air bubbles blocking system.✓
Air bubble returned to zero for each measurement for accurate measurements.✓
Vaseline over cork to prevent water loss.✓ (any 3) (3) [7]

Question 8: Paragraph

Xylem, sclerenchyma and collenchyma are adapted for the function of support in plants. Xylem vessels are large, wide cells✓. They are strengthened with lignin✓ secondary cell walls✓. Xylem tracheids and fibres have a similar structure✓. Sclerenchyma fibres and stone cells have thick lignin cell walls✓. Collenchyma cells have cellulose✓ thickening✓ between the cells✓. Xylem tissue is found making up most of the central part✓ of the stem as wood✓. Collenchyma is found under the epidermis and in leaves✓ for support. Sclerenchyma is found in the vascular bundles✓ for support. (maximum 10) [10]

TOTAL MARKS: 140

Topic 7

Answers to questions

Question 1: Multiple choice

1.1 A✓✓ (2)
1.2 C✓✓ (2)
1.3 A✓✓ (2)
1.4 B✓✓ (2)
1.5 C✓✓ (2)
1.6 A✓✓ (2)
1.7 D✓✓ (2)
1.8 A✓✓ (2)
1.9 B✓✓ (2)
1.10 D✓✓ (2) [20]

Question 2: True/false

2.1 True✓✓ (2)
2.2 False✓
The collar bone is called the clavicle.✓
OR
The breast bone is called the sternum.✓ (2)
2.3 True✓✓ (2)
2.4 False✓
Mammals have an endoskeleton for structure, support and protection.✓
OR
Arthropods/Insecta/Crustacea have an exoskeleton for structure, support and protection.✓ (2)
2.5 True✓✓ (2)
2.6 True✓✓ (2)
2.7 True✓✓ (2)
2.8 False✓
Muscles are joined to bone by tendons.✓
OR
Bones✓ are joined to bones by ligaments. (2)
2.9 False✓
The shaft of a long bone is the diaphysis. ✓
OR
The end of a long bone is the epiphysis. ✓ (2)
2.10 True✓✓ (2) [20]

Question 3: Scientific terminology

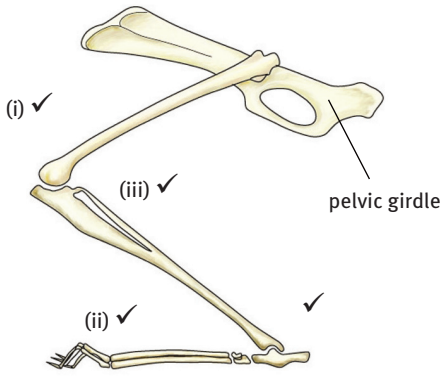
3.1 hyaline cartilage✓ (1)
3.2 sarcolemma✓ (1)
3.3 Haversian canals✓ (1)
3.4 costal✓ (1)
3.5 lacuna✓ (1)
3.6 skeletal/cardiac✓ (1)
3.7 voluntary✓ (1)
3.8 myofibril✓ (1) [8]

Question 4: Matching columns

4.1 F✓ (1)
4.2 D✓ (1)
4.3 A✓ (1)
4.4 B✓ (1)
4.5 C✓ (1)
4.6 E✓ (1)
4.7 K✓ (1)
4.8 J✓ (1)
4.9 L✓ (1)
4.10 G✓ (1)
4.11 H✓ (1) [11]

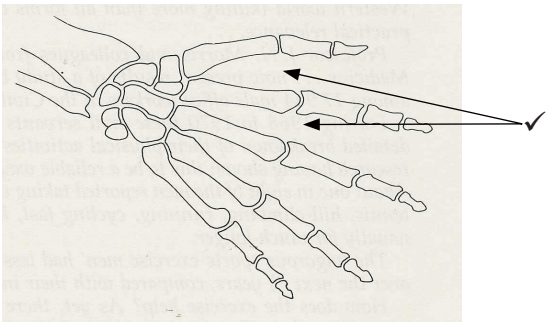
Question 5: Diagrams

5.1



[3]

5.2 5.2.1



(1)

5.2.2 Use ratio and proportion: $\frac{\text{palm width of diagram}}{\text{own palm width}}$

Mark negative sign ✓ and ratio ✓ (2)

5.2.3 Underneath each finger joint✓ attached to both sides of the joint✓ (2) [5]

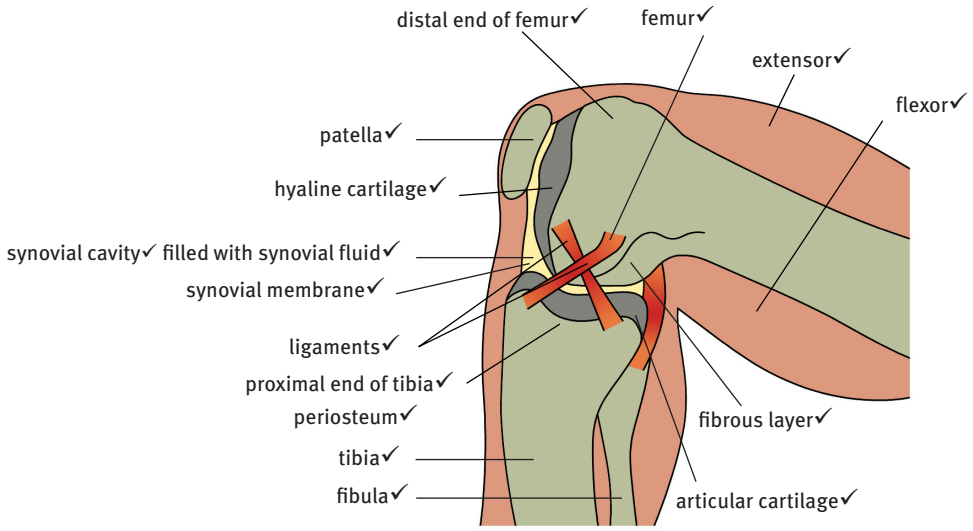
5.3 5.3.1scapula✓, clavicle✓, humerus✓, radius✓, ulna✓ carpals✓, metacarpals✓, phalanges✓ (8)

5.3.2 A – triceps✓;
B – biceps✓ (2)

5.3.3 When A contracts, arm is extended.✓✓
When B contracts, arm bends.✓✓ (4)

5.3.4 Hinge joint✓
Movement (up and down)✓ around the elbow occurs✓ (3) [17]

5.4 Drawing showing the structure of a knee synovial joint✓ and the flexor and extensor muscle✓



(2) (16) [18]

5.5

	Flat bones	Long bones	Irregular bones	Short bones
Axial skeleton			E✓	
Appendicular skeleton	D✓	F✓		A✓, B✓, C✓

[6]

5.6 5.6.1 Diagram A – Pelvic girdle and lower limb (leg)✓
Diagram B – Pectoral girdle and upper limb (arm)✓ (2)

5.6.2 1 – ilium/pelvis✓
2 – sacrum✓
3 – coccyx✓
4 – epiphysis / head of femur✓
5 – femur✓
6 – patella✓
7 – tibia✓
8 – fibula✓
9 – tarsals✓
10 – metatarsals✓
11 – phalanges✓
12 – clavicle✓
13 – ball-and-socket joint✓
14 – scapula✓
15 – humerus✓
16 – radius✓
17 – ulna✓
18 – carpals✓
19 – metacarpals✓
20 – phalanges✓ (20) [22]

Question 6: Short response

6.1 Synovial joint with cartilage on bone surfaces✓ and synovial fluid✓ (2)

6.2 They cover and protect the internal organs✓ and could damage them✓. (2)

6.3 Through moulting✓ (1)

6.4 Advantages and disadvantages of an exoskeleton in a crab✓

Advantages	Disadvantages
• Plates of armour to support and protect soft internal tissues and organs✓ • Muscles and organs are inside for protection✓ • Provides shape and structural support✓ • Prevents dehydration✓ • Provides good leverage for muscle action✓	• Limits the size of the animal✓ • Creates difficulties in growth✓ • Animal needs to moult to increase in size✓ • Uses a lot of energy in the re-growth stage after each moulting✓

(any 2 from each column) (5)

6.5 movement and locomotion – joints and leavers with muscles✓
protection – vital internal organs: brain, heart, lungs, liver✓
support, strength and shape – muscles, internal organs✓
storage of minerals – calcium, magnesium and phosphate✓
hearing – the three ossicles (the smallest bones in the inner ear) help hearing✓
formation of blood cells – site of formation of red and white blood corpuscles in bone marrow✓ (6)

6.6 They have not hardened yet✓ and the joints are not fixed yet✓. (2)

6.7 rickets✓
osteoporosis✓
arthritis✓ (3) [21]

Question 7: Contextual

7.1 1 – atlas✓✓
2 – axis✓✓
3 – thoracic vertebra✓✓
4 – vertebral discs✓✓
5 – sacrum✓✓ (10)

7.2 atlas✓ (1)

7.3 It surrounds and protects the delicate spinal cord.✓
It is a point of attachment for the ribs✓, the pectoral girdle and the pelvic girdle✓, provides flexible movement✓, absorbs shock✓ and provides entry and exit of nerves and blood vessels✓. (any 3) (3)

7.4 atlas – allows nodding of head✓
axis – allows rotation of head✓ (2)

7.5 Reduces friction✓
Allows bending and movement✓
Absorbs shock✓ (any 2) (2)

7.6 A disc that has moved out of place✓✓ (2) [20]

Question 8: Case study

8.1 Osteoporosis is a condition of porous bone✓. (1)

8.2 the spine✓ (1)

8.3 After menopause✓, smaller amounts of oestrogen✓ are produced. (2)

8.4 They have very little body fat✓ that is needed for the production of oestrogen✓. (2)

8.5 calcium✓
phosphorus✓
vitamin A / C✓ (3)

8.6 It replaces the hormone needs that the body does not make. ✓ (1)

8.7 balanced/healthy diet✓, weight-bearing exercise✓, vitamin supplements✓ (3)

8.8 etidronate✓ (1) [14]

Question 9: Essay

Rickets in children can be caused by an unhealthy diet.✓

The leg bones are weak and bend due to the weight of the body✓.

The minerals calcium and phosphorus✓ and the vitamins A and C✓ are essential for strong and healthy bones✓.

Osteoporosis is a disease that causes bone to lose mass and the bone tissue to break down✓.

Bone becomes weaker✓.

In younger people osteoporosis is caused by lack of food (starvation), diabetes / lack of vitamin C ✓ and over-activity of the adrenal glands / not enough exercise✓.

A healthy diet and exercise are needed to manage the disease✓.

Arthritis is an illness that can cause pain and swelling in your joints✓.

The two most common ones are:

- osteoarthritis✓ – comes with age and sometimes follows an injury to a joint✓
- rheumatoid arthritis✓ – occurs when the body's defence system does not work properly / affects joints, bones (often in the hands and feet), and organs✓. [15]

TOTAL MARKS: 200

Topic 8

Answers to questions

Question 1: Multiple choice

1.1 D✓✓ (2)
1.2 D✓✓ (2)
1.3 B✓✓ (2)
1.4 B✓✓ (2)
1.5 C✓✓ (2)
1.6 A✓✓ (2)
1.7 A✓✓ (2)
1.8 A✓✓ (2)
1.9 D✓✓ (2) [18]

Question 2: True/false

2.1 True✓✓ (2)
2.2 True✓✓ (2)
2.3 False✓
Ventricular systole is the contraction of the ventricles.✓
OR
Atrial systole is the contraction of the atria.✓ (2)
2.4 False✓
Pulmonary arteries carry deoxygenated blood.✓
OR
Pulmonary veins carry oxygenated blood.✓ (2)
2.5 False✓
The pacemaker is known as the sinoatrial node. ✓ (2) [10]

Question 3: Scientific terminology

3.1 pulmonary veins✓ (1)
3.2 superior vena cava✓ (1)
3.3 smooth✓ (1)
3.4 pericardium✓ (1)
3.5 plasma✓ (1)
3.6 tissue fluid✓ (1)
3.7 thoracic duct✓ (1)
3.8 valves✓ (1)
3.9 tricuspid valve✓ (1)
3.10 hepatic portal system✓ (1) [10]

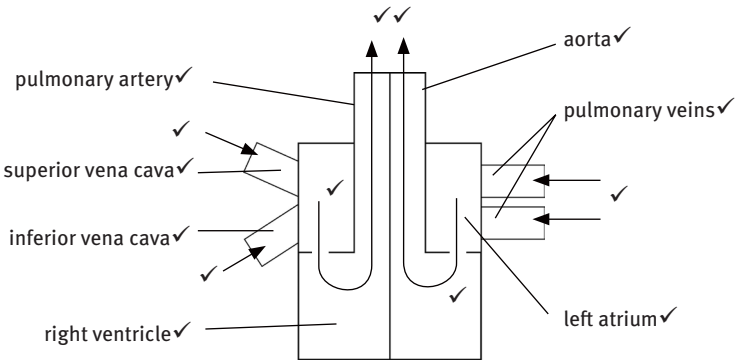
Question 4: Matching columns

4.1 C✓ (1)
4.2 A✓ (1)
4.3 B✓ (1)
4.4 E✓ (1)
4.5 D✓ (1)
4.6 F✓ (1)
4.7 J✓ (1)
4.8 L✓ (1)
4.9 G✓ (1)
4.10 I✓ (1) [10]

Question 5: Diagrams

5.1 A – superior vena cava✓
B – aorta✓
C – pulmonary artery✓
D – lymph node✓
E – capillaries of the lung✓
F – pulmonary veins✓
G – aorta✓
H – right atrium✓
I – septum✓
J – lymphatic capillaries✓ (10)

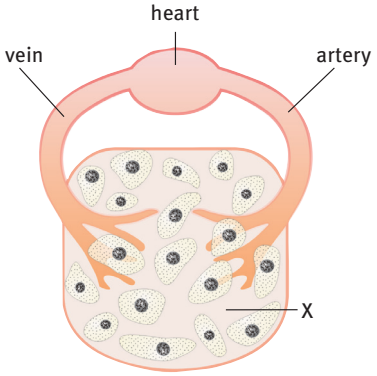
5.2



[24]

6.1 6.1.1 tetanus✓ (1)
6.1.2 tuberculosis✓ (1)
6.1.3 influenza✓ (1)
6.2 55%✓ (2)
6.3 6.3.1 capillary✓ (1)

6.3.2



(2)

6.3.3 Pumps blood to all parts of the body✓ (1) [9]

Question 7: Tables

7.1 Comparison of a closed cardiovascular system and open lymphatic system in humans

	Closed cardiovascular system	Open lymph circulatory system
Function	Blood is responsible for collecting and distributing oxygen, nutrients and hormones to the tissues of entire body.✓	Lymph is responsible for collecting and removing waste products left behind in the tissues.✓
Movement	Blood is pumped by the heart into the arteries that carry it to the rest of the body. Veins return blood from all parts of the body to the heart.✓	Lymph is not pumped. It passively flows from the tissues into the lymph capillaries. Flow within the lymphatic vessels is aided by other body movements such as deep breathing and the action of nearby muscles and blood vessels.✓
Vessels	Arteries, veins and capillaries in which the blood moves.✓	Lymph ducts (veins) and capillaries through which lymph moves.✓
Fluid	Blood consists of the liquid plasma that transports the red and white blood cells and platelets.✓	Lymph that has been filtered and is ready to return to the cardiovascular system is a clear or milky white fluid similar to blood plasma. ✓ Unfiltered lymph consists of plasma, tissue fluid, red and white (lymphocytes) blood cells and chyle (proteins and lipids).✓

(10)

7.2 Differences between types of blood vessel ✓

Arteries	Capillaries	Veins
Small lumen✓	Very small lumen✓	Large lumen✓
Have one layer of endothelium✓	Have one layer of endothelium✓	Have one layer of endothelium✓
Have a thick layer of smooth muscle✓	Have no smooth muscle✓	Have a thin layer of smooth muscle✓
Have some connective tissue✓	Have no connective tissue✓	Have some connective tissue✓
No semilunar valves (except at the base of aorta and pulmonary arteries)✓	No semilunar valves✓	Contain semilunar valves to ensure the blood flows in one direction only✓

(16) [26]

Topic 8

Question 8: Data response

8.1 8.1.1 (a) 22✓ beats in 20 seconds✓ (2)

(b) 66✓ beats per minute✓ (2)

8.1.2 resting heart rate✓ (1)

8.1.3 It will increase. ✓ (1)

8.2 8.2.1To determine the relationship between cigarette smoking✓ and annual deaths from heart disease in males✓ (2)

8.2.2 Number of cigarettes smoked daily✓ per age group✓ (2)

8.2.3 Annual number of deaths✓ (per 100 000) ✓ (2)

8.2.4 355✓ deaths per 100 000✓ (2)

8.2.5 Deaths increase✓ with the more cigarettes smoked✓

Deaths increase✓ with age✓ (4) [18]

Question 9: Essay

- Deoxygenated blood returns to the right atrium.✓
- The sinoatrial (SA) node✓, the pacemaker, is found in the wall of the right atrium✓.
- It sends an electrical impulse to the muscle of the left and right atria✓.
- The two atria contract together (atrial systole). ✓
- The tricuspid and bicuspid valves open.✓
- Blood flows into the two ventricles.✓
- Deoxygenated blood arrives in the right ventricle.✓
- Oxygenated blood arrives in the left ventricle.✓
- Electrical signal waves travel through the muscles of the atria✓ and reach the atrioventricular (AV) node✓.
- This signal goes through the atrioventricular bundle✓ to the ventricles✓.
- The tricuspid and bicuspid valves close✓ and the two ventricles contract together (ventricular systole). ✓
- Blood is forced into the aorta✓ and the pulmonary artery✓.
- Deoxygenated blood is sent to the lungs✓ through the pulmonary arteries.
- After oxygenation in the lungs the oxygenated blood returns to the left atrium.✓
- Oxygenated blood arrives in the left ventricle.✓
- Oxygenated blood is sent in arteries to the tissues.✓
- In general systole both the atria and ventricles relax.✓
- The semilunar valves at the base of the aorta and pulmonary artery close✓, preventing
  backflow of blood✓.
- Blood moves into the atria from the superior✓ and inferior vena cava✓ and the pulmonary veins✓. (maximum 25) [25]

TOTAL MARKS: 150

Topic 9

Answers to questions

Question 1: Multiple choice

1.1 D✓✓ (2)
1.2 B✓✓ (2)
1.3 A✓✓ (2)
1.4 D✓✓ (2)
1.5 B / C✓✓ (2)
1.6 C✓✓ (2)
1.7 D✓✓ (2)
1.8 B✓✓ (2)
1.9 A✓✓ (2)
1.10 B✓✓ (2)
1.11 B✓✓ (2) [22]

Question 2: True/false

2.1 True✓✓
2.2 True✓✓
2.3 False✓

A population is a collection of organisms of the same kind living in the same area at the same time.✓

OR

A community is all the populations of all the different species living in the same area at the same time. ✓

2.4 False✓

Hydrophytes have leaves with a large surface area.✓

OR

Xerophytes have leaves with a small/reduced surface area.✓

2.5 True✓✓ [10]

Question 3: Scientific terminology

3.1 herbivores / primary consumers✓ (1)
3.2 saprophytes / decomposers✓ (1)
3.3 transpiration✓ (1)
3.4 carrying capacity✓ (1)
3.5 Savanna✓ (1)
3.6 species✓ (1)
3.7 abiotic factors✓ 1)
3.8 edaphic factors✓ (1)

3.9 loam✓ (1)
3.10 biosphere✓ (1) [10]

Question 4: Matching columns

4.1 4.1.1 I✓
4.1.2 D✓
4.1.3 A✓
4.1.4 F✓
4.1.5 K✓
4.1.6 B✓
4.1.7 H✓
4.1.8 J✓
4.1.9 C✓
4.1.10 E✓ (10)
4.2 4.2.1 both A and B✓
4.2.2 A✓
4.2.3 B✓
4.2.4 B✓
4.2.5 both A and B✓
4.2.6 A✓
4.2.7 B✓
4.2.8 A✓ (8) [18]

Question 5: Missing words

5.1 5.1.1 habitat✓
5.1.2 community✓
5.1.3 biotic✓
5.1.4 abiotic✓
5.1.5 ecosystem✓ (5)
5.2 5.2.1 sun✓
5.2.2 food chain✓
5.2.3 plants✓
5.2.4 consumers✓
5.2.5 lost✓ (5) [10]

Question 6: Short response

6.1 lion✓ (1)
6.2 rabbit / zebra / impala / mouse✓ (1)
6.3 lion✓
zebra / rabbit / impala✓ (2)

6.4 grass✓ (1) [5]

Question 7: Graphs

7.1 carnivore✓
7.2 secondary consumer✓
7.3 primary consumer✓
7.4 single✓
7.5 carnivore✓
7.6 group / pack✓
7.7 saprophyte / decomposer✓
7.8 secondary consumer / tertiary consumer✓
7.9 secondary consumer / tertiary consumer✓
7.10 pairs✓ [10]

Question 8: Graphs

8.1 arctic plants✓ ⇢ lemmings✓ ⇢ snowy owls✓ (3)

8.2 8.2.1 No snowy owl predators to feed off them✓ (1)

8.2.2 They are prey to snowy owls✓ (1)

8.2.3 Snowy owl population peaks after the lemmings.✓
When lemmings are at their peak, then the snowy owls increase.✓
When lemmings are limited, then snowy owls start to decline.✓ (3)

8.2.4 The lemmings would increase in number.✓
Overpopulation will occur and the carrying capacity will be exceeded.✓
This will lead to limited resources and the lemmings will die off / decline in number.✓ (3)

8.2.5 (a) sun / sunlight / radiant energy✓ (1)
(b) photosynthesis✓ (1) [13]

Question 9: Contextual

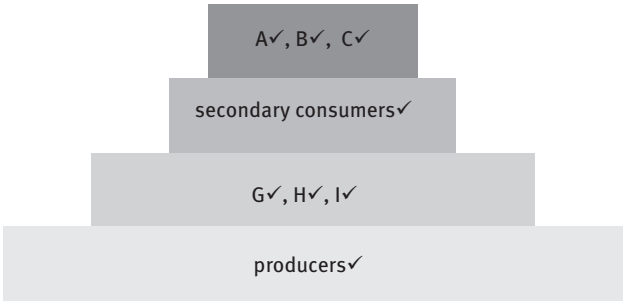
9.1 9.1.1 (a) sun / sunlight / radiant energy✓ (1)
(b) evaporation✓ (1)
(c) transpiration✓ (1)
(d) evaporation✓ and condensation✓ (2)

9.1.2 Photosynthesis✓
Transport of nutrients / translocation✓
Transpiration✓ (any 2) (2)

9.1.3 (a) Water moves from the soil✓ into the root hair by osmosis✓, across the cell wall and cell membrane of the root hair, along a concentration gradient✓. The vacuole in the root hair contains salts that cause osmosis✓. (any 3) (3)

(b) Sea water is salty✓. It causes the plants to lose water✓ through osmosis and become dehydrated✓. (3) [13]

9.2 9.2.1 and 9.2.2



(8)

9.2.3 Hydra population will increase✓ in size as water fleas increase✓ in numbers; they are not eaten by the mosquito larvae.

Hydra population will increase in size✓ as the water boatmen that feed on them will decline in number✓. (4) [12]

9.3 9.3.1 Combustion fumes from cars✓ (1)

9.3.2 Burning leaves✓

Changing pH of the soil✓ (2)

9.3.3 Reduce emissions✓

Use alternative energy sources✓

Decrease population growth✓

Change people's attitudes / Reduce wants to needs only✓ (any 2) (2)

9.3.4 No legs✓

Soft bodies✓

Shells✓ (any 1) (1)

9.3.5 (a) frogs / blackfly larvae✓ (1)

(b) clams✓ (1)

(c) burns tissues / causes dehydration✓ (1) [9]

Question 10: Data response

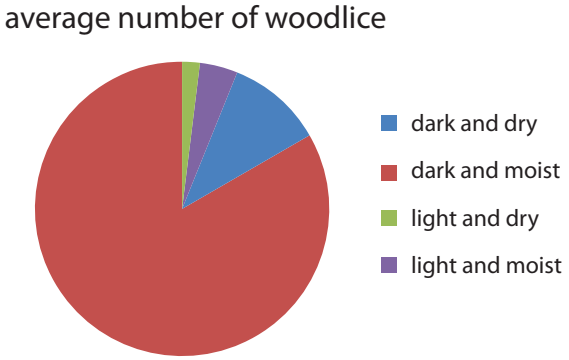
10.1 10.1.1 24✓

10.1.2 6✓

10.1.3 4✓

10.1.4 1✓ (4)

10.2



Mark: ✓✓ per sector – label and size (8)

10.3 (a) dark and moist✓ (1)

(b) moist to prevent drying out✓

dark as water evaporation will be limited✓ (2)

10.4 Increase number of repetitions✓

Increase numbers in sample✓

To get a more refined average✓ (3) [18]

Question 11: Essay

Ecology is the study ✓ of the Earth's surface where living biological organisms known as biotic factors ✓interact with each other and the non-living or abiotic factors ✓ of the environment. These areas are known as ecosystems✓. Organisms found in these areas are plants ✓ and animals ✓. The energy of the Sun is captured by plants and made into food. They are known as producers ✓. As a result the plants are also known as autotrophs because they make their own food ✓. Animals are not able to produce their own food and are called heterotrophs ✓. To obtain their food they eat other organisms and are called consumers ✓. All living organisms are part of a group of identical organisms called a species ✓. Each species has specific characteristics that allow them to cope with the environments they are found in. So each organism is adapted to survive in its unique environment ✓. In an area there may be many different groups of different animals and plants that live together. These organisms are all members of a community ✓. Decomposers break down dead organisms and biological wastes into chemicals that are called nutrients ✓. Decomposers are collectively called saprophytes ✓. Plants make food using these nutrients. They are in turn eaten by animals called herbivores ✓. These animals are eaten in a sequence called a food chain ✓ by other animals called carnivores ✓. As animals can eat different kinds of food they become part of different food chains that are linked. These interlinked food chains are called food webs ✓. The survival of animals relies on interactions between different organisms that live together in an ecosystem. These interactions are known as symbiosis ✓. [20]

TOTAL MARKS: 170

Topic 10

Answers to questions

Question 1: Multiple choice

1.1 A✓✓ (2)
1.2 D✓✓ (2)
1.3 B✓✓ (2)
1.4 D✓✓ (2)
1.5 D✓✓ (2)
1.6 D✓✓ (2)
1.7 A✓✓ (2)
1.8 A✓✓ (2)
1.9 C✓✓ (2)
1.10 B✓✓ (2) [20]

Question 2: True/false

2.1 False✓
Nomenclature is naming organisms. ✓
OR
Taxonomy/systematics is classifying organisms. ✓ (2)
2.2 True✓✓ (2)
2.3 False✓
The domain Archaea are bacteria that live in extreme environments. ✓
OR
The domain Eubacteria are bacteria that do not live in extreme environments. ✓ (2)
2.4 False✓
Indigenous species are organisms that live within a certain country only. ✓
OR
Endemic species are organisms that live within a certain area only. ✓ (2)
2.5 True✓✓ (2) [10]

Question 3: Scientific terminology

3.1 prokaryotic – unicellular organisms without a true membrane-bound nucleus✓ (1)
3.2 classification – identifying organisms✓ (1)
3.3 eukaryotic – organisms with cells containing a true membrane-bound nucleus✓ (1)
3.4 nomenclature – naming organims✓ (1)
3.5 systematics – methodically organising organisms into groups using shared characteristics✓ (1)
3.6 binomial – name made of two parts: a genus and species✓ (1)
3.7 Eubacteria – unicellular bacteria✓ (1)

3.8 Mycota – kingdom of fungi✓ (1)
3.9 Monera – kingdom of bacteria✓ (1)
3.10 Archaea – bacteria found in extreme environments✓ (1) [10]

Question 4: Matching columns

4.1 C✓
4.2 F✓
4.3 A✓
4.4 B✓
4.5 H✓
4.6 E✓
4.7 J✓
4.8 I✓
4.9 G✓
4.10 D✓ [10]

Question 5: Short response

5.1 5.1.1 Specimen A – *Lithobiomorpha*✓✓
Specimen B – *Araneae*✓✓
Specimen C – *Lithobiomorpha*✓✓
Specimen D – *Odonata*✓✓ (8)

5.1.2 The number of legs✓✓
Segmented body parts✓✓
Exoskeleton✓✓ (any 2) (4)

5.2 A – *Sorex araneus*✓✓
B – *Talpa europaea*✓✓
C – *Clethrionomys glareolus*✓✓
D – *Oryctolagus cuniculus*✓✓
E – *Sciurus caroliniensis*✓✓ (10) [22]

Question 6: Tables

	Kingdom				
Organism	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Earthworm					×✓
Bread mould			×✓		
Fern				×✓	
Seaweed		×✓			
Eagle					×✓
Cockroach					×✓
Lily				×✓	
Mushroom			×✓		
B. cholera	×✓				
Snail					×✓

[10]

Question 7: Contextual

7.1 A – Monera✓✓

B – Plantae✓✓ (4)

7.2 A – prokaryote✓; no membrane-bound nucleus / DNA free in cytoplasm✓

B – eukaryote✓; membrane-bound nucleus / cellulose cell wall / chloroplast / membrane-bound organelles✓ (4) [8]

TOTAL MARKS: 90

Topic 11

Answers to questions

Question 1: Multiple choice

1.1 C✓✓ (2)
1.2 B✓✓ (2)
1.3 D✓✓ (2)
1.4 C✓✓ (2)
1.5 A✓✓ (2)
1.6 B✓✓ (2)
1.7 D✓✓ (2)
1.8 A✓✓ (2)
1.9 A✓✓ (2)
1.10 B✓✓ (2)
1.11 C✓✓ (2)
1.12 C✓✓ (2)
1.13 A✓✓ (2)
1.14 A✓✓ (2)
1.15 D✓✓ (2)
1.16 B✓✓ (2) [32]

Question 2: True/false

2.1 True✓✓
2.2 True✓✓
2.3 False✓
Preserved hardened tree sap is called <u>amber</u>.✓
OR
A <u>footprint</u> is called a trace fossil.✓
2.4 False✓
The oldest stratum of the earth is found <u>deep down under</u> the surface.✓
OR
The <u>youngest</u> stratum of the earth is found near the surface.✓
2.5 True✓✓ [10]

Question 3: Scientific terminology

3.1 sedimentary rock – rocks made of layers of sand deposited over time as a sediment✓ (1)

3.2 trace fossil – evidence of the activity of an organism preserved in rock, but not the organism itself✓ (1)

3.3 strata – layers of rock✓ (1)

3.4 index fossil – a fossil unique to a particular period (i.e. not found in any other), used to help date strata and the associated fossils✓ (1)

3.5 transition fossil – a fossil that shows how one group of organisms changed to become another✓ (1)

3.6 living fossil – an organism that is found as fossils and that is also still alive today✓ (1)

3.7 relative dating – a fossil dating method that determines the age of the fossil compared to the age of another fossil✓ (1)

3.8 radiometric dating – absolute dating is done by calculating the ratio between the original amount of radioactive isotopes present and the amount now remaining✓ (1)

3.9 microfossils – fossilised micro-organisms✓ (1)

3.10 tectonic plates – solid land masses on which the continents are found✓ (1) [10]

Question 4: Matching columns

4.1 B ✓

4.2 F ✓

4.3 H ✓

4.4 D ✓

4.5 A ✓

4.6 C ✓

4.7 E ✓

4.8 I ✓

4.9 J ✓

4.10 L ✓ [10]

Question 5: Short response

5.1 5.1.1 Pangaea✓ (1)

5.1.2 X – (a)✓

Y – (c)✓ (2)

5.1.3 North America✓, Europe✓, Asia✓ (3) [6]

5.2 5.2.1 It must be typical of a particular geological time period✓ and have lived only in that particular geological time period✓ (2)

5.2.2 Palaeozoic era✓✓ (2)

5.2.3 Region E✓✓ (2)

5.2.4 Weathering through erosion✓ or wind action✓ (2)

5.2.5 Rock layer B✓✓ [10]

Question 6: Tables

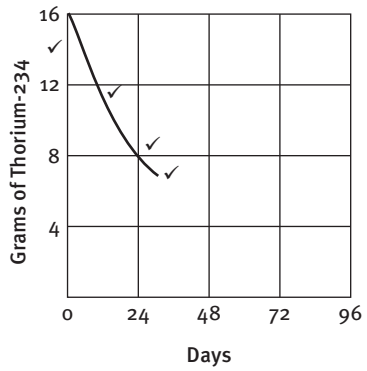
6.1 6.1.1 rubidium-87✓✓ (2)

6.1.2 lead-206✓✓ (2)

6.1.3 carbon-14✓✓ (2) [6]

Question 7: Graphs

7.1



(4)

7.2 6✓ days✓ (2) [6]

Question 8: Essay

There are many different types of fossils such as entirely preserved organisms✓, structures such as teeth and bones✓, or trace fossils✓. Palaeontologists can use the preserved structures from an organism to calculate the age✓ of the fossil and to determine the size✓ and structure✓ of the organism. (any 4) (4)

Since the soft structures do not fossilise well✓, palaeontologists must infer the appearance✓ of the soft tissue. Palaeontologists also infer the behaviour✓ and diet of fossilised organisms✓. (4)

There are gaps in the fossil record because not every organism dies under conditions that allow it to become fossilised✓. Also, many fossils remain buried✓ and have not been discovered✓ yet. However, scientists use the current fossil record to predict the transitional fossils✓ that most likely existed. (4)

Additional marks:

Coherence✓

Factual relevance✓

Focused scientific language✓ (3) [15]

TOTAL MARKS: 107

Exam Papers

LIFE SCIENCES

GRADE 10

NOVEMBER EXAMINATIONS

PAPER 1

Marks: 110 | Reading time: 10 minutes

Examiner: | Writing time: 90 minutes

Moderators:

This paper contains 9 pages.

INSTRUCTIONS:

Read the following instructions carefully before answering the questions.

1 Answer ALL the questions on the FOLIO PAPER provided.
2 Start EACH question on a NEW page.
3 NUMBER the answers correctly according to the numbering system used in this question paper.
4 ALL drawings should be done in pencil and labelled in blue or black ink.
5 Draw diagrams and flow charts ONLY when requested to do so.
6 The diagrams in this question paper may NOT necessarily be drawn to scale.
7 Non-programmable calculators, protractors and compasses may be used.
8 Write neatly and legibly in blue or black ink.

Exam Papers

SECTION A

QUESTION 1

1.1 Various possible options are provided as answers to the following questions.
Choose the correct answer and write only the letter (A–D) next to the question number (1.1.1–1.1.5).
For example, 1.1.8 A

1.1.1 Which of the following contains the others?

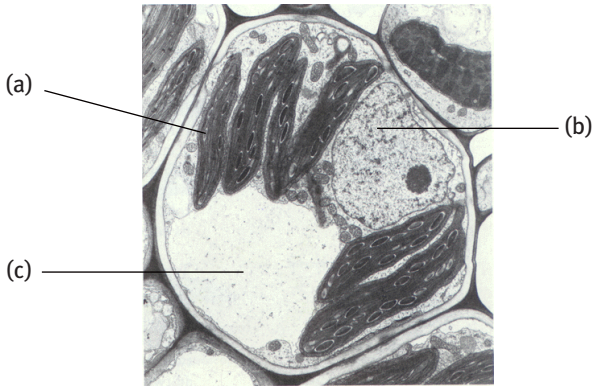
A starch granule
B stroma
C granum
D chloroplast

1.1.2 Arrange the following according to an increase in size and organisation:

(i) tree
(ii) mesophyll
(iii) spongy parenchyma cell
(iv) leaf.

A (i), (iv), (ii), (iii)
B (iii), (ii), (iv), (i)
C (iii), (ii), (i), (iv)
D (iv), (i), (iii), (ii)

Questions 1.1.3 and 1.1.4 apply to the micrograph below.



1.1.3 Structure (a), (b) and (c) in the above micrograph are respectively responsible for:

	Structure (a)	Structure (b)	Structure (c)
A	cellular respiration	storage	support
B	photosynthesis	support	phagocytosis
C	photosynthesis	cell control	turgidity
D	protein synthesis	turgidity	mitosis

1.1.4 What type of tissue has the cell been isolated from?

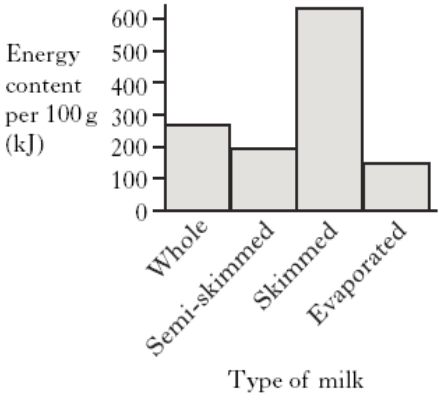
A meristematic
B epidermal
C sclerenchyma
D parenchyma

1.1.5 The table below shows the energy content of four types of milk.

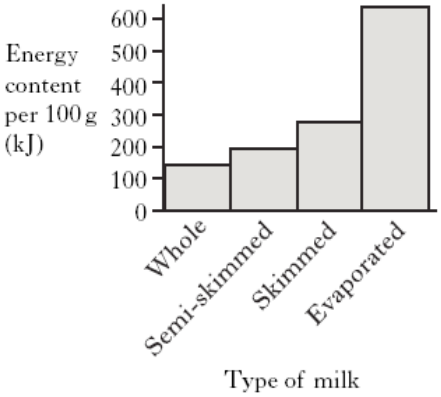
Type of milk	Energy content per 100 g (kJ)
Whole	275
Semi-skimmed	195
Skimmed	145
Evaporated	630

Which of the following graphs correctly represents this information?

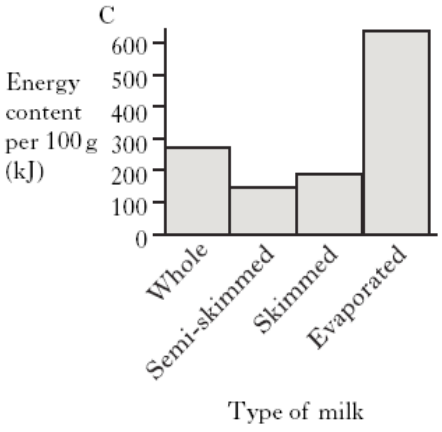
A



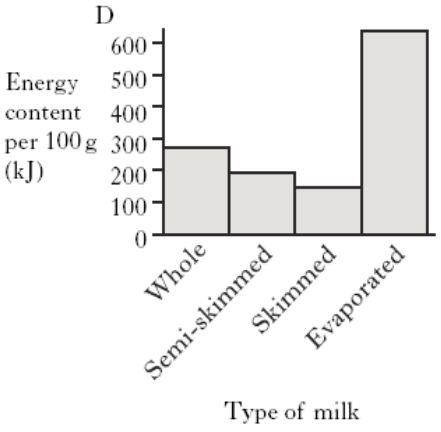
B



C



D



5 × 2 (10)

1.2 Give the correct biological term for each of the following descriptions.
Write only the term next to the question number (1.2.1–1.2.8).

1.2.1 The movement of water into a cell
1.2.2 The element found as the centre of the chlorophyll molecule
1.2.3 Movement of fertilisers through the soil
1.2.4 Conditions at which enzymes function at their best
1.2.5 Deficiency of vitamin D
1.2.6 Fats and oils
1.2.7 Carbohydrate making up the primary cell wall
1.2.8 Vacuole containing catalase

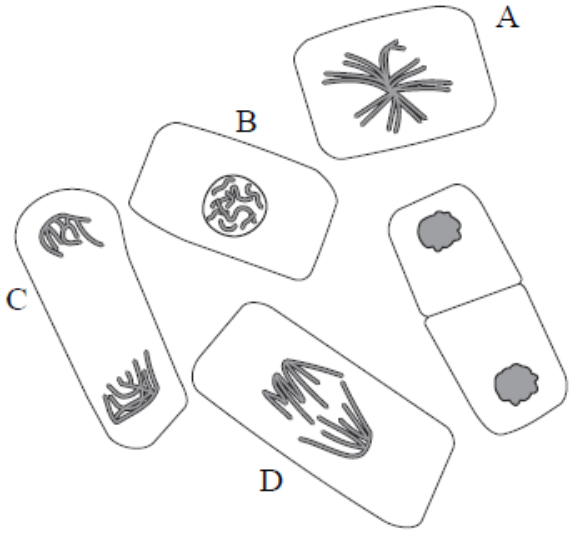
8 × 1 (8)

1.3 Match the description in COLUMN I with the scientific term in COLUMN II.
Write down only the letter of the term chosen next to the question number.
For example, 1.3.1 E

COLUMN I		COLUMN II	
1.3.1	Patterned thickening in cells	A	involuntary
1.3.2	Companion cells	B	phloem
1.3.3	Large opening in skull	C	xylem
1.3.4	Cardiac muscle	D	guard cells
1.3.5	Pores in a leaf	E	foramen magnum
		F	stomata

5 × 1 (5)

1.4 The following diagrams illustrate different stages during the complete division of a cell.



1.4.1 Name the process represented by the diagrams. (1)
1.4.2 Place the stages in the correct order, beginning with the earliest stage shown. Write down only the letters shown next to each diagram (A–E). (5)
1.4.3 What process in cell division is represented by diagram A? (1)
1.4.4 Which diagram represents anaphase? (1)
1.4.5 What is the significance of the stage shown by cell D? (2)
[10]

1.5 A learner tested four types of seeds for the presence of starch, sugar and protein.
The nutrient tests and reagents used were:

- Starch test – iodine solution
- Sugar test – Fehling's A and B
- Protein test – Biuret test.

The results are shown in the table below.

	Colour produced		
Seed type	Starch test	Sugar test	Protein test
barley	black	blue	blue
pea	black	blue	violet
cabbage	brown	orange	blue
mustard	brown	orange	violet

1.5.1 State the aim of the investigation. (1)

1.5.2 State the colour changes expected for a positive and negative test for sugar using the nutrient test used. (2)

1.5.3 List the steps in the method used to test for starch. (2)

1.5.4 Which seed stores only sugar? (1)

1.5.5 What do the different results for cabbage and mustard seeds indicate? (2)

1.5.6 State ONE way in which the data can be verified. (1)

[42]

SECTION B

QUESTION 2

2.1 The root length of the germinating kidney bean seed was measured every two days. The results are shown in the table below.

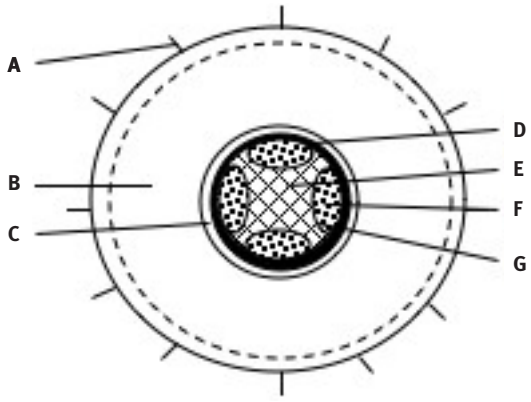
Time (days)	Root length (mm)
0	0
2	4
4	8
6	18
8	27

2.1.1 Use the grid provided on the answer sheet and draw a suitable graph by:
- (a) providing labels for the horizontal and vertical axis (2)
- (b) completing the scale on the vertical axis (1)
- (c) plotting the results. (2)

2.1.2 Between which two days was there the greatest increase in root length? (1)

2.1.3 Which tissue is responsible for the increase in length of the radicle? (1)

2.2 A cross section of the radicle was made as indicated by line X—Y and examined under a microscope.
The diagram below was produced from the section observed.



2.2.1 Identify parts A and E. (2)

2.2.2 Name the tissues found at B, D and G. (3)

2.2.3 State the functions of parts A, C and F. (3)

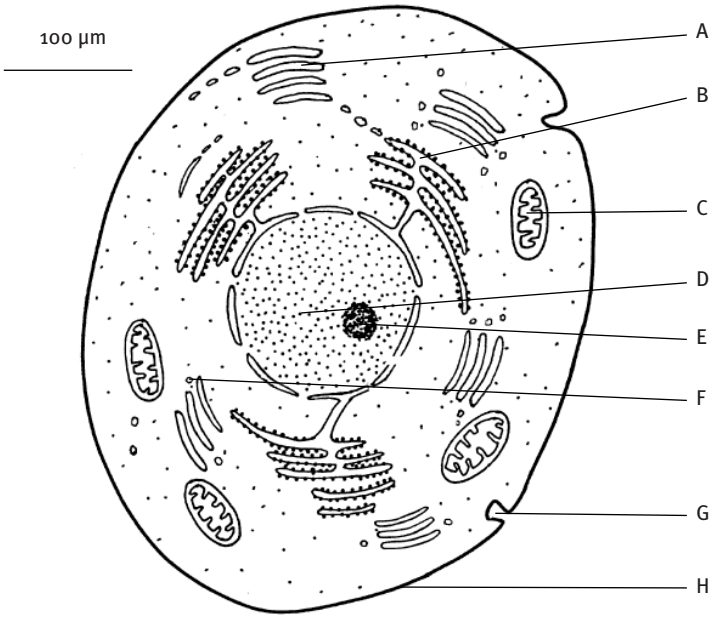
2.2.4 State THREE structural features of tissue E to suit its function of support and transport. (3)

2.3 List FOUR adaptations of leaves to suit their function.
Provide reasons for each adaptation mentioned. (8)

[26]

QUESTION 3

3.1 The drawing below shows a cell from the pancreas.



3.1.1	Calculate the magnification of the cell diagram using the scale bar only.	(4)
3.1.2	Name ONE organic substance that is found only in structure D.	(1)
3.1.3	Which labelled structures in this cell show that it is involved in the secretion of protein? Explain with reference to the drawing.	(2)
3.1.4	Identify structures C and E.	(2)
3.1.5	Structure F contains catalase enzyme. What is the function of catalase in a living cell?	(2)
3.1.6	Structure G can be involved in TWO processes. Name them.	(2)

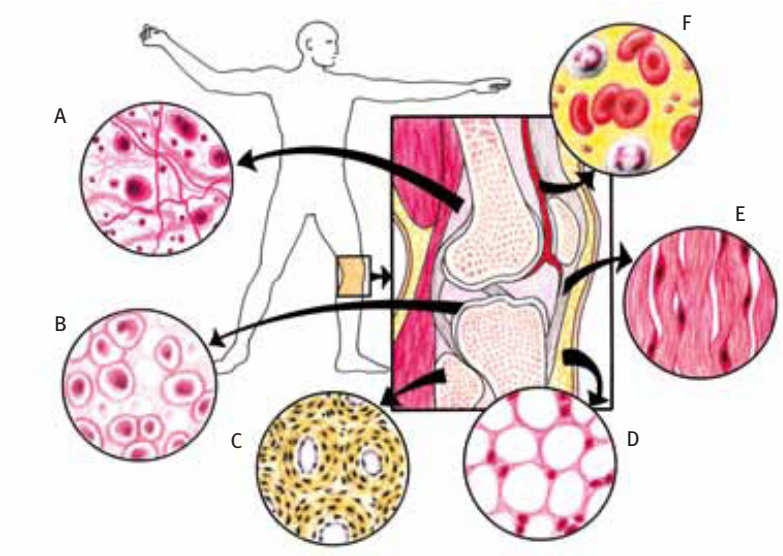
3.2 Tabulate THREE differences in structure between animal and plant cells. (5)

[18]

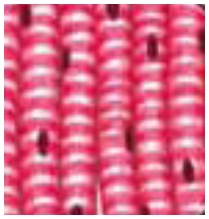
SECTION C

QUESTION 4

4.1 The tissues in diagrams A to G are found making up the knee joint.



G



(a) Where in the joint is tissue G found? (1)

(b) Name the tissue group to which tissues A to F belong? (1)

(c) State THREE features that tissues A to F share. (3)

(d) Explain the structure of tissue G and how it supports movement. (4)

4.2 Write an essay on bone disorders, their symptoms, causes and management. Refer to the disorders rickets, arthritis and osteoporosis. (15)

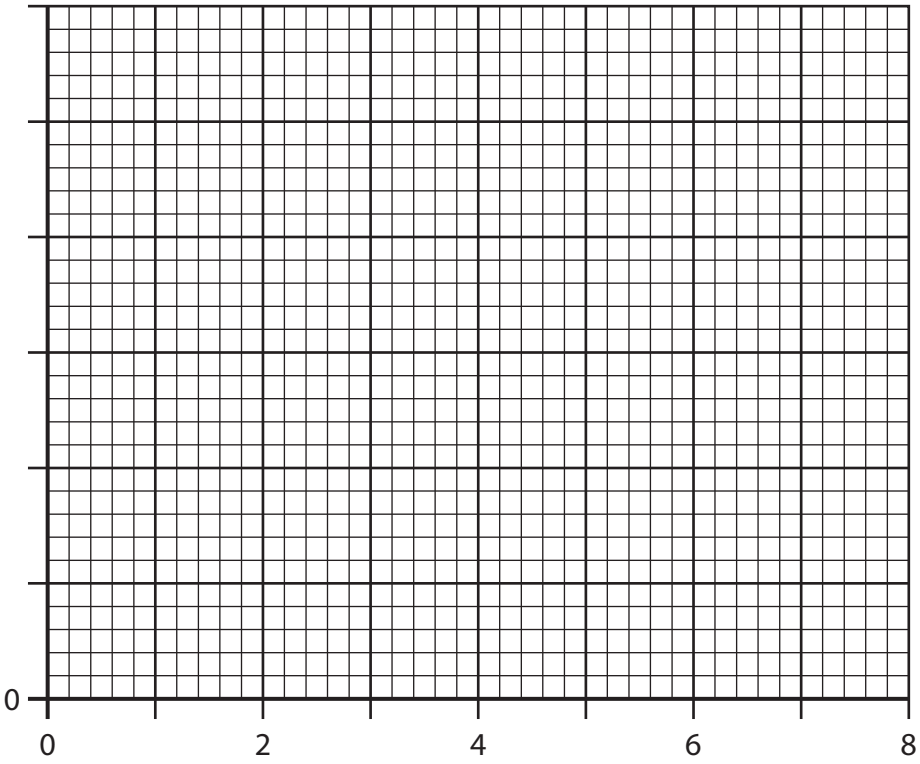
[24]

Total [110]

Name: _____ Class:_____ Teacher:_____

ANSWER SHEET

Use the grid / graph paper provided to answer question 2.2.1.



Answers to exam papers

November examinations: Paper 1

SECTION A

QUESTION 1

1.1	1.1.1	D✓✓	
	1.1.2	B✓✓	
	1.1.3	C✓✓	
	1.1.4	D✓✓	
	1.1.5	D✓✓	(5 × 2) (10)
1.2	1.2.1	endosmosis✓	
	1.2.2	magnesium✓	
	1.2.3	leaching✓	
	1.2.4	optimum✓	
	1.2.5	rickets✓	
	1.2.6	lipids✓	
	1.2.7	cellulose✓	
	1.2.8	peroxisome✓	(8 × 1) (8)
1.3	1.3.1	C✓	
	1.3.2	B✓	
	1.3.3	E✓	
	1.3.4	A✓	
	1.3.5	F✓	(5 × 1) (5)
1.4	1.4.1	mitosis✓	(1)
	1.4.2	B✓ ⇢ A✓ ⇢ D✓ ⇢ C✓ ⇢ E✓	(5)
	1.4.3	metaphase✓	(1)
	1.4.4	D✓	(1)
	1.4.5	Separates the chromatids / duplicated chromosomes / duplicated DNA content✓ into two sets✓ in preparation for cytokinesis	(2)
1.5	1.5.1	To determine the presence of starch, sugar and protein in four types of seeds✓	(1)
	1.5.2	Sugar test using Fehling's A and B: Positive test – green, yellow, orange, red colour✓ Negative test – blue colour✓	(2)
	1.5.3	Crush the seeds in water✓ Place a drop of iodine solution in seed extract✓ Mix✓ Note the colour change after 1 minute✓ (any 2 in correct order)	(2)
	1.5.4	Cabbage✓	(1)
	1.5.5	Cabbage seeds – contain sugar✓ Mustard seeds – contain sugar and protein✓	(2)
	1.5.6	Repetition✓ of investigation to see if the same results are obtained	(1)
			[42]

SECTION B

QUESTION 2

2.1 2.1.1 The graph of root length over time is given on the next page.
Mark:
Labels for the horizontal and vertical axis ✓✓
Completing the scale on the vertical axis✓
Plotting the results✓✓ (5)

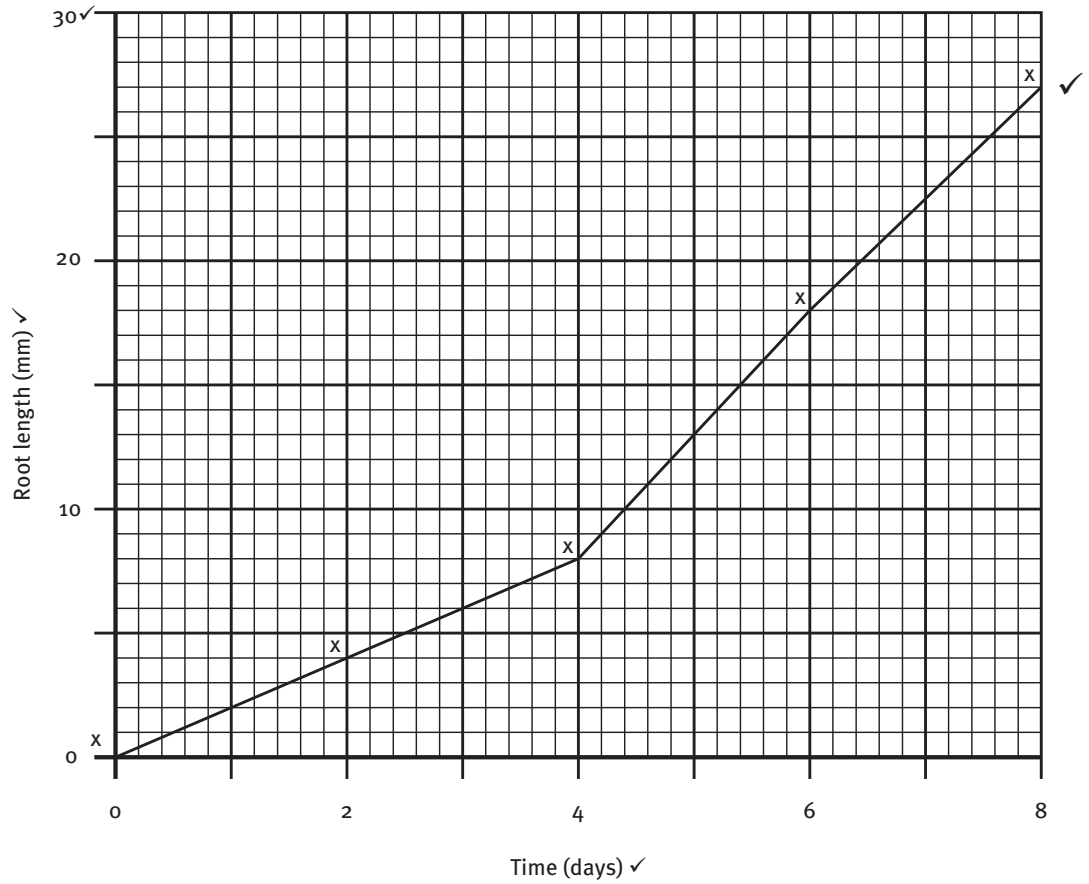
2.1.2 Days 4 and 6✓ (1)

2.1.3 Meristematic tissue✓ (1)

2.2 2.2.1 A – epidermis (with root hair) / rhizodermis✓
E – xylem✓ (2)

2.2.2 B – parenchyma✓
D – sclerenchyma✓
G – meristematic✓ (3)

Root length over time



2.2.3 A – protection and water absorption / water uptake✓
C – control of water movement into the stele✓
F – transport of manufactured food from the leaves to the roots✓ (3)

2.2.4 Secondary cell wall thickened with lignin / secondary thickening✓
Hollow / dead cells✓
Continuous tubes✓
No intercellular spaces / tightly packed✓ (any 3) (3)

2.3 Thin thickness✓ – for effective gaseous exchange✓
Large surface area✓ – for maximum sunlight absorption and gaseous exchange✓
Many stomata on the ventral surface✓ – much gaseous exchange✓
Many chloroplasts / palisade parenchyma✓ – maximum photosynthesis✓ (8)
[30]

QUESTION 3

3.1 3.1.1 $\frac{\text{actual length of scale bar in µm}✓}{\text{length of size indication on scale bar}} = \frac{19\,000\ \text{µm}✓}{100\ \text{µm}} = 190✓ \times ✓$ (4)

3.1.2 DNA / RNA✓ (1)

3.1.3 A and B✓
B manufactures proteins that are secreted by A✓ (2)

3.1.4 C – mitochondrion✓; E – nucleolus✓ (2)

3.1.5 Catalase breaks down hydrogen peroxide into water and oxygen✓
Catalase kills off damaged tissues✓ (2)

3.1.6 endocytosis✓ / exocytosis✓ / phagocytosis✓ / pinocytosis✓ (any 2) (2)

3.2 Differences between animal and plant cells

Animal cells✓	**Plant cells**✓
Centrosome present	No centrosome present✓
Cell membrane and no cell wall	Cellulose cell wall✓
No chloroplasts / plastids	Chloroplasts / plastids✓
Many small vacuoles	One large vacuole✓

(Mark: Column headings and any 3 pairs) (5)
[18]

SECTION C

QUESTION 4

4.1 (a) In the muscles that cause the movement of the joint (quadriceps and hamstring muscles)✓ (1)

(b) Connective tissues✓ (1)

(c) Background matrix✓
Fibres: collagen / elastin✓
Different types of cell✓ (3)

(d) Skeletal striated voluntary muscle✓
Made of parallel striped muscle fibres✓
Contains contraction myofibrils✓
Actin and myosin are involved in contracting the muscle cells✓
Nuclei found on the side of the cells✓
May be more than one nucleus✓ (any 4) (4)

4.2 Rickets, osteoporosis and arthritis
Rickets in children can be caused by an unhealthy diet.✓
The leg bones are weak and bend due to the weight of the body✓.
The minerals calcium and phosphorus✓ and the vitamins A and C✓ are essential for

strong and healthy bones✓.
Osteoporosis is a disease that causes bone to lose mass and the bone tissue to break down✓.
Bone becomes weaker✓.
In younger people osteoporosis is caused by lack of food (starvation), diabetes / lack of vitamin C / and over-activity of the adrenal glands / plus not enough exercise✓.
A healthy diet and exercise is needed to manage the disease✓
Arthritis is an illness that can cause pain and swelling in your joints✓.
The two most common ones are rheumatoid arthritis and osteoarthritis.

- Osteoarthritis✓ – comes with age and sometimes follows an injury to a joint✓.
- Rheumatoid arthritis✓ – occurs when the body's defence system does not work properly / affects joints, bones (often in the hands and feet), and organs✓. (15)

NOTE:
NO marks will be awarded for answers in the form of flow charts or diagrams.

The following rubric will be used to assess the essay.

CRITERIA	MARKS			
	1	2	3	4
Rickets	ONE appropriate thought / fact	TWO appropriate thoughts / facts	THREE or more appropriate thoughts / facts	FOUR or more appropriate thoughts / facts
Osteoporosis	ONE appropriate thought / fact	TWO appropriate thoughts / facts	THREE or more appropriate thoughts / facts	FOUR or more appropriate thoughts / facts
Arthritis	ONE appropriate thought / fact	TWO appropriate thoughts / facts	THREE or more appropriate thoughts / facts	FOUR or more appropriate thoughts / facts
Synthesis	Significant gaps in the logic and flow of the answer	Minor gaps in the logic and flow of the answer	Well structured – shows insight and understanding of the question	

Total: Section C [24]
GRAND TOTAL [110]

Exam Papers

NOVEMBER EXAMINATIONS

PAPER 2

Marks: 150 Reading time: 10 minutes

Examiner: Writing time: 120 minutes

Moderators:

This paper contains 14 pages.

INSTRUCTIONS:

Read the following instructions carefully before answering the questions.

1 Answer ALL the questions on the FOLIO PAPER provided.
2 Start EACH question on a NEW page.
3 NUMBER the answers correctly according to the numbering system used in this question paper.
4 ALL drawings should be done in pencil and labelled in blue or black ink.
5 Draw diagrams and flow charts ONLY when requested to do so.
6 The diagrams in this question paper may NOT necessarily be drawn to scale.
7 Non-programmable calculators, protractors and compasses may be used.
8 Write neatly and legibly in blue or black ink.

Exam Papers

SECTION A

QUESTION 1

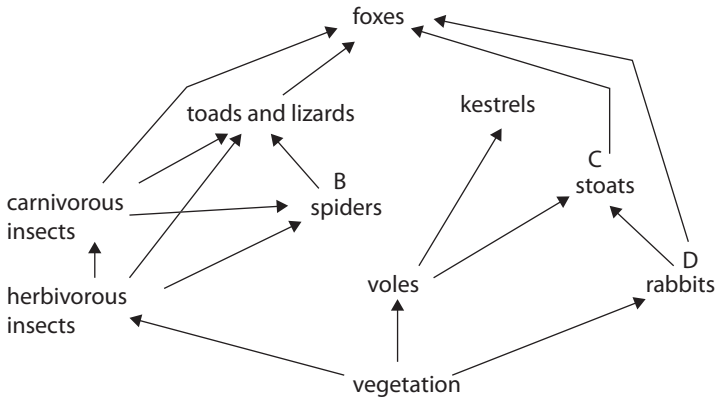
1.1 Various possible options are provided as answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.1.1–1.1.5). For example, 1.1.5 A

1.1.1 Which line in the table below shows correctly the change in concentrations of oxygen and carbon dioxide in the blood as it passes through the lungs?

	Concentration in blood	
	Oxygen	**Carbon dioxide**
A	increases	decreases
B	increases	increases
C	decreases	decreases
D	decreases	increases

1.1.2 A generalised food chain may be shown as follows:
producer ⇢ primary consumer ⇢ secondary consumer ⇢ tertiary consumer

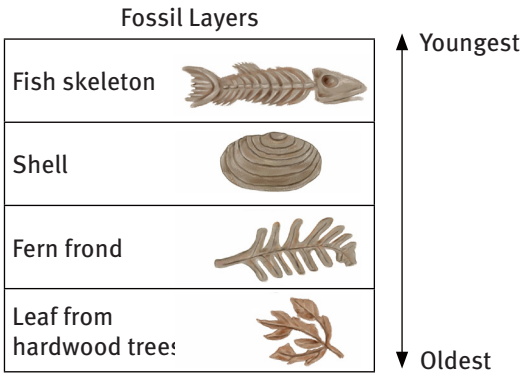
Which labelled organisms in the food web below are both secondary and tertiary consumers?



1.1.3 The diagram shows a flowering plant. Using the key, identify this plant.

1	Three petals..... More than three petals.....	Go to 2 Go to 3
2	Leaves longer than they are wide..... Leaves wider than they are long.....	A B
3	Leaves parallel-veined..... Leaves not parallel-veined.....	C D

1.1.4 Several fossils were uncovered in different layers of rock in a desert area. The following diagram indicates the age of the layers of rock and the fossils found in each.



© Science CPD

Based on the fossils found, this area was most likely once a:

A lake that was replaced by a forest
B forest that was replaced by a sea
C rainforest that was replaced by a forest
D forest that was replaced by grassland.

1.1.5 Which set of words correctly shows the organisation of living things from the largest to the smallest?

A species ⇢ biosphere ⇢ community
B biosphere ⇢ community ⇢ species
C individual ⇢ biosphere ⇢ community
D species ⇢ individual ⇢ community

5 × 2 (10)

1.2 Give the correct scientific term for each of the following descriptions. Write only the term next to the question number (1.2.1–1.2.8).

1.2.1 The type of muscle tissue found in the walls of arteries and veins
1.2.2 The biome that is a mixture of grass and trees
1.2.3 Unicellular organisms without a membrane-bound nucleus
1.2.4 The ancient land mass made of all of the modern continents
1.2.5 The semilunar structures found in veins
1.2.6 Non-living factors found in the environment
1.2.7 The kingdom in which mushrooms and moulds are found
1.2.8 Layers of rock in which fossils are found

8 × 1 (8)

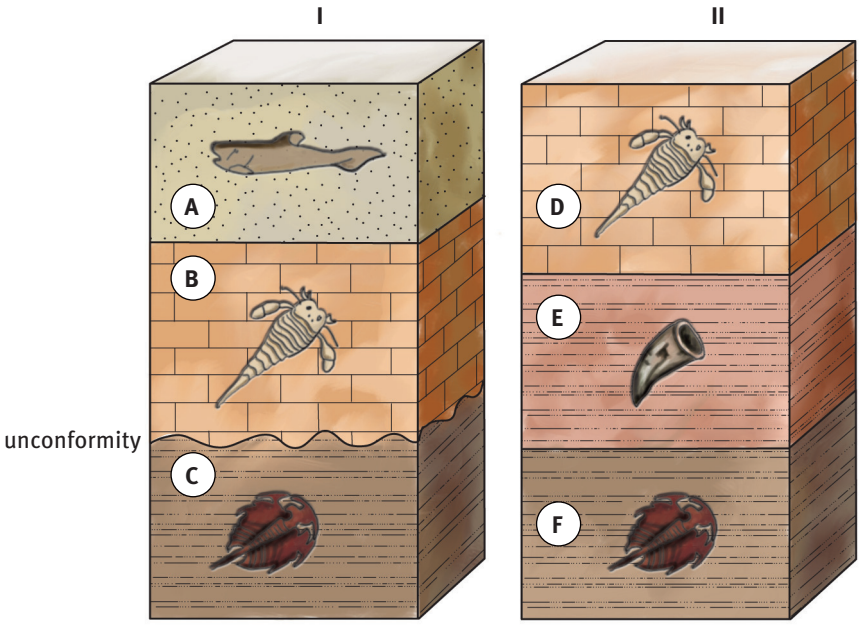
1.3 Match the description in COLUMN I with the scientific term in COLUMN II. Write down only the letter of the term chosen next to the question number. For example, 1.3.1 E

COLUMN I		COLUMN II	
		A	precipitation
1.3.1	Fluid found in the thoracic duct	B	Whittaker
1.3.2	Water falling to Earth as rain	C	capillary
1.3.3	Binomial nomenclature	D	consumers
1.3.4	Organisms that eat each other	E	Linnaeus
1.3.5	Narrowest blood vessel	F	lymph
		G	artery

5 × 1 (5)

1.4 Study the diagrams below which represent two bedrock outcrops, I and II, found several kilometres apart from each other, and answer the questions that follow.

Rock layers are lettered A through F. The drawings represent specific index fossils.



1.4.1 Describe one characteristic a fossil must have in order to be considered a good index fossil. (2)

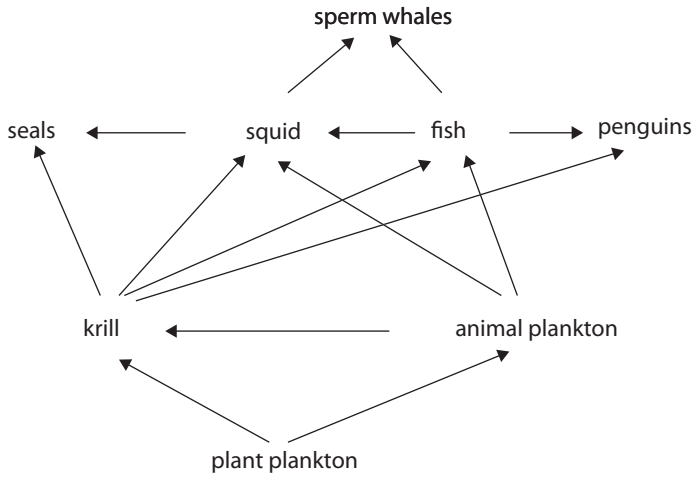
1.4.2 During which geological time period was rock layer C deposited? (2)

1.4.3 Which layer from outcrop II may be considered missing where the region labelled as an unconformity in outcrop I is found? (2)

1.4.4 State which TWO weathering processes could have caused the unconformity if rock layer E is sedimentary rock. (2)

1.4.5 Which rock layer in outcrop I is most likely the same relative age as rock layer D at position II? (2)

1.5 The diagram below shows part of an Antarctic food web.



1.5.1 Explain why a decrease in sperm whale numbers may lead to an increase in seal numbers.
(2)

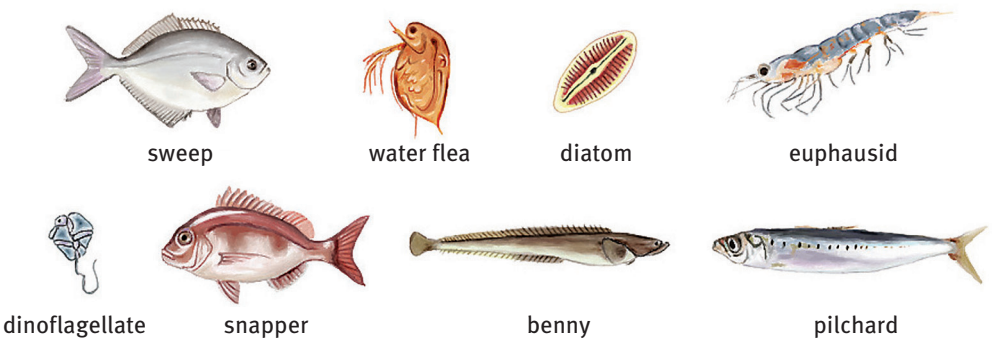
1.5.2 Decide if each of the following statements is TRUE or FALSE.
Write the words TRUE or FALSE next to the letter associated with each statement.

If the statement is FALSE, write the correct word to replace the word(s) underlined
in the statement.

Statement
(a) In this food web, krill are herbivores.
(b) The population of sperm whales has the highest biomass.
(c) The range of species in a population is called biodiversity.

(6)

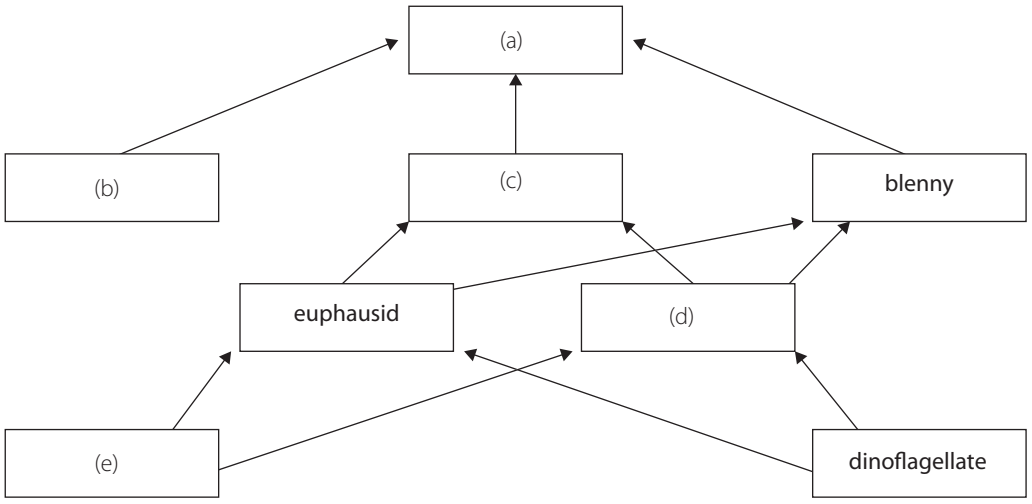
1.6 The pictures show some organisms from a marine ecosystem.
(The pictures are not to scale.)



The table below shows information about the feeding relationships in the marine ecosystem.

Organism	Food eaten
euphasid	dinoflagellate, diatom
dinoflagellate	none
sweep	diatom
snapper	sweep, pilchard, blenny
pilchard	water flea, euphausid
blenny	water flea, euphausid
diatom	none
water flea	diatom, dinoflagellate

1.6.1 Study the food web below and use the information in the table to complete it. Write the letter in the food web and next to it provide the name of the organism found at that position.



(5)

1.6.2 What term is used to describe the snapper in this ecosystem? (2)

1.6.3 A pod of dolphins arrived in the area. Dolphins feed on snappers.

(a) Describe the effect of the dolphins on the size of the euphausid population. (1)

(b) Explain your answer above. (1)

[50]

(e)

SECTION B

QUESTION 2

2.1 In African grasslands impala, giraffe and zebra feed on Acacia trees. Impala and zebra also graze on grasses.

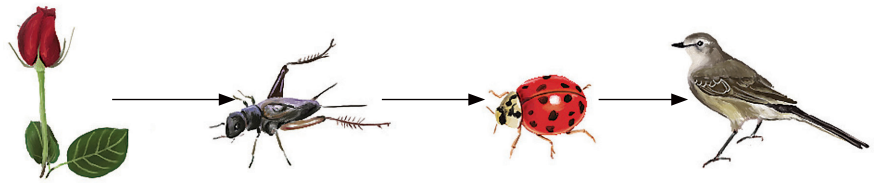
2.1.1 State ONE way in which competition for food is reduced between zebras and giraffes. (1)

2.1.2 The Acacia tree is adapted to withstand long periods of drought.
Suggest an adaptation the Acacia tree may show that allows it to survive. (1)

2.2 In South African grasslands, cattle are often found as grazers. A very large flock of cattle was introduced into an area of ungrazed grassland. Explain what their effect would be on the biodiversity within this area.

(2)

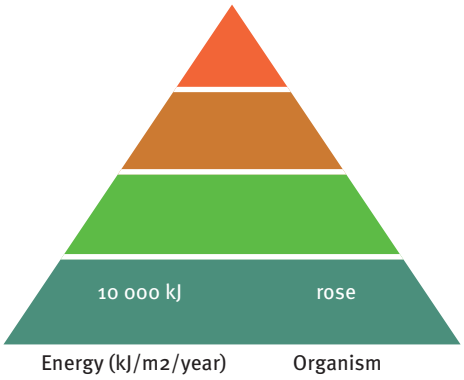
2.3 The diagram below represents a food chain in a garden.
(The organisms are not to scale.)



rose bush greenfly ladybird blackbird

2.3.1 What term describes the greenfly in this food chain? (1)

2.3.2 A rose bush contains 10 000 kJ/m²/year of energy and only 10% of this energy is passed on at each stage of the food chain.
Copy the pyramid and use the information to complete the pyramid of energy for this food chain.

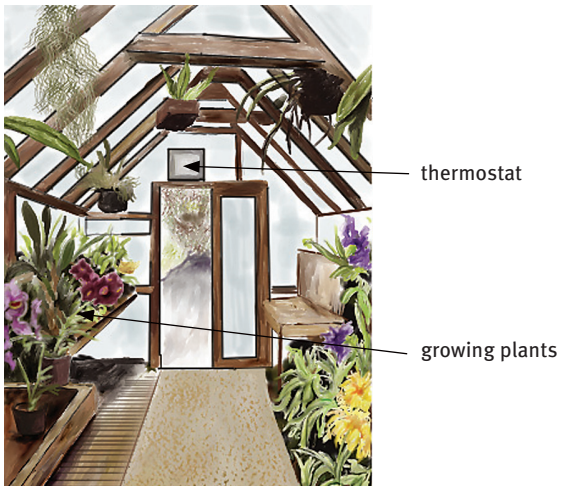


(3)

2.3.3 What happens to the energy that is not passed on at each stage of the food chain? (1)

2.3.4 Many ladybirds were seen over the summer in the garden. They were able to interbreed and produce fertile offspring.
What can be concluded about the ladybirds, using all this information? (1)

2.4 The photograph below shows a greenhouse.



2.4.1 What is the function of the thermostat in the greenhouse? (1)

2.4.2 State ONE method of providing ventilation in this greenhouse. (1)

2.4.3 The table below shows the temperatures taken inside and outside a greenhouse over a 24-hour period in winter.

Time (hours)	Temperature (°C)	
	Inside	Outside
0	14	0
4	14	3
8	15	4
12	14	6
16	15	5
20	13	3

24	14	2

Use the grid / graph paper provided on the answer sheet to answer this question.
On the grid / graph paper, complete the line graph by:

(a) providing a heading for the graph (2)
(b) providing a scale for the horizontal axis (1)
(c) providing a label for the horizontal axis (2)
(d) plotting the results for the temperature outside the greenhouse. (3)

2.5 Read the following passage carefully.

Different areas of the country have different types of soil. Some areas have clay soil which is heavy to dig, is made of small particles and has a high mineral content. It drains poorly and can easily become waterlogged and it has low air content. Other areas have sandy soil which has large particles and a low mineral content. It is light to dig, has high air content and drains freely. Loam soil is also found in some areas. Loam has medium-sized particles, is easy to dig, is rich in organic matter and minerals, and has good air content. It doesn't drain too quickly, or become waterlogged.

Use the information in the passage to answer the following questions.

2.5.1 Complete the table below by writing the letter (a to f), and the information needed next to the letter.

Type of soil	Ease of digging	Air content	(a)
clay	(b)	low	small
(c)	easy	good	medium-sized
(d)	light	(e)	(f)

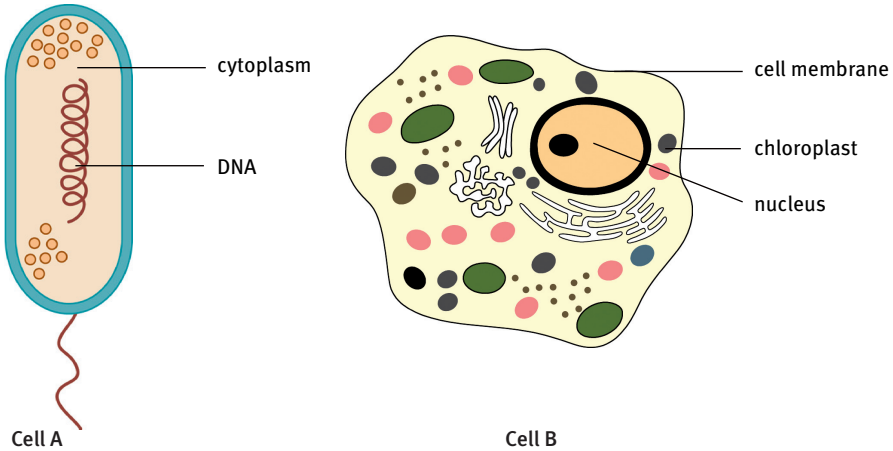
(6)

2.5.2 Which type of soil easily becomes waterlogged? (2)

2.5.3 Compare the mineral content of clay soil with that of sandy soil. (2) [30]

QUESTION 3

3.1 Study the diagrams of cells A and B below and answer the questions.
(The cells are not drawn to scale.)



3.1.1 Classify cells A and B into a suitable kingdom. (2)

3.1.2 Identify each of these cells as a prokaryote or a eukaryote.
Provide reasons for your decision. (4)

3.2 The table lists commonly used radioactive isotopes and their half-lives.
Study the table and answer the following questions.

Half-lives of selected radioactive isotopes		
Radioactive isotope	Approximate half-life	Decay product
Rubidium-87	48,6 billion years	Strontium-87
Thorium-232	14,0 billion years	Lead-208
Potassium-40	8,4 billion years	Argon-40
Uranium-238	4,5 billion years	Lead-206
Uranium-235	0,7 billion years	Lead-207
Carbon-14	5 730 years	Nitrogen-14

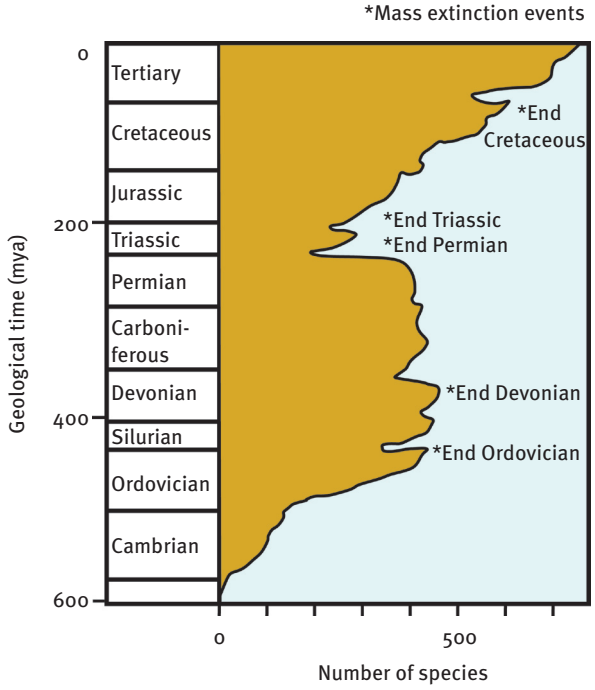
3.2.1 Which isotope has the longest half-life? (2)

3.2.2 Which stable element does uranium-238 decay into? (2)

3.2.3 Which isotope will be most helpful in dating bones that are 6 000 years old? (2)

3.2.4 Explain how the carbon nutrient cycle supports the carbon dating of fossils. (5)

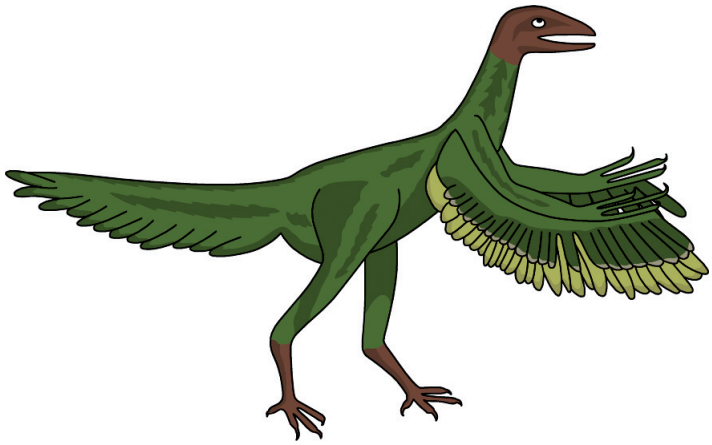
3.3 Study the diagram on the extinction of species through the history of life on Earth and answer the questions that follow.



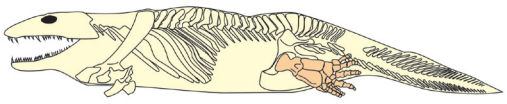
3.3.1 How many large extinction events changed the species biodiversity on Earth? (1)

3.3.2 The extinction that occurred at the end of the Cretaceous period is thought to have been caused by an asteroid. Explain how this may have occurred. (5)

3.4 Study the drawings below of certain fossils and answer the questions that follow.



Fossil A



Fossil B

3.4.1 Explain the following:

(a) body fossil (2)

(b) transition fossil. (2)

3.4.2 Which of the fossils provided above may be considered as an organism that shows the transition from water onto land? (1)

3.4.3 Explain, using TWO visible features, how fossil A can be considered a transition fossil showing how birds developed out of lizard ancestors. (2)

[30]

SECTION C

QUESTION 4

4.1 Explain why an organism that has a closed circulatory system and a four-chambered heart is classified into the kingdom Animalia and the domain Eukarya.
Refer to cellular structure, nutrition, support, movement and transport. (8)

4.2 Why do animal fossils not show fossilised hearts? Propose an explanation. (3)

4.3 A student, when at rest, measured her heart rate three times using a stethoscope and a stopwatch. The results are shown in the table.

Measurement	Number of beats in 20 seconds
1	21
2	21
3	24

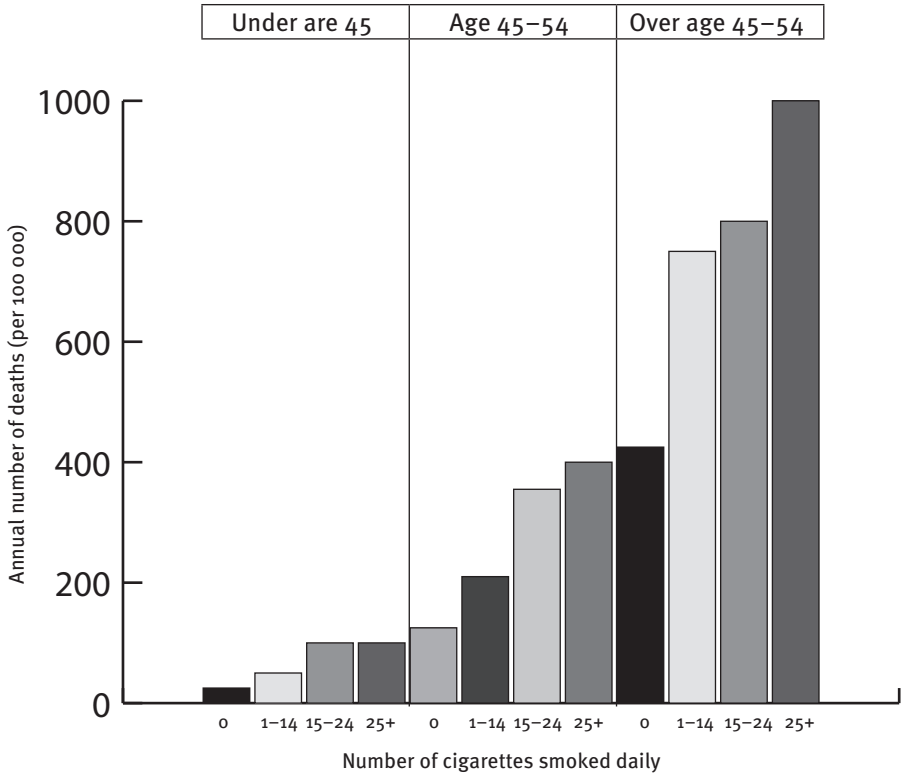
4.3.1 Calculate the student's:
(a) average heart rate in 20 seconds (1)
(b) average pulse rate in beats per minute. (1)

4.3.2 What scientific reason can be provided for taking measurements three times and calculating an average? (2)

4.3.3 The student then exercised for 30 minutes. What effect would this have on her pulse rate? (1)

4.3.4 What term is used to describe a person's heart rate when the person is inactive or resting? (1)

4.4 The bar chart shows the relationship between cigarette smoking and annual deaths from heart disease in males.



4.4.1 Formulate a hypothesis that could have been used for the investigation. (2)

4.4.2 Identify the independent variable used in the investigation. (1)

4.4.3 Identify the dependent variable used in the investigation. (1)

4.4.4 What is the annual number of deaths (per 100 000) for males aged between 45 and 54 who smoked between 15 and 24 cigarettes per day? (2)

4.4.5 Explain the TWO trends seen in the graph. (2)

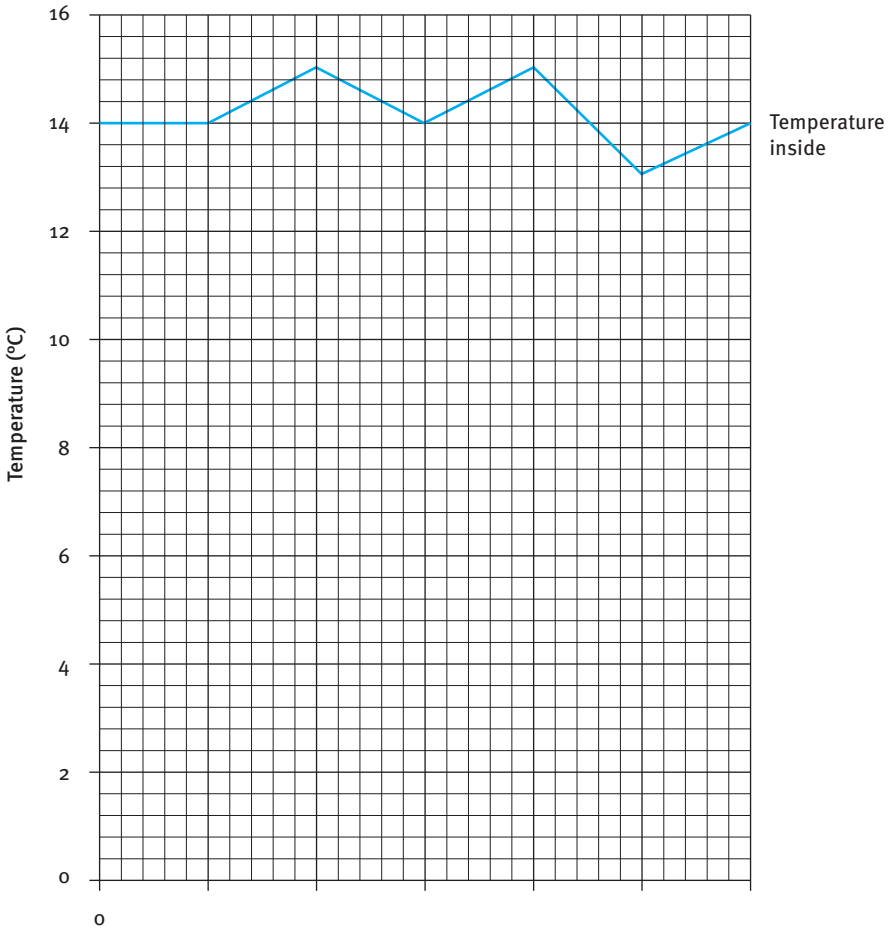
4.5 Describe the circulation of blood through the heart. Refer to the important structures and processes that are involved in managing the flow of blood. (15)

[40]

Total [150]

Name: _____ Class:_____ Teacher:_____

Use the grid / graph paper provided to answer question 2.4.3.



Answers to exam papers

November examinations: Paper 2

SECTION A

QUESTION 1

1.1	1.1.1	A✓✓	
	1.1.2	B✓✓	
	1.1.3	D✓✓	
	1.1.4	B✓✓	
	1.1.5	B✓✓	(5 × 2) (10)
1.2	1.2.1	smooth / unstriated / involuntary✓	
	1.2.2	savannah✓	
	1.2.3	prokaryote / bacteria✓	
	1.2.4	Pangaea✓	
	1.2.5	valves✓	
	1.2.6	abiotic✓	
	1.2.7	Mycota / Fungi✓	
	1.2.8	strata✓	(8 × 1) (8)
1.3	1.3.1	F✓	
	1.3.2	A✓	
	1.3.3	E✓	
	1.3.4	D✓	
	1.3.5	C✓	(5 × 1) (5)
1.4	1.4.1	Index fossils are: – unique to a particular period✓ – only found in that geological time period✓ – found all over the world✓	(any 2) (2)
	1.4.2	Palaeozoic era✓✓	(2)
	1.4.3	Rock layer E✓✓	(2)
	1.4.4	Weathering through erosion✓ or wind action✓	(2)
	1.4.5	Rock layer B✓✓	(2)
1.5	1.5.1	Sperm whales eat squid and the squid population will increase✓ with decreased sperm whales. Seals eat squid and an increase in squid will support an increase in seal numbers✓ as more food will be available.	(2)
	1.5.2	(a) False✓. Omnivores✓ (b) True✓✓ (c) False✓. Community✓	(6)
1.6	1.6.1	(a) snapper✓ (b) sweep✓ (c) pilchard✓ (d) water flea✓ (e) diatom✓	(5)
	1.6.2	consumer / carnivore / heterotroph✓✓	(2)
	1.6.3	(a) Blenny and pilchards will increase in number✓.	(1)
		(b) Both feed off euphasids and they will decrease in number✓.	(1)
			[50]

SECTION B

QUESTION 2

2.1 2.1.1 Zebras and giraffe feed at different levels. /
Zebras are grazers and giraffe are browsers✓. (1)

2.1.2 Thorns / small leaves (reduced leaf surface area)✓ (1)

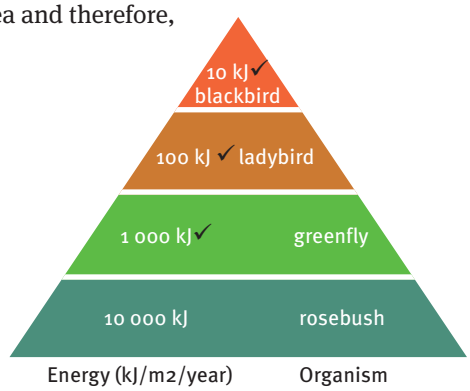
2.2 Grazing will remove various species of grass✓ and therefore decrease the food sources for other organisms that depend on the grasses being grazed.
This will decrease the species✓ found in that area and therefore, the biodiversity. (2)

2.3 2.3.1 herbivore /
primary consumer /
heterotroph✓ (1)

2.3.2 See alongside (3)

2.3.3 Lost to the system as heat✓ (1)

2.3.4 They may be considered as a species✓. (1)

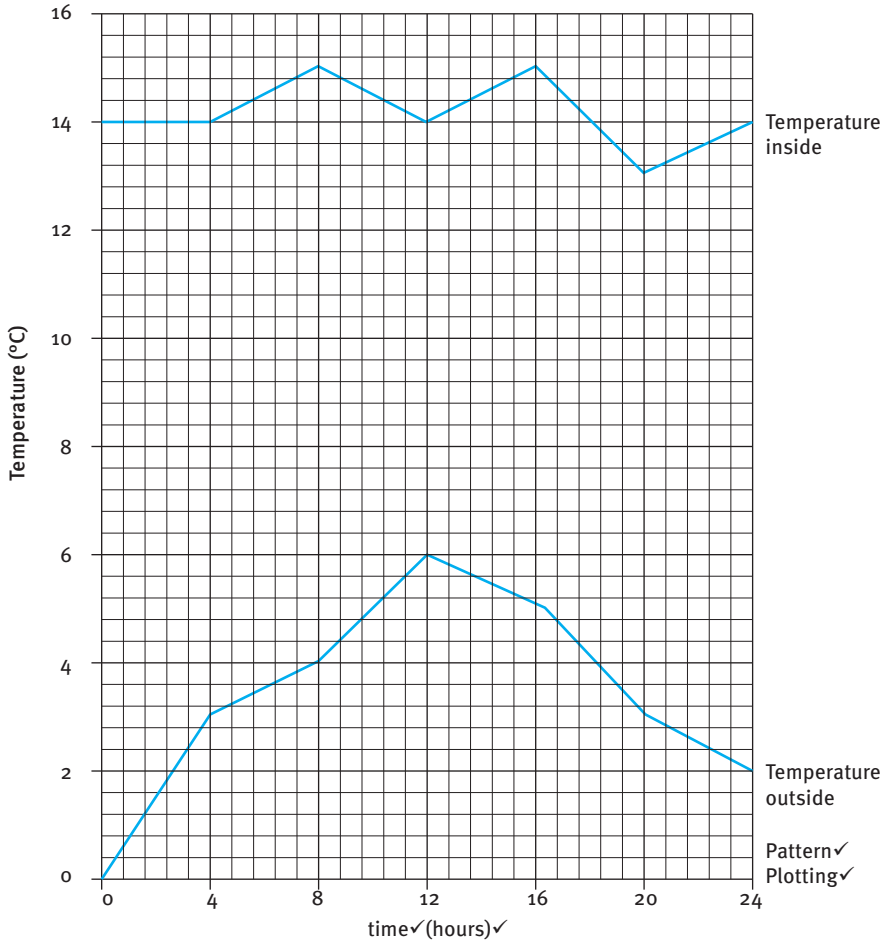


2.4 2.4.1 To maintain a constant temperature✓ (1)

2.4.2 Use of fans✓ (1)

2.4.3 (a) to (d) – see below (8)

Internal and external temperature changes✓ over 24 hours✓ for a greenhouse



2.5 2.5.1 (a) particle size✓

(b) heavy✓
(c) loam✓
(d) sand✓
(e) high✓
(f) large✓ (6)

2.5.2 Clay✓✓ (2)

2.5.3 Mineral content of clay soil – high mineral content✓
Mineral content of sandy soil – low mineral content✓ (2)

[30]

QUESTION 3

3.1 3.1.1 Cell A – Monera✓
Cell B – Plantae✓ (2)

3.1.2 Cell A – prokaryote✓
DNA free in cytoplasm / not membrane bound✓
Cell B – eukaryote✓
Membrane-bound nucleus / membrane-bound organelles (chloroplast) in cytoplasm✓ (4)

3.2 3.2.1 Rubidium-87✓✓ (2)

3.2.2 Lead-206✓✓ (2)

3.2.3 Carbon-14✓✓ (2)

3.2.4
- Plants and animals living at a certain time period are part of the carbon cycle✓.
- Plants take up carbon during photosynthesis✓.
- Carbon makes up carbohydrates and adds to their body mass✓.
- Herbivores eat plants and the carbon adds to their body mass✓.
- Carnivores and omnivores eat living organisms and the carbon adds to their body mass✓.
- When living organisms die and become fossilised the carbon in their bodies and in the atmosphere at the time is captured in the fossils✓.
- This carbon radioactively decays and can be dated✓. (max 5) (5)

3.3 3.3.1 Five✓ (1)

3.3.2
- Asteroid hit Earth✓.
- Tectonic movement was affected✓.
- Enormous killer tsunamis along occurred along the coastlines✓.
- Sediments were deposited by the tsunamis✓.
- Impact caused acid rain✓ and
- an ash cloud that blocked out the sun for months✓.
- Severe global cooling✓ known as the 'nuclear winter' occurred which killed off many species.
- Atmospheric CO_2 increased✓ resulting in a period of global warming✓ and
- the sea level rose✓. (max 5) (5)

3.4 3.4.1 (a) body fossil – dead organisms preserved in their complete form✓ through mineral replacement, permineralisation, mould/cast✓. (2)

(b) transition fossil – fossil that shows how one group of organisms✓ changed to become another✓. (2)

3.4.2 Fossil B✓ (1)

3.4.3 Bird features – feathers / wings✓
Lizard features – teeth / tail / well developed hind legs (2)

[30]

Answers to exam papers

SECTION C

QUESTION 4

4.1 Domain: Eukarya
- Cellular structure: membrane-bound nucleus✓, no plastids / chloroplasts / cell walls✓

Kingdom: Animalia
- Nutrition: consumer / heterotrophic✓
- Support: endoskeleton✓, vertebrate / vertebral column✓
- Movement: muscles✓
- Transport: four-chambered heart✓, closed circulatory system✓ (8)

4.2 Hearts are made of soft tissues✓.
Are decomposed or easily burnt before or during fossilisation✓
Contain no mineral salts that can become crystallised✓ (3)

4.3 4.3.1 (a) 22 beats in 20 seconds✓ (1)
(b) 66 beats per minute✓ (1)

4.3.2 Validity / accuracy of measurement✓✓ (2)

4.3.3 It would increase✓. (1)

4.3.4 Resting heart rate✓ (1)

4.4 4.4.1 To determine the relationship between cigarette smoking✓ and annual deaths from heart disease in males✓ (2)

4.4.2 Number of cigarettes smoked daily / age groups✓ (1)

4.4.3 Annual number of deaths per 100 000✓ (1)

4.4.4 350✓ annual number of deaths (per 100 000)✓ (2)

4.4.5 Deaths increase with the more cigarettes smoked✓
Deaths increase✓ with age✓ (2)

4.5 Circulation of blood through the heart:
- The cardiac cycle✓ moves blood through the heart.
- The cardiac cycle involves:
  – systole: contraction of the heart muscle✓
  – diastole: relaxation of the heart muscle✓.
- The heart distributes blood to all parts of the body through two sets✓ of muscular contractions, which pump blood. / The heart beats twice:
  – atria contract (atrial systole) ✓ and force blood through the heart into the ventricles✓;
  – ventricles contract (ventricle systole) ✓ and force blood out of the heart✓.
- Four sets of valves✓ found at the entrance and near the exit of the ventricles control the direction of blood flow through the heart.
- Deoxygenated blood✓ from the body enters the right atrium from the superior vena cava and inferior vena cava✓.
- Deoxygenated blood✓ from the heart leaves the right ventricle and enters the lungs through the pulmonary arteries✓.
- Oxygenated blood✓ from the lungs enters the left atrium from the lungs through the pulmonary veins✓.
- During the atrial systole (0,1 seconds long):
  – the sinoatrial node✓ sends an electrical impulse to the muscle of the left and right atria✓
  – the two atria contract together✓
  – the tricuspid and bicuspid valves open✓
  – blood flows into the two ventricles: deoxygenated blood from the right atrium into the right ventricle; oxygenated blood from the left atrium into the left

ventricle ✓.

- During the ventricular systole (0,3 seconds long):
  - electrical signals go through the muscles of the atria to the atrioventricular (AV) node✓
  - this signal goes through the atrioventricular bundle to the ventricles✓
  - the two ventricles contract together✓
  - the tricuspid and bicuspid valves close✓ to prevent backflow into the atria.
  - blood is forced into the aorta and the pulmonary artery✓
  - deoxygenated blood is sent to the lungs through the pulmonary artery ✓.
- After oxygenation in the lungs the oxygenated blood returns to the left atrium✓.
- Oxygenated blood moves into the left ventricle during atrial systole.
- Oxygenated blood is then sent into the aorta✓ during ventricular systole and through arteries to the tissues✓.
- During general diastole (0,4 seconds long):
  - both the atria and ventricles relax✓
  - the semilunar valves at the base of the aorta and pulmonary artery close, preventing backflow of blood✓
  - blood moves into the atria from the superior vena cava and inferior vena cava and the pulmonary veins. (max 15) (15)

The following rubric will be used to assess the essay.

CRITERIA	MARKS			
	1	2	3	4
Movement of blood during atrial systole	ONE appropriate thought/fact	TWO appropriate thoughts/facts	THREE or more appropriate thoughts/facts	FOUR or more appropriate thoughts/facts
Movement of blood during ventricular systole	ONE appropriate thought/fact	TWO appropriate thoughts/facts	THREE or more appropriate thoughts/facts	FOUR or more appropriate thoughts/facts
Neural stimulation for contraction	ONE appropriate thought/fact	TWO appropriate thoughts/facts	THREE or more appropriate thoughts/facts	FOUR or more appropriate thoughts facts
Synthesis	Significant gaps in the logic and flow of the answer	Minor gaps in the logic and flow of the answer	Well structured – shows insight and understanding of the question	

Total: Section C [40]
GRAND TOTAL [150]