Cambridge Assessment International Education

# Syllabus

# Cambridge O Level

# Biology 5090

Use this syllabus for exams in 2026, 2027 and 2028.
Exams are available in the June and November series.

This syllabus is **not** available in all administrative zones.
Please check the syllabus page at **www.cambridgeinternational.org/5090** to see if this syllabus is available in your administrative zone.

Version 1

For the purposes of screen readers, any mention in this document of Cambridge IGCSE refers to Cambridge International General Certificate of Secondary Education.

Cambridge Pathway

# Why choose Cambridge International?

Cambridge International prepares school students for life, helping them develop an informed curiosity and a lasting passion for learning. We are part of the University of Cambridge.

Our Cambridge Pathway gives students a clear path for educational success from age 5 to 19. Schools can shape the curriculum around how they want students to learn – with a wide range of subjects and flexible ways to offer them. It helps students discover new abilities and a wider world, and gives them the skills they need for life, so they can achieve at school, university and work.

Our programmes and qualifications set the global standard for international education. They are created by subject experts, are rooted in academic rigour and reflect the latest educational research. They provide a strong platform for learners to progress from one stage to the next, and are well supported by teaching and learning resources. Learn more about our research at **www.cambridgeassessment.org.uk/our-research/**

We believe education works best when curriculum, teaching, learning and assessment are closely aligned. Our programmes develop deep knowledge, conceptual understanding and higher-order thinking skills, to prepare students for their future. Together with schools, we develop Cambridge learners who are confident, responsible, reflective, innovative and engaged – equipped for success in the modern world.

Every year, nearly a million Cambridge students from 10 000 schools in 160 countries prepare for their future with the Cambridge Pathway.

**School feedback:** 'We think the Cambridge curriculum is superb preparation for university.'
**Feedback from:** Christoph Guttentag, Dean of Undergraduate Admissions, Duke University, USA

### Quality management

Cambridge International is committed to providing exceptional quality. In line with this commitment, our quality management system for the provision of international education programmes and qualifications for students aged 5 to 19 is independently certified as meeting the internationally recognised standard, ISO 9001:2015. Learn more at **www.cambridgeinternational.org/about-us/our-standards/**

# Contents



**Important: Changes to this syllabus**

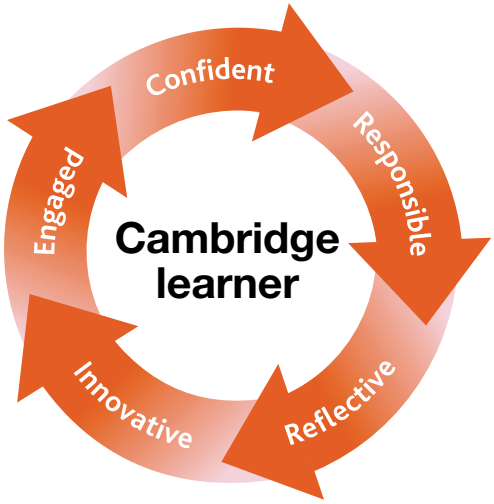
The latest syllabus is version 1, published September 2023. There are no significant changes which affect teaching.

Any textbooks endorsed to support the syllabus for examination from 2023 are still suitable for use with this syllabus.

# 1 Why choose this syllabus?

## Key benefits

Cambridge O Level is typically for 14 to 16 year olds and is an internationally recognised qualification. It has been designed especially for an international market and is sensitive to the needs of different countries. Cambridge O Level is designed for learners whose first language may not be English, and this is acknowledged throughout the examination process.




Our programmes promote a thorough knowledge and understanding of a subject and help to develop the skills learners need for their next steps in education or employment.

**Cambridge O Level Biology** develops a set of transferable skills including handling data, practical problem-solving and applying the scientific method. Learners develop relevant attitudes, such as concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness. They acquire the essential scientific skills required for progression to further studies or employment.

Our approach in Cambridge O Level Biology encourages learners to be:

**confident**, interested in learning about science, questioning ideas and using scientific language to communicate their views and opinions

**responsible**, working methodically and safely when working alone or collaboratively with others

**reflective**, learning from their experiences and interested in scientific issues that affect the individual, the community and the environment

**innovative**, solving unfamiliar problems confidently and creatively

**engaged**, keen to develop scientific skills, curious about scientific principles and their application in the world.

**School feedback:** 'Cambridge O Level has helped me develop thinking and analytical skills which will go a long way in helping me with advanced studies.'

**Feedback from:** Kamal Khan Virk, former student at Beaconhouse Garden Town Secondary School, Pakistan, who went on to study Actuarial Science at the London School of Economics

## International recognition and acceptance

Our expertise in curriculum, teaching and learning, and assessment is the basis for the recognition of our programmes and qualifications around the world. The combination of knowledge and skills in Cambridge O Level Biology gives learners a solid foundation for further study. Candidates who achieve grades A* to C are well prepared to follow a wide range of courses including Cambridge International AS & A Level Biology.

Cambridge O Levels are accepted and valued by leading universities and employers around the world as evidence of academic achievement. Cambridge students can be confident that their qualifications will be understood and valued throughout their education and career, in their home country and internationally. Many universities require a combination of Cambridge International AS & A Levels and Cambridge O Levels or equivalent to meet their entry requirements.

Learn more at **www.cambridgeinternational.org/recognition**

## Supporting teachers

We believe education is most effective when curriculum, teaching and learning, and assessment are closely aligned. We provide a wide range of resources, detailed guidance, innovative training and targeted professional development so that you can give your students the best possible preparation for Cambridge O Level. To find out which resources are available for each syllabus go to our School Support Hub.

The School Support Hub is our secure online site for Cambridge teachers where you can find the resources you need to deliver our programmes. You can also keep up to date with your subject and the global Cambridge community through our online discussion forums.

Find out more at **www.cambridgeinternational.org/support**

| **Support for Cambridge O Level** | | | |
|---|---|---|---|
| **Planning and preparation**<br>• Syllabuses<br>• Schemes of work<br>• Specimen Question Papers and Mark Schemes<br>• Teacher guides | **Teaching and assessment**<br>• Endorsed resources<br>• Online forums | **Learning and revision**<br>• Example candidate responses<br>• Past papers and mark schemes<br>• Specimen paper answers<br>• Test Maker | **Results**<br>• Candidate Results Service<br>• Principal examiner reports for teachers |

Sign up for email notifications about changes to syllabuses, including new and revised products and services, at **www.cambridgeinternational.org/syllabusupdates**

Syllabuses and specimen materials represent the final authority on the content and structure of all of our assessments.

## Professional development

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**www.cambridgeinternational.org/support-and-training-for-schools/professional-development/**

**Supporting exams officers**

We provide comprehensive support and guidance for all Cambridge exams officers.
Find out more at: **www.cambridgeinternational.org/eoguide**

# 2 Syllabus overview

## Aims

The aims describe the purposes of a course based on this syllabus.

You can deliver some of the aims using suitable local, international or historical examples and applications, or through collaborative experimental work.

The aims are to enable students to:

- acquire scientific knowledge and understanding of scientific theories and practice
- develop a range of experimental skills, including handling variables and working safely
- use scientific data and evidence to solve problems and discuss the limitations of scientific methods
- communicate effectively and clearly, using scientific terminology, notation and conventions
- understand that the application of scientific knowledge can benefit people and the environment
- enjoy science and develop an informed interest in scientific matters which support further study.

Cambridge Assessment International Education is an education organisation and politically neutral. The contents of this syllabus, examination papers and associated materials do not endorse any political view. We endeavour to treat all aspects of the exam process neutrally.

## Content overview

Candidates study the following topics:

1 Cells
2 Classification
3 Movement into and out of cells
4 Biological molecules
5 Enzymes
6 Plant nutrition
7 Transport in flowering plants
8 Human nutrition
9 Human gas exchange
10 Respiration
11 Transport in humans
12 Disease and immunity
13 Excretion
14 Coordination and control
15 Coordination and response in plants
16 Development of organisms and continuity of life
17 Inheritance
18 Biotechnology and genetic modification
19 Relationships of organisms with one another and with the environment

## Assessment overview

All candidates take three components. Candidates will be eligible for grades A* to E.

| Paper 1: Multiple Choice | | | Paper 2: Theory | |
|---|---|---|---|---|
| 1 hour | | | 1 hour 30 minutes | |
| 40 marks | 30% | **AND** | 80 marks | 50% |
| 40 four-option multiple-choice questions | | | Short-answer and structured questions | |
| Externally assessed | | | Externally assessed | |

### Practical assessment

All candidates take one practical paper from a choice of two:

| Paper 3: Practical Test | | | Paper 4: Alternative to Practical | |
|---|---|---|---|---|
| 1 hour 30 minutes | | | 1 hour | |
| 40 marks | 20% | **OR** | 40 marks | 20% |
| Questions will be based on the experimental skills in Section 4 | | | Questions will be based on the experimental skills in Section 4 | |
| Externally assessed | | | Externally assessed | |

Information on availability is in the **Before you start** section.

# Assessment objectives

The assessment objectives (AOs) are:

## AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

- scientific phenomena, facts, laws, definitions, concepts and theories
- scientific vocabulary, terminology and conventions (including symbols, quantities and units)
- scientific instruments and apparatus, including techniques of operation and aspects of safety
- scientific and technological applications with their social, economic and environmental implications.

Subject content defines the factual material that candidates may be required to recall and explain.

Candidates will also be asked questions which require them to apply this material to unfamiliar contexts and to apply knowledge from one area of the syllabus to another.

## AO2 Handling information and problem-solving

Candidates should be able, in words or using other written forms of presentation (i.e. symbolic, graphical and numerical), to:

- locate, select, organise and present information from a variety of sources
- translate information from one form to another
- manipulate numerical and other data
- use information to identify patterns, report trends and form conclusions
- present reasoned explanations for phenomena, patterns and relationships
- make predictions based on relationships and patterns
- solve problems, including some of a quantitative nature.

Questions testing these skills may be based on information that is unfamiliar to candidates, requiring them to apply the principles and concepts from the syllabus to a new situation, in a logical, deductive way.

## AO3 Experimental skills and investigations

Candidates should be able to:

- demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- make and record observations, measurements and estimates
- interpret and evaluate experimental observations and data
- evaluate methods and suggest possible improvements.

## Weighting for assessment objectives

The approximate weightings allocated to each of the assessment objectives (AOs) are summarised below.

### Assessment objectives as a percentage of the qualification

| Assessment objective | Weighting in O Level % |
|---|---|
| AO1 Knowledge with understanding | 50 |
| AO2 Handling information and problem-solving | 30 |
| AO3 Experimental skills and investigations | 20 |
| Total | 100 |

### Assessment objectives as a percentage of each component

| Assessment objective | Weighting in components % | | |
|---|---|---|---|
| | Paper 1 | Paper 2 | Papers 3 and 4 |
| AO1 Knowledge with understanding | 63 | 63 | 0 |
| AO2 Handling information and problem-solving | 37 | 37 | 0 |
| AO3 Experimental skills and investigations | 0 | 0 | 100 |
| Total | 100 | 100 | 100 |

# 3 Subject content

This syllabus gives you the flexibility to design a course that will interest, challenge and engage your learners. Where appropriate you are responsible for selecting resources and examples to support your learners' study. These should be appropriate for the learners' age, cultural background and learning context as well as complying with your school policies and local legal requirements.

This syllabus gives you the flexibility to design a course that will interest, challenge and engage your learners. Where appropriate you are responsible for selecting resources and examples to support your learners' study. These should be appropriate for the learners' age, cultural background and learning context as well as complying with your school policies and local legal requirements.

Scientific subjects are, by their nature, experimental. Learners should pursue a fully integrated course which allows them to develop their experimental skills by doing practical work and investigations.

Practical work helps students to:

- use equipment and materials accurately and safely
- develop observational and problem-solving skills
- develop a deeper understanding of the syllabus topics and the scientific approach
- appreciate how scientific theories are developed and tested
- transfer the experimental skills acquired to unfamiliar contexts
- develop positive scientific attitudes such as objectivity, integrity, cooperation, enquiry and inventiveness
- develop an interest and enjoyment in science.

## 1 Cells

### 1.1 Cell structure and function

1 Examine under the microscope, animal cells and plant cells from any suitable locally available material, using an appropriate temporary staining technique, such as methylene blue or iodine solution

2 Draw diagrams to represent observations of the animal and plant cells examined above

3 Identify on diagrams, photomicrographs or electron micrographs, the ribosomes, mitochondria, nucleus, cytoplasm and cell membrane in an animal cell

4 Identify on diagrams, photomicrographs or electron micrographs, the ribosomes, mitochondria, chloroplasts, nucleus, sap vacuole, cytoplasm, cell membrane and cellulose cell wall in a plant cell

5 Describe the structure of a bacterial cell, limited to: ribosomes, circular deoxyribonucleic acid (DNA) and plasmids, cytoplasm, cell membrane and cell wall

6 Describe the functions of the above structures in animal, plant and bacterial cells

### 1.2 Specialised cells, tissues and organs

1 Understand that cells can become specialised and that their structures are related to their specific functions, as illustrated by examples covered in the syllabus

2 Understand the terms cell, tissue, organ, organ system and organism as illustrated by examples covered in the syllabus

3 State and use the formula magnification $= \frac{\text{image size}}{\text{actual size}}$

# 2 Classification

## 2.1 Concept and use of a classification system

1 Understand that organisms can be classified into groups by the features they share

2 Describe a species as a group of organisms that can reproduce to produce fertile offspring

3 Describe the binomial system of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species

4 Construct and use dichotomous keys based on identifiable features

## 2.2 Features of organisms

1 State the main features used to place all organisms into one of the five kingdoms: Animal, Plant, Fungus, Prokaryote, Protoctist

2 State the main features used to place organisms into groups within the animal kingdom, limited to:

(a) the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish

(b) the main groups of arthropods: myriapods, insects, arachnids, crustaceans

3 State the main features used to place organisms into groups within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons)

4 Classify organisms using the features identified in 2.2.1, 2.2.2 and 2.2.3

5 State the main features of viruses, limited to protein coat and genetic material

6 Understand that viruses can only replicate in living cells

# 3 Movement into and out of cells

## 3.1 Diffusion and osmosis

1 Describe the role of water as a solvent in organisms with reference to digestion, excretion and transport

2 Understand that the energy for diffusion and osmosis comes from the kinetic energy of random movement of molecules and ions

3 Understand diffusion as the net movement of molecules or ions from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement

4 Investigate the factors that influence diffusion, limited to: surface area, temperature, concentration gradient and distance

5 Understand osmosis as the net movement of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane

6 Understand that plants are supported by the pressure of water inside the cells pressing outwards on the cell wall

7 Describe the effects of osmosis on plant and animal tissues and explain the importance of water potential gradient and osmosis in the uptake and loss of water

8 Investigate and explain the effects on plant tissues of immersing them in solutions of different concentrations, using the terms turgid, turgor pressure, plasmolysis and flaccid

9 Investigate osmosis using materials such as dialysis tubing

### 3.2 Active transport

1 Understand active transport as the movement of molecules or ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration (i.e. against a concentration gradient), using energy released during respiration

2 Explain the importance of active transport in ion uptake by root hair cells

## 4 Biological molecules

### 4.1 Biological molecules

1 List the chemical elements that make up:
- (a) carbohydrates
- (b) lipids (fats and oils)
- (c) proteins
- (d) DNA

2 State that large molecules are made from smaller molecules, limited to: starch, cellulose and glycogen from glucose; proteins from amino acids; lipids from fatty acids and glycerol; DNA from nucleotides

3 Describe and be able to do chemical tests for:
- (a) starch (iodine solution)
- (b) glucose and maltose (Benedict's solution)
- (c) protein (biuret test)
- (d) lipids (ethanol emulsion test)

## 5 Enzymes

### 5.1 Enzyme action

1 Describe a catalyst as a substance that increases the rate of a chemical reaction and is not changed by the reaction

2 Describe enzymes as proteins that function as biological catalysts and are involved in all metabolic reactions

3 Explain enzyme action with reference to the substrate, active site, enzyme-substrate complex, and product

4 Explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate ('lock and key' hypothesis)

### 5.2 Effects of temperature and pH

1 Understand that the progress of enzyme-catalysed reactions can be followed by measuring the concentrations of reactants and products

2 Investigate and describe the effects of temperature and pH on enzyme activity

3 Explain the effect of changes in temperature and pH on enzyme activity in terms of kinetic energy, shape and fit, denaturation and the frequency of effective collisions

# 6 Plant nutrition

## 6.1 Photosynthesis

1 Understand that photosynthesis is the process by which plants make carbohydrates from raw materials using energy from light

2 State that chlorophyll is a green pigment that is found in chloroplasts

3 State that chlorophyll transfers light energy into chemical energy for the formation of glucose and other carbohydrates

4 Outline the subsequent use and storage of the carbohydrates made in photosynthesis, limited to:
- (a) starch as an energy store
- (b) cellulose to build cell walls
- (c) glucose used in respiration to provide energy
- (d) sucrose for transport through the plant

5 State the word equation and balanced chemical equation for photosynthesis

6 Investigate the need for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls

7 Describe and explain the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis

8 Investigate the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis using submerged aquatic plants and hydrogencarbonate indicator solution

9 Identify and explain the limiting factors of photosynthesis in different environmental conditions

## 6.2 Leaf structure

1 State that most leaves have a large surface area and are thin, and explain how these features are adaptations for photosynthesis

2 Identify and label the cuticle, cellular and tissue structures of a dicotyledonous leaf, as seen in diagrams or photomicrographs, and explain how these structures are adaptations for photosynthesis and gas exchange, limited to:
- (a) stomata and guard cells
- (b) spongy and palisade mesophyll cells
- (c) air spaces
- (d) vascular bundles (xylem and phloem)
- (e) distribution of chloroplasts
- (f) upper and lower epidermis

## 6.3 Mineral nutrition

1 Explain the importance of nitrate ions for making amino acids, required for the production of proteins

2 Explain the importance of magnesium ions for making chlorophyll

# 7 Transport in flowering plants

## 7.1 Uptake and transport of water and ions

1 Relate the structure of root hair cells to their function of water and ion uptake

2 Outline the pathway taken by water through the root, stem and leaf, limited to: root hair cells, root cortex cells, xylem and mesophyll cells

3 Investigate, using a suitable stain, the pathway of water in a cut stem

## 7.2 Transpiration and translocation

1 Describe transpiration as the loss of water vapour from leaves

2 Understand that water evaporates from the surfaces of the mesophyll cells into air spaces and then diffuses out of the leaves through the stomata as water vapour

3 Explain:

(a) the effects of wind speed, and the variation of temperature, humidity and light intensity on transpiration rate

(b) how wilting occurs

4 Investigate the effects of wind speed, light intensity and temperature variation on transpiration rate

5 Explain the mechanism by which water moves upwards in the xylem in terms of a transpiration pull that draws up a column of water molecules, held together by forces of attraction between water molecules

6 Describe translocation as the movement of sucrose and amino acids in the phloem from parts of plants that produce or release them (sources) to parts of plants that use or store them (sinks)

7 Identify the positions of tissues as seen in transverse sections of non-woody dicotyledonous roots and stems, limited to: xylem, phloem and cortex

8 State the functions of xylem as transport of water and mineral ions, and support

9 Relate the structure of xylem vessels to their function, limited to:

(a) thick walls with lignin (details of lignification are **not** required)

(b) no cell contents

(c) cells joined end-to-end with no cross walls to form a long continuous tube

# 8 Human nutrition

## 8.1 Diet

1 List the principal sources of, and describe the dietary importance of, carbohydrates, lipids, proteins, vitamins (C and D only), mineral salts (calcium and iron only), fibre (roughage) and water

2 Name the diseases and describe the symptoms resulting from deficiencies of vitamin C (scurvy), vitamin D (rickets), calcium (rickets) and iron (anaemia)

3 Understand the concept of a balanced diet

## 8.2 Human digestive system

1 Identify the main regions of the digestive system: mouth, salivary glands, oesophagus, stomach, small intestine (duodenum and ileum), pancreas, liver, gall bladder and large intestine (colon, rectum and anus)

2 Explain why most foods must be digested before they can be absorbed

3 Describe physical digestion as the breakdown of food into smaller pieces without chemical change to the food molecules

4 Describe chemical digestion as the breakdown of large molecules into small molecules

5 State that physical digestion increases the surface area of food for the action of enzymes in chemical digestion

6 Identify the types of human teeth (incisors, canines, premolars and molars)

7 Describe the structure of human teeth, limited to: enamel, dentine, pulp, nerves and cement, and understand that teeth are embedded in the gum

8 Describe the functions of the types of human teeth in physical digestion of food

9 Describe the functions of the main regions of the digestive system, limited to:

- (a) mouth – ingestion, physical digestion, chemical digestion of starch by amylase
- (b) salivary glands – secretion of saliva containing amylase
- (c) stomach – physical digestion, chemical digestion of protein by protease, presence of hydrochloric acid in gastric secretions
- (d) small intestine (duodenum and ileum) – chemical digestion of starch by amylase, maltose by maltase, protein by protease and lipids by lipase
- (e) liver – production of bile and storage of glycogen
- (f) gall bladder – storage of bile
- (g) pancreas – alkaline secretion containing amylase, protease and lipase
- (h) ileum and colon – absorption
- (i) rectum and anus – egestion

10 Describe the functions of amylase, maltase, protease and lipase, listing the substrates and end-products, limited to:

- (a) amylase breaks down starch to maltose
- (b) maltase breaks down maltose to glucose
- (c) protease (pepsin and trypsin) breaks down protein to amino acids
- (d) lipase breaks down lipids to fatty acids and glycerol

11 Describe the function of hydrochloric acid in the stomach as killing ingested bacteria

12 Understand that the different proteases present in the stomach and the duodenum work best at different pH levels

13 Outline the role of bile in emulsifying fats to increase the surface area for the chemical digestion of fat to fatty acids and glycerol by lipase

14 Describe peristalsis as waves of contractions of longitudinal and circular muscles which move food through the digestive system

### 8.3 Absorption and assimilation

1 State that the small intestine is the region where nutrients are absorbed
2 Understand that absorption (by diffusion, osmosis and active transport) is the movement of nutrients from the intestines into cells lining the digestive system and then into the blood
3 Understand that assimilation is the uptake and use by cells of nutrients from the blood
4 Describe the structure of a villus and the roles of capillaries and lacteals
5 Explain the significance of villi and microvilli in increasing the internal surface area of the ileum
6 Understand that water is absorbed from the lumen of the small intestine and the colon, but that most absorption of water happens in the small intestine
7 State the function of the hepatic portal vein as the route taken to the liver by most of the molecules and ions absorbed from the ileum

## 9 Human gas exchange

### 9.1 Human gas exchange

1 Describe the features of gas exchange surfaces in humans, limited to: large surface area, thin surface, good blood and air supply
2 State the percentages of the gases in atmospheric air
3 Investigate and explain the differences between inspired and expired air
4 Identify, on diagrams and images, the larynx, trachea, lungs, bronchi, bronchioles, alveoli and associated capillaries
5 State the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange
6 Identify, on diagrams and images, the ribs, internal and external intercostal muscles and the diaphragm
7 Explain the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes in the thorax, causing the movement of air into and out of the lungs (breathing)
8 Investigate and explain the effect of physical activity on rate and depth of breathing
9 Explain the role of goblet cells, ciliated cells and mucus in protecting the gas exchange system from pathogens and particles

## 10 Respiration

### 10.1 Respiration

1 Describe respiration as the chemical reactions in all living cells that release energy from glucose
2 State the uses of energy in living organisms including muscle contraction, protein synthesis, cell division, active transport, growth, the passage of electrical impulses along neurones and the maintenance of a constant body temperature
3 Investigate and describe the effect of temperature on respiration in yeast

### 10.2 Aerobic respiration

1 Describe aerobic respiration as the release of a relatively large amount of energy by the breakdown of glucose in the presence of oxygen

2 State the word equation and balanced chemical equation for aerobic respiration

### 10.3 Anaerobic respiration

1 Describe anaerobic respiration as the release of a relatively small amount of energy by the breakdown of glucose without using oxygen

2 State the word equation for anaerobic respiration in humans

3 State the word equation for anaerobic respiration in yeast

4 Explain why lactic acid builds up in muscles and blood during vigorous exercise causing Excess Post-exercise Oxygen Consumption (EPOC) or an 'oxygen debt'

5 Outline how the oxygen debt is removed after exercise, limited to:

(a) continuation of fast heart rate to transport lactic acid in blood from muscles to the liver

(b) continuation of deeper and faster breathing to supply oxygen for the breakdown of lactic acid in the liver

## 11 Transport in humans

### 11.1 Circulatory system

1 Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood

2 Describe a double circulation as a system in which blood passes through the heart twice for each complete circuit

3 Understand that a double circulation provides a low pressure circulation to the lungs and a high pressure circulation to the body tissues

### 11.2 Heart

1 Identify the structures of the mammalian heart, limited to: the muscular wall, the septum, the left and right ventricles and atria, atrioventricular and semilunar valves and coronary arteries

2 Explain the relative thickness:

(a) of the muscle walls of the left and right ventricles

(b) of the muscle walls of the atria compared to those of the ventricles

3 Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves in a heartbeat

4 State that blood is pumped away from the heart in arteries and returns to the heart in veins

5 State that the activity of the heart may be monitored by electrocardiogram (ECG), pulse rate and listening to sounds of valves closing

6 Investigate and explain the effect of physical activity on heart rate

7 Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors including diet, sedentary lifestyle, stress, smoking, genetic predisposition, age and gender

8 Discuss the role of diet and exercise in reducing the risk of coronary heart disease

## 11.3 Blood vessels

1 Name the main blood vessels that carry blood to and from the heart, lungs, liver and kidneys, limited to: aorta, vena cava, pulmonary artery, pulmonary vein, hepatic vein, hepatic artery, hepatic portal vein, renal artery and renal vein

2 Describe, and identify on diagrams and photomicrographs, the structure of arteries, veins and capillaries, limited to:

- (a) relative thickness of wall
- (b) composition of wall (muscle and elastic tissue)
- (c) diameter of lumen
- (d) presence of valves

3 Explain how the structure of arteries, veins and capillaries is related to the pressure of the blood that they transport

## 11.4 Blood

1 Identify red and white blood cells (lymphocytes and phagocytes) as seen under the light microscope on prepared slides, and in diagrams and photomicrographs

2 List the components of blood as red blood cells, white blood cells, platelets and plasma

3 State the functions of the components of blood:

- (a) red blood cells – oxygen transport
- (b) white blood cells – antibody production by lymphocytes and engulfing pathogens by phagocytes
- (c) platelets – clotting by converting soluble fibrinogen to insoluble fibrin to prevent blood loss and the entry of pathogens
- (d) plasma – transport, limited to: blood cells, ions, glucose, amino acids, hormones, carbon dioxide, urea, vitamins and plasma proteins

4 Describe the transfer of substances between blood in capillaries, tissue fluid and body cells

# 12 Disease and immunity

## 12.1 Disease

1 Describe a pathogen as a disease-causing organism

2 Describe a transmissible disease as a disease in which the pathogen can be passed from one host to another

3 Understand that a pathogen may be transmitted:

(a) through direct contact, including through blood or other body fluids

(b) indirectly, including from contaminated surfaces or food, from animals, or from the air

4 Describe the human body's barriers to the entry of pathogens, limited to: skin, hairs in the nose, mucus, stomach acid

5 Understand the role of the mosquito as a vector of disease

6 Describe the malarial pathogen as an example of a parasite and explain how it is transmitted

7 Describe the control of the mosquito that transmits malaria with reference to its life cycle

8 Explain that human immunodeficiency virus (HIV) is a viral pathogen

9 Describe how HIV is transmitted

10 Understand that HIV infection may lead to Acquired Immune Deficiency Syndrome (AIDS)

11 Describe the methods by which HIV may be controlled

12 Describe cholera as a disease caused by a bacterium, which is transmitted in contaminated water

13 Explain the importance of a clean water supply, hygienic food preparation, good personal hygiene, waste disposal and sewage treatment in controlling the spread of cholera (details of the stages of sewage treatment are **not** required)

14 Explain that the cholera bacterium produces a toxin that causes secretion of chloride ions into the small intestine, causing osmotic movement of water into the gut, resulting in diarrhoea, dehydration and loss of ions from the blood

15 Describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications

16 Describe the effects of tobacco smoke and its major toxic components (nicotine, tar and carbon monoxide): strong association with bronchitis, emphysema, lung cancer, heart disease, and the association between smoking during pregnancy and reduced birth weight of the baby

## 12.2 Antibiotics

1 Describe a drug as any substance taken into the body that modifies or affects chemical reactions in the body

2 Describe the use of antibiotics for the treatment of bacterial infection

3 State that antibiotics kill bacteria but do not affect viruses

4 Explain how development of antibiotic-resistant bacteria, including MRSA, can be minimised by using antibiotics only when essential

### 12.3 Immunity

1 Describe active immunity as defence against a pathogen by antibody production in the body
2 State that each pathogen has its own antigens, which have specific shapes
3 Describe antibodies as proteins that bind to antigens leading to direct destruction of pathogens, or marking of pathogens for destruction by phagocytes
4 State that specific antibodies have complementary shapes which fit specific antigens
5 Explain that active immunity is gained after an infection by a pathogen, or by vaccination
6 Outline the process of vaccination:
   (a) weakened pathogens or their antigens are given
   (b) the antigens stimulate an immune response by lymphocytes which produce antibodies
   (c) memory cells are produced that give long-term immunity
7 Explain the role of vaccination in controlling the spread of transmissible diseases
8 Explain that passive immunity is a short-term defence against a pathogen by antibodies acquired from another individual, limited to: across the placenta and in breast milk
9 Explain the importance of breast-feeding for the development of passive immunity in infants
10 State that memory cells are not produced in passive immunity
11 Outline how HIV affects the immune system, limited to: decreased lymphocyte numbers and reduced ability to produce antibodies, which weakens the immune system

## 13 Excretion

### 13.1 Excretion

1 Describe excretion as the removal of toxic materials and the waste products of metabolism from organisms
2 State that carbon dioxide is a waste product of respiration, which is excreted through the lungs
3 State that urea is a toxic waste product produced in the liver from the breakdown of excess amino acids

### 13.2 Urinary system

1 Identify, on diagrams, the kidneys, ureters, bladder and urethra and state the function of each (the function of the kidney should be described simply as removing urea and excess salts and water from the blood as urine)
2 Explain the need for excretion, limited to toxicity of urea
3 Outline the structure of a nephron and its associated blood vessels, limited to: Bowman's capsule, glomerulus, tubules, loop of Henle and collecting duct
4 Outline the function of a nephron and its associated blood vessels, limited to:
   (a) the role of the glomerulus in the filtration from the blood of water, glucose, urea and ions
   (b) the role of the nephron in the reabsorption of all of the glucose, some of the ions and most of the water back into the blood
   (c) the formation of urine containing urea, excess water and excess ions
   (details of these processes are **not** required)
5 Describe the role of the liver in the assimilation of amino acids by converting them to proteins
6 Describe deamination in the liver as the removal of the nitrogen-containing part of amino acids, resulting in the formation of urea

# 14 Coordination and control

## 14.1 Mammalian nervous system

1 State that the nervous system (brain, spinal cord and nerves) coordinates and regulates body functions

2 Describe the mammalian nervous system in terms of:
- (a) the central nervous system (CNS) consisting of the brain and the spinal cord
- (b) the peripheral nervous system (PNS) consisting of the nerves outside the brain and spinal cord

3 Identify, on diagrams, sensory, relay and motor neurones

4 State that electrical impulses travel along neurones

5 Describe simple reflex arcs in terms of receptor, sensory neurone, relay neurone, motor neurone and effector (muscles and glands)

6 Describe a reflex action as a rapid and automatic response to a stimulus

7 Describe a synapse as a junction between two neurones

8 Describe the structure of a synapse, including the presence of vesicles containing neurotransmitter molecules, the synaptic gap and receptor proteins

9 Describe the events at a synapse:
- (a) an impulse stimulates the release of neurotransmitter molecules from vesicles into the synaptic gap
- (b) the neurotransmitter molecules diffuse across the gap and bind with receptor proteins
- (c) an impulse is stimulated in the next neurone

10 State that synapses ensure that impulses travel in one direction only

## 14.2 Mammalian sense organs

1 Describe sense organs as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals

2 Identify, on a diagram, the structures of the eye, limited to: cornea, iris, pupil, lens, ciliary muscles, suspensory ligaments, retina, fovea, optic nerve and blind spot

3 Describe the function of each part of the eye, limited to:
- (a) cornea – refracts light
- (b) iris – controls how much light enters the pupil
- (c) lens – focuses light onto the retina
- (d) ciliary muscles and suspensory ligaments – control the shape of the lens
- (e) retina – contains light receptors, some sensitive to light of different colours
- (f) fovea – contains the greatest density of light receptors
- (g) optic nerve – carries impulses to the brain

4 Explain the pupil reflex in terms of light intensity and antagonistic action of circular and radial muscles in the iris

5 Explain accommodation to view near and distant objects in terms of the contraction and relaxation of the ciliary muscles, tension in the suspensory ligaments, shape of the lens and refraction of light

## 14.3 Mammalian hormones

1 Describe a hormone as a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs

2 Identify, on a diagram, endocrine glands that produce hormones and state the hormones they produce, limited to:

- (a) the adrenal glands – produce adrenaline
- (b) the pancreas – produces insulin and glucagon
- (c) the pituitary gland – produces follicle-stimulating hormone (FSH) and luteinising hormone (LH)
- (d) the testes – produce testosterone
- (e) the ovaries – produce oestrogen and progesterone

3 Understand the role of the hormone adrenaline, produced by the adrenal glands, in increasing the blood glucose concentration and heart rate and give examples of situations in which these may occur

4 Compare nervous and hormonal control, limited to speed of action and duration of effect

## 14.4 Homeostasis

1 Describe homeostasis as the maintenance of a constant internal environment

2 Explain the concept of control by negative feedback with reference to a set point

## 14.5 Temperature control

1 Identify, on a diagram of the skin: hairs, hair erector muscles, sweat glands, receptors, sensory neurones, blood vessels and fatty tissue

2 Describe the role of insulation in maintaining a constant internal body temperature in mammals

3 Describe the roles of the hypothalamus and of temperature receptors in the skin in maintaining a constant internal body temperature in mammals

4 Explain how each of the following processes contributes to the maintenance of constant internal body temperature in mammals:

- (a) sweating
- (b) shivering
- (c) contraction of hair erector muscles
- (d) vasodilation and vasoconstriction of arterioles supplying skin surface capillaries

## 14.6 Blood glucose control

1 Explain the need to control blood glucose concentration

2 Describe the control of blood glucose concentration by the liver and pancreas and the roles of insulin and glucagon

3 Describe the signs of Type 1 diabetes (limited to increased blood glucose concentration and glucose in urine) and its treatment (administration of insulin)

# 15 Coordination and response in plants

## 15.1 Coordination and response in plants

1 Describe gravitropism as a response in which parts of a plant grow towards or away from gravity

2 Describe phototropism as a response in which parts of a plant grow towards or away from light

3 Explain the role of auxin in controlling shoot growth, limited to:

(a) auxin is made in the shoot tip

(b) auxin spreads through the plant from the shoot tip

(c) auxin is unequally distributed in response to light and gravity

(d) auxin stimulates cell elongation

4 Investigate gravitropism and phototropism in shoots and roots

# 16 Development of organisms and continuity of life

## 16.1 Nuclear division

1 Understand that chromosomes contain DNA, which carries genetic information in the form of genes

2 Describe a haploid nucleus as a nucleus containing a single set of chromosomes

3 Describe a diploid nucleus as a nucleus containing two sets of chromosomes

4 State that in a diploid cell there is a pair of each type of chromosome and in a human diploid cell there are 23 pairs

5 Describe mitosis as nuclear division giving rise to genetically identical cells in which the chromosome number is maintained (details of stages are **not** required)

6 Outline the role of mitosis in growth, repair of damaged tissues, replacement of dying cells and asexual reproduction

7 Describe stem cells as unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions

8 State that meiosis is involved in the production of gametes

9 Describe meiosis as a reduction division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells (details of stages are **not** required)

10 Understand that cancers form as a result of uncontrolled cell division

## 16.2 Asexual and sexual reproduction

1 Describe asexual reproduction as a process resulting in the production of genetically identical offspring from one parent

2 Identify examples of asexual reproduction

3 Describe sexual reproduction as the process involving the fusion of haploid nuclei (fertilisation) to form a diploid zygote and the production of genetically different offspring

4 Discuss the advantages and disadvantages of asexual reproduction and sexual reproduction

## 16.3 Sexual reproduction in plants

1 Identify and draw the sepals, petals, stamens (anthers and filaments) and carpels (stigmas, styles, ovaries and ovules) of an insect-pollinated flower

2 Identify and draw the anthers and stigmas of a wind-pollinated flower

3 Relate the structure of the parts of flowers to their functions, limited to the parts listed in 16.3.1

4 Compare the flower structure and the pollen from insect-pollinated and wind-pollinated flowers

5 Outline the process of pollination and distinguish between self-pollination and cross-pollination

6 Discuss the potential effects of self-pollination and cross-pollination on a population, in terms of variation, capacity to respond to changes in the environment and reliance on pollinators

7 Describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are **not** required)

8 Understand that after fertilisation the ovules develop into seeds and the ovary develops into a fruit

9 Investigate and describe the structure of a seed, limited to embryo (radicle, plumule and cotyledons) and testa

10 Understand that seed and fruit dispersal by wind and by animals is a means of colonising new areas and of reducing competition

11 Relate the features of wind-dispersed fruits and animal-dispersed fruits to their functions

12 Investigate and state the environmental conditions that affect germination of seeds, limited to: suitable temperature, water and oxygen

13 Describe the process of germination, including the role of enzymes

## 16.4 Sexual reproduction in humans

1 Identify, on diagrams of the male reproductive system: the testes, scrotum, sperm ducts, prostate gland, urethra and penis, and describe their functions

2 Identify, on diagrams of the female reproductive system: the ovaries, oviducts, uterus, cervix and vagina, and describe their functions

3 Explain how the structure of a sperm cell is related to its function, limited to: flagellum, mitochondria and enzymes in the acrosome

4 Explain how the structure of an egg cell is related to its function, limited to energy stores and the jelly coat that changes at fertilisation

5 Describe fertilisation as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell)

6 Compare male and female gametes in terms of size, structure, numbers and motility

7 Describe the roles of testosterone and oestrogen in the development and regulation of secondary sexual characteristics during puberty

8 Describe the menstrual cycle in terms of development and release of an egg and changes in the lining of the uterus

9 Explain the roles of follicle-stimulating hormone (FSH), luteinising hormone (LH), oestrogen and progesterone in controlling the menstrual cycle

10 Describe the early development of the zygote, limited to the formation of a ball of cells (embryo) that becomes implanted in the lining of the uterus

11 State the functions of the amniotic sac and the amniotic fluid

12 Identify, on diagrams, the placenta and umbilical cord and describe their functions in relation to the exchange of dissolved nutrients, gases and excretory products between the blood of the mother and the blood of the fetus (structural details are **not** required)

13 State that some viruses can pass across the placenta and affect the fetus

# 17 Inheritance

## 17.1 Variation

1 Describe variation as differences between individuals of the same species

2 Understand that continuous variation results in a range of phenotypes between two extremes, including body length and body mass

3 Understand that discontinuous variation results in a limited number of phenotypes with no intermediates, including ABO blood groups, seed shape and seed colour in peas

4 Understand that discontinuous variation is usually caused by genes only and continuous variation is caused by genes and the environment

5 Investigate and describe examples of continuous and discontinuous variation

## 17.2 DNA

1 Describe the structure of a DNA molecule:
   (a) two strands coiled together to form a double helix
   (b) each strand is made up of a chain of nucleotides
   (c) each nucleotide contains a base (A, T, C, G; full names are **not** required)
   (d) bonds between pairs of bases hold the strands together
   (e) the bases always pair up in the same way: A with T, and C with G

2 Define a gene as a length of DNA that codes for a protein

3 Explain that DNA controls cell function by controlling the production of proteins, including enzymes

4 State that the sequence of bases in a gene determines the sequence of amino acids needed to make a specific protein (knowledge of the details of nucleotide structure is **not** required)

5 Understand that different sequences of amino acids give different shapes to protein molecules

## 17.3 Inheritance

1 Describe inheritance as the transmission of genetic information from generation to generation

2 Define an allele as an alternative form of a gene

3 Understand and use the terms: dominant, recessive, phenotype, genotype, homozygous and heterozygous

4 Use genetic diagrams, including Punnett squares, to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1 : 1 and 3 : 1 ratios

5 Explain why observed ratios often differ from expected ratios, especially when there are small numbers of offspring

6 State that two identical homozygous individuals that breed together will be pure-breeding

7 Explain codominance by reference to the inheritance of the ABO blood groups (phenotypes A, B, AB, O, gene alleles $I^A$, $I^B$ and $I^o$)

8 Describe the determination of sex in humans (XX and XY chromosomes)

9 Describe a gene mutation as a random change in the base sequence of DNA, using sickle cell anaemia as an example

10 Describe a chromosome mutation as a change in the chromosome number or structure, using Down's syndrome as an example (47 chromosomes instead of 46)

11 State that mutation, meiosis, random mating and random fertilisation are sources of genetic variation in populations

12 Understand that ionising radiation and some chemicals increase the rate of mutation

## 17.4 Selection

1 Describe natural selection with reference to:
   (a) variation within populations
   (b) production of many offspring
   (c) struggle for survival, including competition for resources
   (d) reproduction by individuals that are better adapted to the environment than others
   (e) passing on of their alleles to the next generation

2 Describe how the inherited features of a population can evolve over time as a result of natural selection

3 Describe the development of strains of antibiotic-resistant bacteria, including MRSA, as an example of natural selection

4 Describe artificial selection (selective breeding) with reference to:
   (a) selection by humans of animals or plants with desirable features
   (b) crossing these to produce the next generation
   (c) selection of offspring showing the desirable features
   (d) repetition over many generations

5 Describe the role of artificial selection in the production of economically important plants and animals

# 18 Biotechnology and genetic modification

## 18.1 Biotechnology

1 Explain the role of yeast in the production of bread and ethanol

2 Understand that bacteria are useful in biotechnology and genetic modification due to their rapid reproduction rate and their ability to make complex molecules

3 Discuss why bacteria are useful in biotechnology and genetic modification, limited to:
- (a) no ethical concerns over their manipulation and growth
- (b) presence of plasmids

4 Describe how fermenters can be used for the large-scale production of useful products by bacteria and fungi, including the conditions that need to be controlled, limited to: temperature, pH, oxygen, nutrient supply and waste products

5 Describe the use of:
- (a) enzymes in biological washing powders
- (b) pectinase for fruit juice production
- (c) lactase for lactose-free milk

## 18.2 Genetic modification

1 Describe genetic modification as changing the genetic material of an organism by removing, changing or inserting individual genes

2 Understand that the gene that controls the production of human insulin has been inserted into bacterial DNA, for commercial production of insulin

3 Outline the use of genetic modification in crop plants by inserting genes:
- (a) to confer resistance to herbicides
- (b) to confer resistance to insect pests
- (c) to provide additional vitamins

4 Discuss potential advantages and risks of genetic modification, limited to modifying crop plants and bacteria

# 19 Relationships of organisms with one another and with the environment

## 19.1 Energy flow

1 Understand that the Sun is the principal source of energy input to most biological systems

2 Explain why most forms of life are completely dependent on photosynthesis

3 Describe the flow of energy through food chains and webs including energy from light and energy in living organisms and its eventual transfer to the environment

4 Construct and interpret simple food chains

5 Understand the terms producer, consumer, herbivore, carnivore and decomposer

6 Describe food webs as networks of interconnected food chains and construct and interpret them

7 Explain why the transfer of energy from one trophic level to another is inefficient

8 Explain why food chains usually have fewer than five trophic levels

9 Explain why it is more energy efficient for humans to eat crop plants than to eat livestock that have been fed on crop plants

10 Construct and interpret pyramids of numbers, biomass and energy

## 19.2 Nutrient cycles

1 Describe the carbon cycle, limited to: photosynthesis, respiration, feeding, decomposition, formation of fossil fuels and combustion

2 Outline the nitrogen cycle in making nitrogen available for plant and animal protein, limited to:

(a) decomposition of plant and animal protein to ammonium ions

(b) nitrification

(c) nitrogen fixation by lightning and bacteria

(d) absorption of nitrate ions by plants

(e) production of amino acids and protein

(f) feeding and digestion of proteins

(g) denitrification

(the names of individual bacteria are **not** required)

3 Outline the role of fungi and bacteria in decomposition

## 19.3 Ecosystems and biodiversity

1 Describe a population as a group of organisms of one species, living in the same area, at the same time

2 Describe a community as all of the populations of different species in an ecosystem

3 Describe an ecosystem as a unit containing the community of organisms and their environment, interacting together

4 Describe biodiversity as the number of different species that live in an area

5 Identify and state the factors affecting the rate of population growth for a population of an organism, limited to: food supply, competition, predation and disease

6 Understand that the growth of the human population is increasing the demand for global resources

## 19.4 Effects of humans on ecosystems

1 Outline the causes and describe the consequences of deforestation, limited to its effects on: biodiversity, extinction, loss of soil, flooding and concentration of carbon dioxide in the atmosphere

2 Describe the impacts humans have through:
- (a) over-harvesting of plant and animal species
- (b) introducing a non-native species to an ecosystem

3 Describe the harmful effects of:
- (a) water pollution by untreated sewage and nitrogen-containing fertilisers leading to eutrophication, limited to:
  - (i) increased availability of nitrate and other ions
  - (ii) increased growth of producers
  - (iii) increased decomposition after death of producers
  - (iv) increased aerobic respiration by decomposers
  - (v) reduction in dissolved oxygen
  - (vi) death of organisms requiring dissolved oxygen in water
- (b) air pollution by greenhouse gases (carbon dioxide and methane), contributing to global warming and its likely effects
- (c) pollution due to insecticides and herbicides
- (d) non-biodegradable plastics in the environment, in both aquatic and terrestrial ecosystems

## 19.5 Conservation

1 Discuss reasons for conservation of species with reference to:
- (a) maintenance of biodiversity
- (b) reducing extinction
- (c) protecting vulnerable environments

2 Explain how forests can be conserved using education, protected areas, quotas and replanting

3 Explain how fish stocks can be conserved using education, closed seasons, protected areas, controlled net types and mesh size, quotas and monitoring

4 Describe a sustainable resource as one which is produced as rapidly as it is removed from the environment so that it does not run out

# 4 Details of the assessment

All candidates take three papers. All papers assess grades A* to E.

| Paper 1: Multiple Choice | | Paper 2: Theory |
|---|---|---|
| 1 hour | | 1 hour 45 minutes |
| 40 marks | | 80 marks |
| Forty compulsory multiple-choice items of the four-choice type | **AND** | Compulsory short-answer and structured questions |
| This paper tests assessment objectives AO1 and AO2 | | This paper tests assessment objectives AO1 and AO2 |
| Externally assessed | | Externally assessed |

## Practical assessment

All candidates take one practical paper from a choice of two:

| Paper 3: Practical Test | | Paper 4: Alternative to Practical |
|---|---|---|
| 1 hour 30 minutes | | 1 hour |
| 40 marks | | 40 marks |
| All items are compulsory | | All items are compulsory |
| This paper tests assessment objective AO3 | **OR** | This paper tests assessment objective AO3 |
| Candidates will be required to do experiments in a laboratory as part of this test | | Candidates will not be required to do experiments as part of this test |
| Externally assessed | | Externally assessed |

The Practical Test and Alternative to Practical:

- require the same experimental skills to be developed and learned
- require an understanding of the same experimental contexts
- test the same assessment objective, AO3.

Candidates are expected to be familiar with and may be asked questions using the following experimental contexts:

- simple quantitative experiments, including the measurement of:
  - volumes of gases or solutions/liquids
  - masses
  - temperatures
  - times
  - lengths
- diffusion
- osmosis
- food tests
- rates of enzyme-catalysed reactions
- pH and the use of hydrogencarbonate indicator, litmus and universal indicator
- photosynthesis (rate and limiting factors)
- effect of mineral ions on plant growth
- transpiration
- heart rate and breathing rate
- respiration
- tropic responses
- nervous responses
- observation and dissection of seeds and flowers
- germination
- continuous and discontinuous variation
- sampling techniques
- use of a microscope to examine biological specimens
- calculating the magnification of biological specimens
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate.

Candidates may be required to do the following:

- **demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate):**
  - identify apparatus from diagrams or descriptions
  - draw, complete or label diagrams of apparatus and biological specimens
  - use, or explain the use of, common techniques, apparatus and materials
  - select the most appropriate apparatus or method for the task and justify the choice made
  - describe food tests
  - describe tests to determine the pH of solutions and substances
  - describe and explain hazards and identify safety precautions
  - describe and explain techniques used to ensure the accuracy of observations and data

- **plan experiments and investigations:**
  - identify the independent variable and dependent variable
  - describe how and explain why variables should be controlled
  - suggest an appropriate number and range of values for the independent variable
  - suggest the most appropriate apparatus or technique and justify the choice made
  - describe experimental procedures
  - identify risks and suggest safety precautions
  - describe how to record the results of an experiment
  - describe how to process the results to form a conclusion or to evaluate a prediction
  - make reasoned predictions of expected results

- **make and record observations, measurements and estimates:**
  - take readings from apparatus (analogue and digital) or from diagrams of apparatus with appropriate precision
  - observe and take measurements from biological specimens or images of specimens
  - take sufficient observations or measurements, including repeats where appropriate
  - record qualitative observations from food and other tests
  - record observations and measurements systematically, for example in a suitable table, to an appropriate degree of precision and using appropriate units

- **interpret and evaluate experimental observations and data:**
  - process data, including for use in further calculations or for graph plotting, using a calculator as appropriate
  - present data graphically
  - analyse and interpret observations and data, including data presented graphically
  - use interpolation and extrapolation graphically to determine a gradient or intercept
  - form conclusions justified by reference to observations and data and with appropriate explanation
  - evaluate the quality of observations and data, identifying any anomalous results and taking appropriate action

- **evaluate methods and suggest possible improvements:**
  - evaluate experimental arrangements, methods and techniques, including the use of a control
  - identify sources of error
  - suggest possible improvements to the apparatus, experimental arrangements, methods or techniques

# Apparatus, materials and reagents

These lists give items that candidates should be familiar with using, whether they are taking the Practical Test or the Alternative to Practical.

These items should be available for use in the Practical Test. These lists are not exhaustive and we may also require other items to be sourced for specific examinations. The Confidential Instructions we send before the Practical Test will give the detailed requirements for the examination.

Every effort is made to minimise the cost to and resources required by centres. Experiments will be designed around basic apparatus and materials which should be available in most school laboratories or are easily obtainable.

Hazard codes are used where relevant and in accordance with information provided by CLEAPSS (**www.cleapss.org.uk**). Students should be familiar with the meanings of these codes and terms but will **not** be assessed on them.

**C** corrosive
**HH** health hazard
**F** flammable
**N** hazardous to the aquatic environment
**MH** moderate hazard
**T** acutely toxic
**O** oxidising

The attention of centres is drawn to any national and local regulations relating to safety, first aid and disposal of chemicals. 'Hazard Data Sheets' should be available from your chemical supplier.

Appropriate safety equipment must be provided to students and should at least include eye protection.

## Biological materials

- a selection of prepared slides of plant and animal tissue relating to the syllabus content
- locally available terrestrial and aquatic plant material
- yeast

## Chemicals, reagents and indicators

Please note, hazard symbols were accurate at the time of publication and may change.

- agar jelly
- Benedict's solution **[MH]**
- biuret reagent (sodium or potassium hydroxide solution and copper sulfate solution) **[C] [MH]**
- buffer solutions (buffer tablets are commonly available)
- carbohydrates (starch, glucose, sucrose), proteins, lipids
- dilute acid **[C] [MH]**
- dilute alkali **[C] [MH]**
- distilled or deionised water
- enzymes (e.g. amylase, a protease, lipase) **[C] [HH] [MH]**
- eosin dye/red ink
- ethanol **[F] [HH] [MH]**
- hydrogen peroxide solution **[C] [MH]**

- indicators (red and blue litmus paper or litmus solution, universal indicator paper or solution, hydrogencarbonate indicator)
- iodine in potassium iodide solution (iodine solution) **[MH] [N]**
- limewater **[MH]**
- methylene blue dye **[F] [HH] [MH]**
- petroleum jelly (Vaseline® or similar)
- sodium chloride
- sodium hydrogencarbonate (sodium bicarbonate)

## Apparatus

- aluminium foil or black paper
- balance to measure up to 500 g, with precision of at least 0.1 g
- beakers (various sizes, e.g. 100 $cm^3$, 250 $cm^3$)
- bungs to fit small test-tubes and large test-tubes
- bungs with delivery tubes to fit small test-tubes and large test-tubes
- capillary tubes
- clamp (retort) stands and bosses
- dishes (e.g. Petri dishes)
- electric fan
- electric lamp
- filter paper
- forceps
- funnels
- glass microscope slides and coverslips
- glass rods
- hand lenses (at least ×6 magnification)
- heat-proof mats, tripods and gauzes
- means of cutting biological materials (e.g. scalpels or sharp knives)
- means of heating (e.g. Bunsen burner, spirit burner or other gas burner)
- means of writing on glassware (e.g. wax pencils or water-resistant markers)
- measuring cylinders (various sizes, e.g. 10 $cm^3$, 25 $cm^3$, 100 $cm^3$)
- microscope, with lamp or inbuilt illumination, ideally fitted with:
  - an eyepiece lens, ×10 magnification
  - a low-power objective lens, ×10 magnification
  - a high-power objective lens, ×40 magnification
- mortars and pestles (or access to a blender)
- mounted needles or seekers or long pins with large heads
- partially permeable membrane (e.g. dialysis or Visking® tubing)
- ruler, graduated in mm
- scissors
- small droppers or teat pipettes
- spotting tiles

- stopwatch, reading to 1 s or better
- syringes (without needles, various sizes, e.g. 1 $cm^3$, 5 $cm^3$, 10 $cm^3$)
- test-tubes – small (125 mm × 15 mm) and large (150 mm × 25 mm)
- test-tube racks and test-tube holders
- thermometer, –10 °C to +110 °C, with 1 °C graduations
- wash bottle
- white tiles or other suitable cutting surfaces

## Safety in the laboratory

Teachers should make sure that they do not contravene any school, education authority or government regulations. Responsibility for safety matters rests with centres.

Further information can be found from the following UK associations, publications and regulations.

### Associations

CLEAPSS is an advisory service providing support in practical science and technology.
**www.cleapss.org.uk**

### Publications

*CLEAPSS Laboratory Handbook*, updated 2015 (available to CLEAPSS members only)

*CLEAPSS Hazcards*, 2019 update of 2016 edition (available to CLEAPSS members only)

### UK regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002 and subsequent amendment in 2004

**www.legislation.gov.uk/uksi/2002/2677/contents/made**

**www.legislation.gov.uk/uksi/2004/3386/contents/made**

A brief guide may be found at
**www.hse.gov.uk/pubns/indg136.pdf**

# Mathematical requirements

It is expected that these requirements will be covered as part of a mathematics curriculum at this level of study.

Calculators may be used in all parts of the examination.

## Number

- add, subtract, multiply and divide
- use decimals, fractions, ratios and reciprocals
- calculate and use percentages and percentage change
- use standard form
- use decimal places appropriately
- use significant figures appropriately
- make estimates of numbers, quantities and lengths

## Algebra

- substitute values of quantities into equations, using consistent units
- solve simple algebraic equations for any one term when the other terms are known
- recognise and use direct and inverse proportion

## Geometry

- understand the meaning of: angle, curve, circle, radius, diameter, circumference, square, rectangle and diagonal
- recall and use the equations for the area of a rectangle, area of a triangle and area of a circle
- recall and use the equations for the volume of a rectangular block and volume of a cylinder
- understand surface area and use Surface Area : Volume ratio
- use scale diagrams
- select and use the most appropriate units for recording data and the results of calculations
- convert between metric units, including μm, mm, cm and m; cm3 and dm3; mg, g and kg
- use mathematical instruments (ruler, protractor)

## Graphs, charts and statistics

- draw charts and graphs from data
- interpret charts and graphs, including interpolation and extrapolation of data
- determine the gradient (slope) of a line on a graph
- determine the intercept of the line on a graph, extending the line graphically (extrapolating) where appropriate
- select suitable scales and axes for graphs
- recognise direct proportionality from a graph
- use and interpret Venn diagrams to show groupings and sets
- calculate the mean and range of a set of values
- use simple probability

# Presentation of data

## Taking and recording readings

- Data should be recorded so as to reflect the precision of the measuring instrument, i.e. the smallest difference that can reliably be detected on the measuring instrument scale should be reflected by the number of decimal places given in the measurement.
- A measurement or calculated quantity must be accompanied by a correct unit, where appropriate.
- Each column of a table should be headed with the name or symbol of the measured or calculated quantity and the appropriate unit, e.g. time/s. The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts.
- Units should not be included with data in the body of a table.
- The number of significant figures given for measured quantities should be appropriate to the measuring instrument used.

## Graphs

- The column headings of the table can be directly transferred to the axes of a constructed graph.
- A graph should be drawn with a sharp pencil.
- The axes should be labelled with the name or symbol of the measured or calculated quantity and the appropriate unit, e.g. time/s.
- Unless instructed otherwise, the independent variable should be plotted on the *x*-axis (horizontal axis) and the dependent variable plotted on the *y*-axis (vertical axis).
- Unless instructed otherwise, the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable (or 10, 20 or 50, etc.)
- Points on the graph should be clearly marked as crosses (×) or encircled dots (⊙) of appropriate size.
- Each data point should be plotted to an accuracy of one half of one of the smallest squares on the grid.
- A best-fit line (trend line) should be a single, thin, smooth straight-line or curve, drawn by inspection. The line does not need to coincide exactly with any of the points; where there is scatter evident in the data, examiners would expect a roughly even distribution of points either side of the line over its entire length. Points that are clearly anomalous should be ignored when drawing the best-fit line.
- Candidates should be able to take readings from the graph by extrapolation or interpolation.
- Data values should be read from a line on a graph to an accuracy of one half of one of the smallest squares on the grid. The same accuracy should be used in reading off an intercept.

## Drawings

- These should be drawn using a sharp pencil to give fine lines that are clear and unbroken.
- These should use most of the available space and show all the features observed in the specimen, with no shading.
- Label lines should be drawn with a ruler and touch the object or feature labelled.

## Charts

- Pie charts are generally used to show percentage or proportional data.
- Bar charts should be drawn for categorical or discrete data. They should have bars of equal width that do **not** touch.
- Histograms should be drawn for continuous data. They should have bars that touch.

Further guidance can be found in the following publications:

*ASE, The Language of Mathematics in Science: A Guide for Teachers of 11–16 Science* (2016).

*ASE, The Language of Mathematics in Science: Teaching Approaches* (2016).

**www.ase.org.uk/mathsinscience**

## Conventions (e.g. signs, symbols, terminology and nomenclature)

Candidates are expected to be familiar with the nomenclature used in the syllabus.

The syllabus and question papers conform with accepted international practice. In particular, the following document, produced by the Association for Science Education (ASE), should be used as a guideline.

*Signs, Symbols and Systematics: The ASE Companion to 16–19 Science* (2000).

### Decimal markers

In accordance with current ASE convention, decimal markers in examination papers will be a single dot on the line. Candidates are expected to follow this convention in their answers.

### Numbers

Numbers from 1000 to 9999 will be printed without commas or spaces. Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three digits, e.g. 4 256 789.

### Variables

Independent variables are the variables that are changed in a scientific experiment by the scientist. Changing an independent variable may cause a change in the dependent variable.

Dependent variables are the variables that are observed or measured in a scientific experiment. Dependent variables may change based on changes made to the independent variables.

### Units

To avoid any confusion concerning the symbol for litre, the equivalent quantity, the cubic decimetre ($dm^3$) will be used in place of l or litre.

In practical work, candidates will be expected to use SI units or, where appropriate, units approved for use with the SI (e.g. minute).

In all examinations, where data is supplied for use in questions, candidates will be expected to use units that are consistent with the units supplied and should not attempt conversion to other systems of units unless this is a requirement of the question.

## Command words

Command words and their meanings help candidates know what is expected from them in the exams. The table below includes command words used in the assessment for this syllabus. The use of the command word will relate to the subject context.

| Command word | What it means |
|---|---|
| **Assess** | make an informed judgement |
| **Calculate** | work out from given facts, figures or information |
| **Comment** | give an informed opinion |
| **Compare** | identify/comment on similarities and/or differences |
| **Contrast** | identify/comment on differences |
| **Define** | give precise meaning |
| **Describe** | state the points of a topic / give characteristics and main features |
| **Determine** | establish an answer using the information available |
| **Discuss** | write about issue(s) or topic(s) in depth in a structured way |
| **Evaluate** | judge or calculate the quality, importance, amount, or value of something |
| **Explain** | set out purposes or reasons / make the relationships between things clear / say why and/or how and support with relevant evidence |
| **Give** | produce an answer from a given source or recall/memory |
| **Identify** | name/select/recognise |
| **Outline** | set out the main points |
| **Predict** | suggest what may happen based on available information |
| **Sketch** | make a simple freehand drawing showing the key features, taking care over proportions |
| **State** | express in clear terms |

# 5 What else you need to know

This section is an overview of other information you need to know about this syllabus. It will help to share the administrative information with your exams officer so they know when you will need their support. Find more information about our administrative processes at **www.cambridgeinternational.org/eoguide**

## Before you start

### Previous study

We recommend that learners starting this course should have studied a broad curriculum such as the Cambridge Lower Secondary programme or equivalent national educational framework.

### Guided learning hours

We design Cambridge O Level syllabuses to require about 130 guided learning hours for each subject. This is for guidance only. The number of hours a learner needs to achieve the qualification may vary according to each school and the learners' previous experience of the subject.

### Availability and timetables

All Cambridge schools are allocated to one of six administrative zones. Each zone has a specific timetable. Find your administrative zone at **www.cambridginternational.org/adminzone**. Cambridge O Levels are available to centres in administrative zones 3, 4 and 5.

You can enter candidates in the June and November exam series. You can view the timetable for your administrative zone at **www.cambridgeinternational.org/timetables**

Check you are using the syllabus for the year the candidate is taking the exam.

Private candidates can enter for this syllabus. For more information, please refer to the *Cambridge Guide to Making Entries*.

### Combining with other syllabuses

Candidates can take this syllabus alongside other Cambridge International syllabuses in a single exam series. The only exceptions are:

- Cambridge IGCSE Biology (0610)
- Cambridge IGCSE (9–1) Biology (0970)
- Cambridge IGCSE Combined Science (0653)
- Cambridge IGCSE Co-ordinated Sciences (Double Award) (0654)
- Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973)
- Cambridge O Level Combined Science (5129)
- syllabuses with the same title at the same level.

Cambridge O Level, Cambridge IGCSE™ and Cambridge IGCSE (9–1) syllabuses are at the same level.

# Making entries

Exams officers are responsible for submitting entries to Cambridge International. We encourage them to work closely with you to make sure they enter the right number of candidates for the right combination of syllabus components. Entry option codes and instructions for submitting entries are in the *Cambridge Guide to Making Entries*. Your exams officer has access to this guide.

## Exam administration

To keep our exams secure, we produce question papers for different areas of the world, known as administrative zones. We allocate all Cambridge schools to an administrative zone determined by their location. Each zone has a specific timetable.

Some of our syllabuses offer candidates different assessment options. An entry option code is used to identify the components the candidate will take relevant to the administrative zone and the available assessment options.

## Support for exams officers

We know how important exams officers are to the successful running of exams. We provide them with the support they need to make entries on time. Your exams officer will find this support, and guidance for all other phases of the Cambridge Exams Cycle, at **www.cambridgeinternational.org/eoguide**

## Retakes

Candidates can retake the whole qualification as many times as they want to. Information on retake entries is at **www.cambridgeinternational.org/retakes**

## Language

This syllabus and the related assessment materials are available in English only.

# Accessibility and equality

## Syllabus and assessment design

At Cambridge International, we work to avoid direct or indirect discrimination in our syllabuses and assessment materials. We aim to maximise inclusivity for candidates of all national, cultural or social backgrounds and candidates with protected characteristics, which include special educational needs and disability, religion and belief, and characteristics related to gender and identity. We also aim to make our materials as accessible as possible by using accessible language and applying accessible design principles. This gives all candidates the fairest possible opportunity to demonstrate their knowledge, skills and understanding and helps to minimise the requirement to make reasonable adjustments during the assessment process.

## Access arrangements

Access arrangements (including modified papers) are the principal way in which Cambridge International complies with our duty, as guided by the UK Equality Act (2010), to make 'reasonable adjustments' for candidates with special educational needs (SEN), disability, illness or injury. Where a candidate would otherwise be at a substantial disadvantage in comparison to a candidate with no SEN, disability, illness or injury, we may be able to agree pre-examination access arrangements. These arrangements help a candidate by minimising accessibility barriers and maximising their opportunity to demonstrate their knowledge, skills and understanding in an assessment.

### Important:

Requested access arrangements should be based on evidence of the candidate's barrier to assessment and should also reflect their normal way of working at school. This is explained in the *Cambridge Handbook* **www.cambridgeinternational.org/eoguide**

- For Cambridge International to approve an access arrangement, we will need to agree that it constitutes a reasonable adjustment, involves reasonable cost and timeframe and does not affect the security and integrity of the assessment.
- Availability of access arrangements should be checked by centres at the start of the course. Details of our standard access arrangements and modified question papers are available in the *Cambridge Handbook* **www.cambridgeinternational.org/eoguide**
- Please contact us at the start of the course to find out if we are able to approve an arrangement that is not included in the list of standard access arrangements.
- Candidates who cannot access parts of the assessment may be able to receive an award based on the parts they have completed.

# After the exam

## Grading and reporting

Grades A*, A, B, C, D or E indicate the standard a candidate achieved at Cambridge O Level.

A* is the highest and E is the lowest. 'Ungraded' means that the candidate's performance did not meet the standard required for grade E. 'Ungraded' is reported on the statement of results but not on the certificate.

In specific circumstances your candidates may see one of the following letters on their statement of results:

- Q (PENDING)
- X (NO RESULT).

These letters do not appear on the certificate.

On the statement of results and certificates, Cambridge O Level is shown as GENERAL CERTIFICATE OF EDUCATION (GCE O LEVEL).

## How students and teachers can use the grades

Assessment at Cambridge O Level has two purposes:

1 to measure learning and achievement

The assessment confirms achievement and performance in relation to the knowledge, understanding and skills specified in the syllabus.

2 to show likely future success

The outcomes help predict which students are well prepared for a particular course or career and/or which students are more likely to be successful.

The outcomes help students choose the most suitable course or career.

## Changes to this syllabus for 2026, 2027 and 2028

The syllabus has been updated. This is version 1, published September 2023.

There are no significant changes which affect teaching.

**You must read the whole syllabus before planning your teaching programme.** We review our syllabuses regularly to make sure they continue to meet the needs of our schools. In updating this syllabus, we have made it easier for teachers and students to understand, keeping the familiar features that teachers and schools value.

Any textbooks endorsed to support the syllabus for examination from 2023 are still suitable for use with this syllabus.

We are committed to making our documents accessible in accordance with the WCAG 2.1 Standard. We are always looking to improve the accessibility of our documents. If you find any problems or you think we are not meeting accessibility requirements, contact us at **info@cambridgeinternational.org** with the subject heading: Digital accessibility. If you need this document in a different format, contact us and supply your name, email address and requirements and we will respond within 15 working days.

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