

# SYLLABUS

**Cambridge IGCSE®**

**Biology (US)**

**0438**

For examination in June and November 2016, 2017 and 2018

**This syllabus is available only to Centers participating in the  
NCEE Excellence for All initiative in the USA.**

**If you have any questions about this syllabus, please contact Cambridge  
at [info@cie.org.uk](mailto:info@cie.org.uk) quoting syllabus code 0438**

## Changes to syllabus for 2016

**The syllabus has been revised. You are advised to read the whole of the syllabus before planning your teaching program. The most significant changes are outlined below.**

**Significant changes to the syllabus are indicated by black vertical lines at the side of the text.**

### Changes to the structure of the assessment

A new Multiple Choice paper for Extended candidates has been included. This paper is now Paper 2.

The papers are:

Paper 1: Multiple Choice (Core)

Paper 2: Multiple Choice (Extended)

Paper 3: Theory (Core)

Paper 4: Theory (Extended)

Paper 5: Practical Test

Paper 7: Coursework

Core candidates will now take Paper 1: Multiple Choice (Core), Paper 3: Theory (Core) and either Paper 5: Practical Test or Paper 7: Coursework.

Extended candidates will now take Paper 2: Multiple Choice (Extended), Paper 4: Theory (Extended), and either Paper 5: Practical Test or Paper 7: Coursework.

### Changes to curriculum content

The curriculum content has been revised and updated to modernize and improve the relevance of the syllabus.

The wording of some learning outcomes has been changed for clarification.

Some material has been reordered, removed, moved between sections, or reclassified as either Core or Supplement material.

### New topics

4 Biological molecules\*

10 Diseases and immunity

14.2 Sense organs\*

17.2 Chromosomes, genes and proteins\*

18.2 Adaptive features

20.1–3 Biotechnology and genetic engineering\*

21.1–4 Human influences on ecosystems\*

\*contains some material previously found in other sections of the syllabus

### Deleted topics

II.6.3.7 Assimilation

Minor changes have been made to the wording of the Syllabus Goals, Assessment Objectives and Grade Descriptions for clarity. In addition, the Assessment Objectives include an adjustment to the Assessment Objectives for coursework, on page 56.

### Changes to accreditation for Cambridge IGCSE coursework assessors

We have reviewed the current accreditation process. To ensure that all teachers involved in the marking of internally assessed components can benefit from the training materials provided by Cambridge, we are widening access to these materials and discontinuing the accreditation process after the November 2015 series.

The last exam series requiring teacher accreditation for the marking of certain Cambridge IGCSE components will be November 2015. Guidance on the delivery and assessment of Cambridge coursework and speaking tests will be available for all teachers on our Teacher Support site from January 2016.

Section 8 of this syllabus has been updated to provide more detail on the moderation process

### Note

The subject content of this syllabus is the same as the international version. The alternative to practical paper is not included to ensure that coursework or the practical paper is a mandatory part of the syllabus.

Please read the Cambridge Glossary alongside this syllabus. This is available from our website. Administration materials appear in UK English and are standard for all our international customers.

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# 1. Introduction

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## 1.1 Why Choose Cambridge?

Cambridge International Examinations is part of the University of Cambridge. We prepare school students for life, helping them develop an informed curiosity and a lasting passion for learning. Our international qualifications are recognized by the world's best universities and employers, giving students a wide range of options in their education and career. As a non-profit organization, we devote our resources to delivering high-quality educational programs that can unlock students' potential.

Our programs set the global standard for international education. They are created by subject experts, are rooted in academic rigor, and provide a strong platform for progression to employment or to other qualifications. Over 10,000 schools in 160 countries work with us to prepare nearly a million students for their future with an international education from Cambridge.

### Cambridge Students

Cambridge programs and qualifications develop not only subject knowledge but also skills. We encourage Cambridge students to be:

- **confident** in working with information and ideas—their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **reflective** as students, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

### Recognition

Cambridge IGCSE is recognized by leading universities and employers worldwide, and is an international passport to progression and success. It provides a solid foundation for moving on to higher-level studies. Learn more at [www.cie.org.uk/recognition](http://www.cie.org.uk/recognition)

### Support for Teachers

A wide range of materials and resources is available to support teachers and students in Cambridge schools. Resources suit a variety of teaching methods in different international contexts. Through subject discussion forums and training, teachers can access the expert advice they need for teaching our qualifications. More details can be found in Section 2 of this syllabus and at [www.cie.org.uk/teachers](http://www.cie.org.uk/teachers)

### Support for Exams Officers

Exams officers can trust in reliable, efficient administration of exams entries and excellent personal support from our customer services. Learn more at [www.cie.org.uk/examsOfficers](http://www.cie.org.uk/examsOfficers)

Our systems for managing the provision of international qualifications and education programs for students aged 5 to 19 are certified as meeting the internationally recognized standard for quality management, ISO 9001:2008. Learn more at [www.cie.org.uk/ISO9001](http://www.cie.org.uk/ISO9001)

## 1.2 Why Choose Cambridge IGCSE?

Cambridge IGCSEs are international in outlook but retain a local relevance. The syllabi provide opportunities for contextualized learning, and the content has been created to suit a wide variety of schools, avoid cultural bias, and develop essential lifelong skills, including creative thinking and problem solving.

Our goal is to balance knowledge, understanding, and skills in our programs and qualifications to enable students to become effective learners and to provide a solid foundation for their continuing educational journey.

Through our professional development courses and our support materials for Cambridge IGCSEs, we provide the tools to enable teachers to prepare students to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge IGCSEs are considered to be an excellent preparation for Cambridge International AS and A Levels, the Cambridge AICE (Advanced International Certificate of Education) Group Award, Cambridge Pre-U, and other education programs, such as the US Advanced Placement program and the International Baccalaureate Diploma program. Learn more about Cambridge IGCSEs at [www.cie.org.uk/cambridgesecundary2](http://www.cie.org.uk/cambridgesecundary2)

### Guided Learning Hours

Cambridge IGCSE syllabi are designed with the assumption that candidates have about 130 guided learning hours per subject over the duration of the course, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the candidates' prior experience with the subject.

## 1.3 Why Choose Cambridge IGCSE Biology?

Cambridge IGCSE Biology is accepted by universities and employers as proof of essential knowledge and ability. As well as a subject focus, the biology syllabus enables learners to:

- better understand the technological world, with an informed interest in scientific matters
- recognize the usefulness (and limitations) of scientific method, and how to apply this to other disciplines and in everyday life
- develop relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness
- develop an interest in, and care for, the environment
- better understand the influence and limitations placed on scientific study by society, economy, technology, ethics, the community and the environment
- develop an understanding of the scientific skills essential for both further study and everyday life.

### Prerequisites

We recommend that candidates who are beginning this course should have previously studied a science curriculum such as that of the Cambridge Lower Secondary Program or equivalent national educational frameworks. Candidates should also have adequate mathematical skills for the content contained in this syllabus.

## Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades A\* to C for this qualification are well prepared to follow courses leading to Level 3 AS and A Level GCE Biology, Cambridge Pre-U Biology, IB Certificates in Biology or the Cambridge International AS and A Level Biology.

## 1.4 Cambridge ICE (International Certificate of Education)

Cambridge ICE is a group award for Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognizing the achievements of candidates who pass examinations in a number of different subjects.

Learn more about Cambridge ICE at [www.cie.org.uk/cambridgesecundary2](http://www.cie.org.uk/cambridgesecundary2)

## 1.5 How Can I Find Out More?

### If You Are Already a Cambridge School

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at [info@cie.org.uk](mailto:info@cie.org.uk)

### If You Are Not Yet a Cambridge School

Learn about the benefits of becoming a Cambridge school at [www.cie.org.uk/startcambridge](http://www.cie.org.uk/startcambridge). Email us at [info@cie.org.uk](mailto:info@cie.org.uk) to find out how your organization can register to become a Cambridge school.

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## 2. Teacher support

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### 2.1 Support Materials

We send Cambridge syllabi, past question papers, and examiner reports to cover the last examination series to all Cambridge schools.

You can also go to our public website at **[www.cie.org.uk/igcse](http://www.cie.org.uk/igcse)** to download current and future syllabi together with specimen papers or past question papers and examiner reports from one series.

For teachers at registered Cambridge schools a range of additional support materials for specific syllabi is available from Teacher Support, our secure online support for Cambridge teachers. Go to **<http://teachers.cie.org.uk>** (username and password required).

### 2.2 Resource Lists

We work with publishers providing a range of resources for our syllabi including print and digital materials. Resources endorsed by Cambridge go through a detailed quality assurance process to ensure they provide a high level of support for teachers and learners.

We have resource lists that can be filtered to show all resources, or just those that are endorsed by Cambridge. The resource lists include further suggestions for resources to support teaching.

### 2.3 Training

We offer a range of support activities for teachers to ensure they have the relevant knowledge and skills to deliver our qualifications. See **[www.cie.org.uk/events](http://www.cie.org.uk/events)** for further information.

### 3. Curriculum Content at a Glance

Candidates study the following topics.

<b>1. Characteristics and classification of living organisms</b>
1.1 Characteristics of living organisms
1.2 Concept and use of a classification system
1.3 Features of organisms
1.4 Dichotomous keys
<b>2. Organization of the organism</b>
2.1 Cell structure and organization
2.2 Levels of organization
2.3 Size of specimens
<b>3. Movement in and out of cells</b>
3.1 Diffusion
3.2 Osmosis
3.3 Active transport
<b>4. Biological molecules</b>
<b>5. Enzymes</b>
<b>6. Plant nutrition</b>
6.1 Photosynthesis
6.2 Leaf structure
6.3 Mineral requirements
<b>7. Human nutrition</b>
7.1 Diet
7.2 Alimentary canal
7.3 Mechanical digestion
7.4 Chemical digestion
7.5 Absorption
<b>8. Transport in plants</b>
8.1 Transport in plants
8.2 Water uptake
8.3 Transpiration
8.4 Translocation (Extended candidates only)
<b>9. Transport in animals</b>
9.1 Transport in animals
9.2 Heart
9.3 Blood and lymphatic vessels
9.4 Blood
<b>10. Diseases and immunity</b>

<b>11. Gas exchange in humans</b>
<b>12. Respiration</b>
12.1 Respiration
12.2 Aerobic respiration
12.3 Anaerobic respiration
<b>13. Excretion in humans</b>
<b>14. Coordination and response</b>
14.1 Nervous control in humans
14.2 Sense organs
14.3 Hormones in humans
14.4 Homeostasis
14.5 Tropic responses
<b>15. Drugs</b>
15.1 Drugs
15.2 Medicinal drugs
15.3 Misused drugs
<b>16. Reproduction</b>
16.1 Asexual reproduction
16.2 Sexual reproduction
16.3 Sexual reproduction in plants
16.4 Sexual reproduction in humans
16.5 Sex hormones in humans
16.6 Methods of birth control in humans
16.7 Sexually transmitted infections (STIs)
<b>17. Inheritance</b>
17.1 Inheritance
17.2 Chromosomes, genes and proteins
17.3 Mitosis
17.4 Meiosis
17.5 Monohybrid inheritance
<b>18. Variation and selection</b>
18.1 Variation
18.2 Adaptive features
18.3 Selection

**19. Organisms and their environment**

- 19.1 Energy flow
- 19.2 Food chains and food webs
- 19.3 Nutrient cycles
- 19.4 Population size

**20. Biotechnology and genetic engineering**

- 20.1 Biotechnology and genetic engineering
- 20.2 Biotechnology
- 20.3 Genetic engineering

**21. Human influences on ecosystems**

- 21.1 Food supply
- 21.2 Habitat destruction
- 21.3 Pollution
- 21.4 Conservation

## 4. Assessment at a Glance

All candidates must enter for three papers.

### Core candidates take:

#### **Paper 1** 45 minutes

A multiple-choice paper consisting of 40 items of the four-choice type.

This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.

This paper will be weighted at 30% of the final total mark.

### and:

#### **Paper 3** 1 hour 15 minutes

A written paper consisting of short-answer and structured questions.

This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.

80 marks

This paper will be weighted at 50% of the final total mark.

### Extended candidates take:

#### **Paper 2** 45 minutes

A multiple-choice paper consisting of 40 items of the four-choice type.

This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).

This paper will be weighted at 30% of the final total mark.

### and:

#### **Paper 4** 1 hour 15 minutes

A written paper consisting of short-answer and structured questions.

This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).

80 marks

This paper will be weighted at 50% of the final total mark.

### All candidates take:

#### either:

#### **Paper 5** 1 hour 15 minutes

Practical Test

This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 7.

The paper is structured to assess grade ranges A\*–G.

40 marks

This paper will be weighted at 20% of the final total mark.

#### or:

#### **Paper 7**

Coursework

Internal assessment of practical skills testing assessment objective AO3.

The paper is structured to assess grade ranges A\*–G.

48 marks

This paper will be weighted at 20% of the final total mark.

Candidates who have studied the Core syllabus content, or who are expected to achieve a grade D or below should be entered for Paper 1, Paper 3 and either Paper 5 or Paper 7. These candidates will be eligible for grades C to G.

Candidates who have studied the Extended syllabus content (Core and Supplement), and who are expected to achieve a grade C or above should be entered for Paper 2, Paper 4 and either Paper 5 or Paper 7. These candidates will be eligible for grades A\* to G.

## Availability

This syllabus is examined in the June and November examination series.

Detailed timetables are available from **[www.cie.org.uk/examsOfficers](http://www.cie.org.uk/examsOfficers)**

## Combining This With Other Syllabi

Candidates can combine this syllabus in an examination series with any other Cambridge syllabus, except:

- syllabi with the same title at the same level
- 0653 Cambridge IGCSE Combined Science
- 0654 Cambridge IGCSE Co-ordinated Sciences (Double Award)
- 5129 Cambridge O Level Combined Science

Please note that Cambridge IGCSE, Cambridge International Level 1/Level 2 Certificate and Cambridge O Level syllabi are at the same level.

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## 5. Syllabus Goals and Assessment Objectives

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### 5.1 Goals

The syllabus goals listed below describe the educational purposes of a course based on this syllabus. These goals are not intended as assessment criteria but outline the educational context in which the syllabus content should be viewed. These goals are the same for all students and are not listed in order of priority. Some of these goals may be delivered by the use of suitable local, international or historical examples and applications, or through collaborative experimental work.

The goals are:

1. to provide an enjoyable and worthwhile educational experience for all students, whether or not they go on to study science beyond this level
2. to enable students to acquire sufficient knowledge and understanding to:
  - become confident citizens in a technological world and develop an informed interest in scientific matters
  - be suitably prepared for studies beyond Cambridge IGCSE
3. to allow students to recognize that science is evidence based and understand the usefulness, and the limitations, of scientific method
4. to develop skills that:
  - are relevant to the study and practice of biology
  - are useful in everyday life
  - encourage a systematic approach to problem-solving
  - encourage efficient and safe practice
  - encourage effective communication through the language of science
5. to develop attitudes relevant to biology such as:
  - concern for accuracy and precision
  - objectivity
  - integrity
  - enquiry
  - initiative
  - inventiveness
6. to enable students to appreciate that:
  - science is subject to social, economic, technological, ethical and cultural influences and limitations
  - the applications of science may be both beneficial and detrimental to the individual, the community and the environment

Cambridge IGCSE Biology (US) places considerable emphasis on understanding and use of scientific ideas and principles in a variety of situations, including those that are well-known to the candidate and those that are new to them. It is anticipated that programs of study based on this syllabus will feature a variety of learning experiences designed to enhance the development of skill and comprehension. This approach will focus teachers and candidates on development of transferable life-long skills relevant to the increasingly technological environment in which people find themselves. It will also prepare candidates for an assessment that will, within familiar and unfamiliar contexts, test expertise, understanding, and insight.

## 5.2 Assessment Objectives

### AO1: Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

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

Syllabus 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.

Questions testing this objective will often begin with one of the following words: *define, state, describe, explain (using your knowledge and understanding) or outline* (see the *Glossary of terms used in science papers*).

### 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:

1. locate, select, organize and present information from a variety of sources
2. translate information from one form to another
3. manipulate numerical and other data
4. use information to identify patterns, report trends and draw inferences
5. present reasoned explanations for phenomena, patterns and relationships
6. make predictions and hypotheses
7. 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.

Questions testing these skills will often begin with one of the following words: *predict, suggest, calculate or determine* (see the *Glossary of terms used in science papers*).

### AO3: Experimental skills and investigations

Candidates should be able to:

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

### 5.3 Relationship Between Assessment Objectives and Components

The approximate weightings allocated to each of the assessment objectives are summarized in the table below.

Assessment objective	Papers 1 and 2	Papers 3 and 4	Papers 5 and 7	Weighting of AO in overall qualification
<b>AO1:</b> Knowledge with understanding	63%	63%	–	50%
<b>AO2:</b> Handling information and problem solving	37%	37%	–	30%
<b>AO3:</b> Experimental skills and investigations	–	–	100%	20%
<b>Weighting of paper in overall qualification</b>	30%	50%	20%	

## 5.4 Grade Descriptions

The scheme of assessment is intended to encourage positive achievement by all candidates.

A **Grade A** candidate will be able to:

- recall and communicate precise knowledge and display comprehensive understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present reasoned explanations of familiar and unfamiliar phenomena, to solve complex problems involving several stages, and to make reasoned predictions and hypotheses
- communicate and present complex scientific ideas, observations and data clearly and logically, independently using scientific terminology and conventions consistently and correctly
- independently select, process and synthesize information presented in a variety of ways, and use it to draw valid conclusions and discuss the scientific, technological, social, economic and environmental implications
- devise strategies to solve problems in complex situations which may involve many variables or complex manipulation of data or ideas through multiple steps
- analyze data to identify any patterns or trends, taking account of limitations in the quality of the data and justifying the conclusions reached
- select, describe, justify and evaluate techniques for a large range of scientific operations and laboratory procedures.

A **Grade C** candidate will be able to:

- recall and communicate secure knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present simple explanations of familiar and some unfamiliar phenomena, to solve straightforward problems involving several stages, and to make detailed predictions and simple hypotheses
- communicate and present scientific ideas, observations and data using a wide range of scientific terminology and conventions
- select and process information from a given source, and use it to draw simple conclusions and state the scientific, technological, social, economic or environmental implications
- solve problems involving more than one step, but with a limited range of variables or using familiar methods
- analyze data to identify a pattern or trend, and select appropriate data to justify a conclusion
- select, describe and evaluate techniques for a range of scientific operations and laboratory procedures.

A **Grade F** candidate will be able to:

- recall and communicate limited knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply a limited range of scientific facts and concepts to give basic explanations of familiar phenomena, to solve straightforward problems and make simple predictions
- communicate and present simple scientific ideas, observations and data using a limited range of scientific terminology and conventions
- select a single piece of information from a given source, and use it to support a given conclusion, and to make links between scientific information and its scientific, technological, social, economic or environmental implications
- solve problems involving more than one step if structured help is given
- analyze data to identify a pattern or trend
- select, describe and evaluate techniques for a limited range of scientific operations and laboratory procedures.

## 5.5 Conventions (e.g. Signs, Symbols, Terminology and Nomenclature)

Syllabi and question papers conform with generally 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).

### Liter/dm<sup>3</sup>

To avoid any confusion concerning the symbol for liter, **dm<sup>3</sup>** will be used in place of *l* or liter.

### 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 whole numbers, e.g. 4 256 789.

## 6. Curriculum Content

All candidates should be taught the Core syllabus content. Candidates who are only taught the Core syllabus content can achieve a maximum of grade C. Candidates aiming for grades A\* to C should be taught the Extended syllabus content. The Extended syllabus content includes both the Core and the Supplement.

In delivering the course, teachers should aim to show the relevance of concepts to the students' everyday lives and to the world around them. The syllabus content has been designed so as to allow teachers to develop flexible programs which meet all of the general goals of the syllabus while drawing on appropriate local and international contexts.

Scientific subjects are, by their nature, experimental. Wherever possible, students should pursue a fully integrated course which allows them to develop their practical skills by carrying out practical work and investigations within all of the topics listed.

### 1. Characteristics and classification of living organisms

#### 1.1 Characteristics of living organisms

##### Core

- Describe the characteristics of living organisms by defining the terms:
  - *movement* as an action by an organism causing a change of position or place
  - *respiration* as the chemical reactions in cells that break down nutrient molecules and release energy
  - *sensitivity* as the ability to detect and respond to changes in the environment
  - *growth* as a permanent increase in size
  - *reproduction* as the processes that make more of the same kind of organism
  - *excretion* as removal from organisms of toxic materials and substances in excess of requirements
  - *nutrition* as taking in of materials for energy, growth and development

##### Supplement

- Define the terms:
  - *movement* as an action by an organism or part of an organism causing a change of position or place
  - *respiration* as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism
  - *sensitivity* as the ability to detect or sense stimuli in the internal or external environment and to make appropriate responses
  - *growth* as a permanent increase in size and dry mass by an increase in cell number or cell size or both
  - *excretion* as removal from organisms of the waste products of metabolism (chemical reactions in cells including respiration), toxic materials, and substances in excess of requirements
  - *nutrition* as taking in of materials for energy, growth and development; plants require light, carbon dioxide, water and ions; animals need organic compounds and ions and usually need water

<p>1.2 Concept and use of a classification system</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• State that organisms can be classified into groups by the features that they share</li> <li>• Define <i>species</i> as a group of organisms that can reproduce to produce fertile offspring</li> <li>• Define and describe the <i>binomial system</i> 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</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Explain that classification systems aim to reflect evolutionary relationships</li> <li>• Explain that classification is traditionally based on studies of morphology and anatomy</li> <li>• Explain that the sequences of bases in DNA and of amino acids in proteins are used as a more accurate means of classification</li> <li>• Explain that organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor</li> </ul>
<p>1.3 Features of organisms</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• List the features in the cells of all living organisms, limited to cytoplasm, cell membrane and DNA as genetic material</li> <li>• List the main features used to place animals and plants into the appropriate kingdoms</li> <li>• List the main features used to place organisms into groups within the animal kingdom, limited to: <ul style="list-style-type: none"> <li>– the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish</li> <li>– the main groups of arthropods: myriapods, insects, arachnids, crustaceans</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• List the features in the cells of all living organisms, limited to ribosomes for protein synthesis and enzymes involved in respiration</li> <li>• List the main features used to place all organisms into one of the five kingdoms: Animal, Plant, Fungus, Prokaryote, Protocist</li> <li>• List the main features used to place organisms into groups within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons)</li> <li>• List the features of viruses, limited to protein coat and genetic material</li> </ul>
<p>1.4 Dichotomous keys</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Construct and use simple dichotomous keys based on easily identifiable features</li> </ul>	

2. Organization of the organism	
<p>2.1 Cell structure and organization</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe and compare the structure of a plant cell with an animal cell, as seen under a light microscope, limited to cell wall, nucleus, cytoplasm, chloroplasts, vacuoles and location of the cell membrane</li> <li>State the functions of the structures seen under the light microscope in the plant cell and in the animal cell</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State that the cytoplasm of all cells contains structures, limited to ribosomes on rough endoplasmic reticulum and vesicles</li> <li>State that almost all cells, except prokaryotes, have mitochondria and rough endoplasmic reticulum</li> <li>Identify mitochondria and rough endoplasmic reticulum in diagrams and images of cells</li> <li>State that aerobic respiration occurs in mitochondria</li> <li>State that cells with high rates of metabolism require large numbers of mitochondria to provide sufficient energy</li> </ul>
<p>2.2 Levels of organization</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Relate the structure of the following to their functions: <ul style="list-style-type: none"> <li>ciliated cells – movement of mucus in the trachea and bronchi</li> <li>root hair cells – absorption</li> <li>xylem vessels – conduction and support</li> <li>palisade mesophyll cells – photosynthesis</li> <li>nerve cells – conduction of impulses</li> <li>red blood cells – transport of oxygen</li> <li>sperm and egg cells – reproduction</li> </ul> </li> <li>Define <i>tissue</i> as a group of cells with similar structures, working together to perform a shared function</li> <li>Define <i>organ</i> as a structure made up of a group of tissues, working together to perform specific functions</li> <li>Define <i>organ system</i> as a group of organs with related functions, working together to perform body functions</li> <li>State examples of tissues, organs and organ systems from sections 6 to 16</li> <li>Identify the different levels of organization in drawings, diagrams and images of familiar material</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Identify the different levels of organization in drawings, diagrams and images of unfamiliar material</li> </ul>

<p>2.3 Size of specimens</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Calculate magnification and size of biological specimens using millimeters as units</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Calculate magnification and size of biological specimens using millimeters and micrometers as units</li> </ul>
<p><b>3. Movement in and out of cells</b></p>	
<p>3.1 Diffusion</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>diffusion</i> as the net movement of particles from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of their random movement</li> <li>Describe the importance of diffusion of gases and solutes</li> <li>State that substances move into and out of cells by diffusion through the cell membrane</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State that the energy for diffusion comes from the kinetic energy of random movement of molecules and ions</li> <li>Investigate the factors that influence diffusion, limited to surface area, temperature, concentration gradients and distance</li> </ul>
<p>3.2 Osmosis</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that water diffuses through partially permeable membranes by osmosis</li> <li>State that water moves in and out of cells by osmosis through the cell membrane</li> <li>Investigate and describe the effects on plant tissues of immersing them in solutions of different concentrations</li> <li>State that plants are supported by the pressure of water inside the cells pressing outwards on the cell wall</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define <i>osmosis</i> as the net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane</li> <li>Explain the effects on plant tissues of immersing them in solutions of different concentrations by using the terms <i>turgid</i>, <i>turgor pressure</i>, <i>plasmolysis</i> and <i>flaccid</i></li> <li>Explain the importance of water potential and osmosis in the uptake of water by plants</li> <li>Explain the importance of water potential and osmosis on animal cells and tissues</li> <li>Explain how plants are supported by the turgor pressure within cells, in terms of water pressure acting against an inelastic cell wall</li> </ul>

<p>3.3 Active transport</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>active transport</i> as the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration using energy from respiration</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Discuss the importance of active transport as a process for movement across membranes: <ul style="list-style-type: none"> <li>e.g. ion uptake by root hairs and uptake of glucose by epithelial cells of villi and kidney tubules</li> </ul> </li> <li>Explain how protein molecules move particles across a membrane during active transport</li> </ul>
<p><b>4. Biological molecules</b></p>	
<p><b>Core</b></p> <ul style="list-style-type: none"> <li>List the chemical elements that make up: <ul style="list-style-type: none"> <li>carbohydrates</li> <li>fats</li> <li>proteins</li> </ul> </li> <li>State that large molecules are made from smaller molecules, limited to: <ul style="list-style-type: none"> <li>starch and glycogen from glucose</li> <li>cellulose from glucose</li> <li>proteins from amino acids</li> <li>fats and oils from fatty acids and glycerol</li> </ul> </li> <li>Describe the use of: <ul style="list-style-type: none"> <li>iodine solution to test for starch</li> <li>Benedict's solution to test for reducing sugars</li> <li>biuret test for proteins</li> <li>ethanol emulsion test for fats and oils</li> <li>DCPIP test for vitamin C</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain that different sequences of amino acids give different shapes to protein molecules</li> <li>Relate the shape and structure of protein molecules to their function, limited to the active site of enzymes and the binding site of antibodies</li> </ul> <p style="text-align: right;"><i>cont.</i></p>

<p>4. Biological molecules continued</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• State that water is important as a solvent</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe the structure of DNA as: <ul style="list-style-type: none"> <li>– two strands coiled together to form a double helix</li> <li>– each strand contains chemicals called bases</li> <li>– cross-links between the strands are formed by pairs of bases</li> <li>– the bases always pair up in the same way: A with T, and C with G (full names are <b>not</b> required)</li> </ul> </li> <li>• Describe the roles of water as a solvent in organisms with respect to digestion, excretion and transport</li> </ul>
<p><b>5. Enzymes</b></p>	
<p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Define the term <i>catalyst</i> as a substance that increases the rate of a chemical reaction and is not changed by the reaction</li> <li>• Define <i>enzymes</i> as proteins that function as biological catalysts</li> <li>• Describe why enzymes are important in all living organisms in terms of reaction speed necessary to sustain life</li> <li>• Describe enzyme action with reference to the complementary shape of an enzyme and its substrate and the formation of a product (knowledge of the term <i>active site</i> is <b>not</b> required)</li> <li>• Investigate and describe the effect of changes in temperature and pH on enzyme activity</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Explain enzyme action with reference to the active site, enzyme-substrate complex, substrate and product</li> <li>• Explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate</li> <li>• Explain the effect of changes in temperature on enzyme activity in terms of kinetic energy, shape and fit, frequency of effective collisions and denaturation</li> <li>• Explain the effect of changes in pH on enzyme activity in terms of shape and fit and denaturation</li> </ul>

6. Plant nutrition	
<p>6.1 Photosynthesis</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>photosynthesis</i> as the process by which plants manufacture carbohydrates from raw materials using energy from light</li> <li>State the word equation for photosynthesis: carbon dioxide + water → glucose + oxygen, in the presence of light and chlorophyll</li> <li>Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls</li> <li>Investigate and describe the effects of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis, e.g. in submerged aquatic plants</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the balanced chemical equation for photosynthesis  <math display="block">6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2</math> </li> <li>Explain that chlorophyll transfers light energy into chemical energy in molecules, for the synthesis of carbohydrates</li> <li>Outline the subsequent use and storage of the carbohydrates made in photosynthesis</li> <li>Define the term <i>limiting factor</i> as something present in the environment in such short supply that it restricts life processes</li> <li>Identify and explain the limiting factors of photosynthesis in different environmental conditions</li> <li>Describe the use of carbon dioxide enrichment, optimum light and optimum temperatures in glasshouses in temperate and tropical countries</li> <li>Use hydrogencarbonate indicator solution to investigate the effect of gas exchange of an aquatic plant kept in the light and in the dark</li> </ul>
<p>6.2 Leaf structure</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Identify chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, vascular bundles, xylem and phloem in leaves of a dicotyledonous plant</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain how the internal structure of a leaf is adapted for photosynthesis</li> </ul>
<p>6.3 Mineral requirements</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the importance of: <ul style="list-style-type: none"> <li>nitrate ions for making amino acids</li> <li>magnesium ions for making chlorophyll</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain the effects of nitrate ion and magnesium ion deficiency on plant growth</li> </ul>

## 7. Human nutrition

### 7.1 Diet

#### Core

- State what is meant by the term *balanced diet* for humans
- Explain how age, gender and activity affect the dietary needs of humans including during pregnancy and while breast-feeding
- Describe the effects of malnutrition in relation to starvation, constipation, coronary heart disease, obesity and scurvy
- List the principal sources of, and describe the dietary importance of:
  - carbohydrates
  - fats
  - proteins
  - vitamins, limited to C and D
  - mineral salts, limited to calcium and iron
  - fiber (roughage)
  - water

#### Supplement

- Explain the causes and effects of vitamin D and iron deficiencies
- Explain the causes and effects of protein-energy malnutrition, e.g. kwashiorkor and marasmus

## 7.2 Alimentary canal

**Core**

- Define *ingestion* as the taking of substances, e.g. food and drink, into the body through the mouth
- Define *mechanical digestion* as the breakdown of food into smaller pieces without chemical change to the food molecules
- Define *chemical digestion* as the breakdown of large, insoluble molecules into small, soluble molecules
- Define *absorption* as the movement of small food molecules and ions through the wall of the intestine into the blood
- Define *assimilation* as the movement of digested food molecules into the cells of the body where they are used, becoming part of the cells
- Define *egestion* as the passing out of food that has not been digested or absorbed, as faeces, through the anus
- Describe diarrhea as the loss of watery faeces
- Outline the treatment of diarrhea using oral rehydration therapy
- Describe cholera as a disease caused by a bacterium
  
- Identify the main regions of the alimentary canal and associated organs, limited to mouth, salivary glands, esophagus, stomach, small intestine (duodenum and ileum), pancreas, liver, gall bladder and large intestine (colon, rectum, anus)
- Describe the functions of the regions of the alimentary canal listed above, in relation to ingestion, digestion, absorption, assimilation and egestion of food

**Supplement**

- 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, causing diarrhoea, dehydration and loss of salts from blood

<p>7.3 Mechanical digestion</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Identify the types of human teeth (incisors, canines, premolars and molars)</li> <li>• Describe the structure of human teeth, limited to enamel, dentine, pulp, nerves and cement, as well as the gums</li> <li>• Describe the functions of the types of human teeth in mechanical digestion of food</li> <li>• State the causes of dental decay in terms of a coating of bacteria and food on teeth, the bacteria respiring sugars in the food, producing acid which dissolves the enamel and dentine</li> <li>• Describe the proper care of teeth in terms of diet and regular brushing</li> </ul>	
<p>7.4 Chemical digestion</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• State the significance of chemical digestion in the alimentary canal in producing small, soluble molecules that can be absorbed</li> <li>• State the functions of enzymes as follows: <ul style="list-style-type: none"> <li>– amylase breaks down starch to simpler sugars</li> <li>– protease breaks down protein to amino acids</li> <li>– lipase breaks down fats to fatty acids and glycerol</li> </ul> </li> <li>• State where, in the alimentary canal, amylase, protease and lipase are secreted</li> <li>• State the functions of the hydrochloric acid in gastric juice, limited to killing bacteria in food and giving an acid pH for enzymes</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe the digestion of starch in the alimentary canal: <ul style="list-style-type: none"> <li>– amylase is secreted into the alimentary canal and breaks down starch to maltose</li> <li>– maltose is broken down by maltase to glucose on the membranes of the epithelium lining the small intestine</li> </ul> </li> <li>• Describe pepsin and trypsin as two protease enzymes that function in different parts of the alimentary canal: <ul style="list-style-type: none"> <li>– pepsin in the stomach</li> <li>– trypsin in the small intestine</li> </ul> </li> <li>• Explain the functions of the hydrochloric acid in gastric juice, limited to the low pH: <ul style="list-style-type: none"> <li>– denaturing enzymes in harmful microorganisms in food</li> <li>– giving the optimum pH for pepsin activity</li> </ul> </li> <li>• Outline the role of bile in neutralizing the acidic mixture of food and gastric juices entering the duodenum from the stomach, to provide a suitable pH for enzyme action</li> <li>• 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</li> </ul>

<p>7.5 Absorption</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Identify the small intestine as the region for the absorption of digested food</li> <li>State that water is absorbed in both the small intestine and the colon, but that most absorption of water happens in the small intestine</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain the significance of villi and microvilli in increasing the internal surface area of the small intestine</li> <li>Describe the structure of a villus</li> <li>Describe the roles of capillaries and lacteals in villi</li> </ul>
<p><b>8. Transport in plants</b></p>	
<p>8.1 Transport in plants</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State the functions of xylem and phloem</li> <li>Identify the position of xylem and phloem as seen in sections of roots, stems and leaves, limited to non-woody dicotyledonous plants</li> </ul>	
<p>8.2 Water uptake</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Identify root hair cells, as seen under the light microscope, and state their functions</li> <li>State the pathway taken by water through root, stem and leaf as root hair cell, root cortex cells, xylem and mesophyll cells</li> <li>Investigate, using a suitable stain, the pathway of water through the above ground parts of a plant</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain that the large surface area of root hairs increases the rate of the absorption of water by osmosis and ions by active transport</li> </ul>

<p>8.3 Transpiration</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• State that water is transported from the roots to leaves through the xylem vessels</li> <li>• Define <i>transpiration</i> as loss of water vapour from plant leaves by evaporation of water at the surfaces of the mesophyll cells followed by diffusion of water vapor through the stomata</li> </ul> <ul style="list-style-type: none"> <li>• Investigate and describe the effects of variation of temperature and humidity on transpiration rate</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Explain how water vapor loss is related to the large surface area of cell surfaces, interconnecting air spaces and stomata</li> <li>• 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 cohesion</li> <li>• Explain how and why wilting occurs</li> <li>• Explain the effects of variation of temperature and humidity on transpiration rate</li> </ul>
<p>8.4 Translocation</p>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Define <i>translocation</i> in terms of the movement of sucrose and amino acids in phloem: <ul style="list-style-type: none"> <li>– from regions of production (source)</li> <li>– to regions of storage OR to regions where they are used in respiration or growth (sink)</li> </ul> </li> <li>• Explain that some parts of a plant may act as a source and a sink at different times during the life of a plant</li> </ul>

9. Transport in animals	
<p>9.1 Transport in animals</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the single circulation of a fish</li> <li>Describe the double circulation of a mammal</li> <li>Explain the advantages of a double circulation</li> </ul>
<p>9.2 Heart</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Name and identify the structures of the mammalian heart, limited to the muscular wall, the septum, the left and right ventricles and atria, one-way valves and coronary arteries</li> <li>State that blood is pumped away from the heart into arteries and returns to the heart in veins</li> </ul> <ul style="list-style-type: none"> <li>State that the activity of the heart may be monitored by ECG, pulse rate and listening to sounds of valves closing</li> <li>Investigate and state the effect of physical activity on the pulse rate</li> <li>Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors as diet, stress, smoking, genetic predisposition, age and gender</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Name and identify the atrioventricular and semilunar valves in the mammalian heart</li> <li>Explain the relative thickness: <ul style="list-style-type: none"> <li>of the muscle wall of the left and right ventricles</li> <li>of the muscle wall of the atria compared to that of the ventricles</li> </ul> </li> <li>Explain the importance of the septum in separating oxygenated and deoxygenated blood</li> <li>Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves</li> <li>Explain the effect of physical activity on the heart rate</li> <li>Discuss the roles of diet and exercise in the prevention of coronary heart disease</li> <li>Describe ways in which coronary heart disease may be treated, limited to drug treatment with aspirin and surgery (stents, angioplasty and by-pass)</li> </ul>

<p>9.3 Blood and lymphatic vessels</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe the structure and functions of arteries, veins and capillaries</li> <li>• Name the main blood vessels to and from the: <ul style="list-style-type: none"> <li>– heart, limited to vena cava, aorta, pulmonary artery and pulmonary vein</li> <li>– lungs, limited to the pulmonary artery and pulmonary vein</li> <li>– kidney, limited to the renal artery and renal vein</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Explain how the structures of arteries, veins and capillaries are adapted for their functions</li> <li>• State the function of arterioles, venules and shunt vessels</li> <li>• Outline the lymphatic system in terms of lymphatic vessels and lymph nodes</li> <li>• Describe the function of the lymphatic system in the circulation of body fluids and the protection of the body from infection</li> </ul>
<p>9.4 Blood</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• List the components of blood as red blood cells, white blood cells, platelets and plasma</li> <li>• Identify red and white blood cells, as seen under the light microscope, on prepared slides and in diagrams and photomicrographs</li> <li>• State the functions of the following components of blood: <ul style="list-style-type: none"> <li>– red blood cells in transporting oxygen, including the role of hemoglobin</li> <li>– white blood cells in phagocytosis and antibody production</li> <li>– platelets in clotting (details are <b>not</b> required)</li> <li>– plasma in the transport of blood cells, ions, soluble nutrients, hormones and carbon dioxide</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Identify lymphocyte and phagocyte white blood cells, as seen under the light microscope, on prepared slides and in diagrams and photomicrographs</li> <li>• State the functions of: <ul style="list-style-type: none"> <li>– lymphocytes – antibody production</li> <li>– phagocytes – phagocytosis</li> </ul> </li> <li>• Describe the process of clotting as the conversion of fibrinogen to fibrin to form a mesh</li> <li>• State the roles of blood clotting as preventing blood loss and preventing the entry of pathogens</li> <li>• Describe the transfer of materials between capillaries and tissue fluid (details of the roles of water potential and hydrostatic pressure are <b>not</b> required)</li> </ul>

## 10. Diseases and immunity

### Core

- Define *pathogen* as a disease-causing organism
- Define *transmissible disease* as a disease in which the pathogen can be passed from one host to another
- State that the pathogen for a transmissible disease may be transmitted either through direct contact, e.g. through blood or other body fluids, or indirectly, e.g. from contaminated surfaces or food, from animals, or from the air
- State that the body has defences:
  - mechanical barriers, limited to skin and hairs in the nose
  - chemical barriers, limited to mucus and stomach acid
  - cells, limited to phagocytosis and antibody production by white blood cells
  - which can be enhanced by vaccination
- Explain the importance of hygienic food preparation, good personal hygiene, waste disposal and sewage treatment in controlling the spread of disease

### Supplement

- State that antibodies lock on to antigens leading to direct destruction of pathogens, or marking of pathogens for destruction by phagocytes
- Explain how each pathogen has its own antigens, which have specific shapes, so specific antibodies which fit the specific shapes of the antigens are needed
- Define *active immunity* as defence against a pathogen by antibody production in the body
- Explain that active immunity is gained after an infection by a pathogen, or by vaccination
- Explain the process of vaccination:
  - harmless pathogen given which has antigens
  - antigens trigger an immune response by lymphocytes which produce antibodies
  - memory cells are produced that give long-term immunity
- Explain the role of vaccination in controlling the spread of diseases
- Explain that *passive immunity* is short-term defence against a pathogen by antibodies acquired from another individual, e.g. mother to infant
- State that memory cells are not produced in passive immunity
- Explain the importance of passive immunity for breast-fed infants
- State that some diseases are caused by the immune system targeting and destroying body cells, limited to Type 1 diabetes

## 11. Gas exchange in humans

### Core

- List the features of gas exchange surfaces in humans, limited to large surface area, thin surface, good blood supply and good ventilation with air
- Name and identify the lungs, diaphragm, ribs, intercostal muscles, larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries
- State the differences in composition between inspired and expired air, limited to oxygen, carbon dioxide and water vapor
- Use limewater as a test for carbon dioxide to investigate the differences in composition between inspired and expired air
- Investigate and describe the effects of physical activity on rate and depth of breathing

### Supplement

- Name and identify the internal and external intercostal muscles
- State the functions of the cartilage in the trachea
- Explain the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes in the thorax leading to the ventilation of the lungs
- Explain the differences in composition between inspired and expired air
- Explain the link between physical activity and rate and depth of breathing in terms of the increased carbon dioxide concentration in the blood, detected by the brain, causing an increased rate of breathing
- Explain the role of goblet cells, mucus and ciliated cells in protecting the gas exchange system from pathogens and particles

## 12. Respiration

### 12.1 Respiration

#### Core

- State the uses of energy in the body of humans: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature
- State that respiration involves the action of enzymes in cells

<p>12.2 Aerobic respiration</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>aerobic respiration</i> as the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy</li> <li>State the word equation for aerobic respiration as glucose + oxygen → carbon dioxide + water</li> <li>Investigate the uptake of oxygen by respiring organisms, such as arthropods and germinating seeds</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the balanced chemical equation for aerobic respiration as <math>C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O</math></li> <li>Investigate the effect of temperature on the rate of respiration of germinating seeds</li> </ul>
<p>12.3 Anaerobic respiration</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>anaerobic respiration</i> as the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen</li> <li>State the word equations for anaerobic respiration in muscles during vigorous exercise (glucose → lactic acid) and the microorganism yeast (glucose → alcohol + carbon dioxide)</li> <li>State that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the balanced chemical equation for anaerobic respiration in the microorganism yeast as <math>C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2</math></li> <li>State that lactic acid builds up in muscles and blood during vigorous exercise causing an oxygen debt</li> <li>Outline how the oxygen debt is removed during recovery, limited to: <ul style="list-style-type: none"> <li>aerobic respiration of lactic acid in the liver</li> <li>continuation, after exercise, of fast heart rate to transport lactic acid in blood from muscles to the liver</li> <li>continuation, after exercise, of deeper breathing supplying oxygen for aerobic respiration of lactic acid</li> </ul> </li> </ul>

### 13. Excretion in humans

#### Core

- State that urea is formed in the liver from excess amino acids
- State that carbon dioxide is excreted through the lungs
- State that the kidneys excrete urea and excess water and salts
- Explain that the volume and concentration of urine produced is affected by water intake, temperature and exercise
- Identify on drawings, diagrams and images, the ureters, bladder and urethra

#### Supplement

- Describe the role of the liver in the assimilation of amino acids by converting them to proteins, including plasma proteins, e.g. fibrinogen
- Define *deamination* as the removal of the nitrogen-containing part of amino acids to form urea
- Explain the need for excretion, limited to toxicity of urea and carbon dioxide
- Outline the structure of the kidney, limited to the cortex, medulla and ureter
- Outline the structure and functioning of a kidney tubule, including:
  - the role of the glomerulus in the filtration from the blood of water, glucose, urea and salts
  - the role of the tubule in the reabsorption of all of the glucose, most of the water and some salts back into the blood, leading to the concentration of urea in the urine as well as loss of excess water and salts (details of these processes are **not** required)
- Explain dialysis in terms of salt balance, the maintenance of glucose concentration and the removal of urea
- Describe the use of dialysis in kidney machines
- Discuss the advantages and disadvantages of kidney transplants, compared with dialysis

**14. Coordination and response**

## 14.1 Nervous control in humans

**Core**

- Describe a nerve impulse as an electrical signal that passes along nerve cells called neurons
- Describe the human nervous system in terms of:
  - the central nervous system consisting of brain and spinal cord
  - the peripheral nervous system
  - coordination and regulation of body functions
- Identify motor (effector), relay (connector) and sensory neurons from diagrams
- Describe a simple reflex arc in terms of receptor, sensory neuron, relay neuron, motor neurons and effector
- Describe a reflex action as a means of automatically and rapidly integrating and coordinating stimuli with the responses of effectors (muscles and glands)
- Define a *synapse* as a junction between two neurons

**Supplement**

- Distinguish between voluntary and involuntary actions
- Describe the structure of a synapse, including the presence of neurotransmitter containing vesicles, the synaptic cleft and neurotransmitter receptor molecules
- Describe how an impulse triggers the release of a neurotransmitter from vesicles into the synaptic gap and how the neurotransmitter diffuses across to bind with receptor molecules, in the membrane of the neurone after the synaptic gap, causing the impulse to continue
- State that in a reflex arc the synapses ensure that impulses travel in one direction only
- State that many drugs, e.g. heroin act upon synapses

## 14.2 Sense organs

**Core**

- Define *sense organs* as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals
- Identify the structures of the eye, limited to cornea, iris, pupil, lens, retina, optic nerve and blind spot
- Describe the function of each part of the eye, limited to:
  - cornea – refracts light
  - iris – controls how much light enters pupil
  - lens – focuses light onto retina
  - retina – contains light receptors, some sensitive to light of different colors
  - optic nerve – carries impulses to the brain
- Explain the pupil reflex in terms of light intensity and pupil diameter only

**Supplement**

- Explain the pupil reflex in terms of light intensity and antagonistic action of circular and radial muscles in the iris
- 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
- State the distribution of rods and cones in the retina of a human
- Outline the function of rods and cones, limited to greater sensitivity of rods for night vision and three different kinds of cones absorbing light of different colours for colour vision
- Identify the position of the fovea

<p>14.3 Hormones in humans</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define a <i>hormone</i> as a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs</li> <li>Identify specific endocrine glands and their secretions, limited to adrenal glands and adrenaline, pancreas and insulin, testes and testosterone and ovaries and estrogen</li> <li>Describe adrenaline as the hormone secreted in 'fight or flight' situations and its effects, limited to increased breathing and pulse rate and widened pupils</li> <li>Give examples of situations in which adrenaline secretion increases</li> </ul> <ul style="list-style-type: none"> <li>State the functions of insulin, estrogen and testosterone</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Discuss the role of the hormone adrenaline in the chemical control of metabolic activity, including increasing the blood glucose concentration and pulse rate</li> <li>Compare nervous and hormonal control systems in terms of speed and longevity of action</li> </ul>
<p>14.4 Homeostasis</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>homeostasis</i> as the maintenance of a constant internal environment</li> </ul> <ul style="list-style-type: none"> <li>Name and identify on a diagram of the skin: hairs, hair erector muscles, sweat glands, receptors, sensory neurons, blood vessels and fatty tissue</li> <li>Describe the maintenance of a constant internal body temperature in humans in terms of insulation, sweating, shivering and the role of the brain (limited to blood temperature receptors and coordination)</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain that homeostasis is the control of internal conditions within set limits</li> <li>Explain the concept of control by negative feedback</li> <li>Describe the control of the glucose concentration of the blood by the liver and the roles of insulin and glucagon from the pancreas</li> <li>Outline the symptoms and treatment of Type 1 diabetes (detail of <math>\beta</math> cells is <b>not</b> required)</li> </ul> <ul style="list-style-type: none"> <li>Describe the maintenance of a constant internal body temperature in humans in terms of vasodilation and vasoconstriction of arterioles supplying skin surface capillaries</li> </ul>

<p>14.5 Tropic responses</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>gravitropism</i> as a response in which parts of a plant grow towards or away from gravity</li> <li>Define <i>phototropism</i> as a response in which parts of a plant grow towards or away from the direction from which light is coming</li> <li>Investigate gravitropism and phototropism in shoots and roots</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain phototropism and gravitropism of a shoot as examples of the chemical control of plant growth</li> <li>Explain the role of auxin in controlling shoot growth, limited to: <ul style="list-style-type: none"> <li>auxin made in shoot tip (only)</li> <li>auxin spreads through the plant from the shoot tip</li> <li>auxin is unequally distributed in response to light and gravity</li> <li>auxin stimulates cell elongation</li> </ul> </li> <li>Describe the use in weedkillers of the synthetic plant hormone 2,4-D</li> </ul>
<p><b>15. Drugs</b></p>	
<p>15.1 Drugs</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define a <i>drug</i> as any substance taken into the body that modifies or affects chemical reactions in the body</li> </ul>	
<p>15.2 Medicinal drugs</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the use of antibiotics for the treatment of bacterial infection</li> <li>State that some bacteria are resistant to antibiotics which reduces the effectiveness of antibiotics</li> <li>State that antibiotics kill bacteria but do not affect viruses</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain how development of resistant bacteria such as MRSA can be minimized, limited to using antibiotics only when essential and ensuring treatment is completed</li> <li>Explain why antibiotics kill bacteria, but do not affect viruses</li> </ul>

<p>15.3 Misused drugs</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the effects of excessive alcohol consumption and abuse of heroin, limited to: <ul style="list-style-type: none"> <li>powerful depressant drugs</li> <li>effect on reaction times and self-control</li> <li>addiction and withdrawal symptoms</li> <li>negative social implications, e.g. crime</li> </ul> </li> <li>State that injecting heroin can cause infections such as HIV</li> <li>State that excessive alcohol consumption can cause liver damage</li> <li>State that tobacco smoking can cause chronic obstructive pulmonary disease (COPD), lung cancer and coronary heart disease</li> <li>Describe the effects on the gas exchange system of tobacco smoke and its major toxic components, limited to carbon monoxide, nicotine and tar</li> <li>State that the liver is the site of break down of alcohol and other toxins</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain how heroin affects the nervous system, limited to its effect on the function of synapses</li> <li>Discuss the evidence for the link between smoking and lung cancer</li> <li>Discuss the use of hormones to improve sporting performance, limited to testosterone and anabolic steroids</li> </ul>
<p><b>16. Reproduction</b></p>	
<p>16.1 Asexual reproduction</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>asexual reproduction</i> as a process resulting in the production of genetically identical offspring from one parent</li> <li>Identify examples of asexual reproduction from information provided</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Discuss the advantages and disadvantages of asexual reproduction: <ul style="list-style-type: none"> <li>to a population of a species in the wild</li> <li>to crop production</li> </ul> </li> </ul>

<p>16.2 Sexual reproduction</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>sexual reproduction</i> as a process involving the fusion of the nuclei of two gametes (sex cells) to form a zygote and the production of offspring that are genetically different from each other</li> <li>Define <i>fertilization</i> as the fusion of gamete nuclei</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State that the nuclei of gametes are haploid and that the nucleus of a zygote is diploid</li> <li>Discuss the advantages and disadvantages of sexual reproduction: <ul style="list-style-type: none"> <li>to a population of a species in the wild</li> <li>to crop production</li> </ul> </li> </ul>
<p>16.3 Sexual reproduction in plants</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Identify and draw, using a hand lens if necessary, the sepals, petals, stamens, filaments and anthers, carpels, style, stigma, ovary and ovules, of an insect-pollinated flower</li> <li>State the functions of the sepals, petals, anthers, stigmas and ovaries</li> <li>Use a hand lens to identify and describe the anthers and stigmas of a wind-pollinated flower</li> <li>Distinguish between the pollen grains of insect-pollinated and wind-pollinated flowers</li> <li>Define <i>pollination</i> as the transfer of pollen grains from the anther to the stigma</li> </ul> <ul style="list-style-type: none"> <li>State that fertilization occurs when a pollen nucleus fuses with a nucleus in an ovule</li> <li>Describe the structural adaptations of insect-pollinated and wind-pollinated flowers</li> <li>Investigate and state the environmental conditions that affect germination of seeds, limited to the requirement for water, oxygen and a suitable temperature</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define <i>self-pollination</i> as the transfer of pollen grains from the anther of a flower to the stigma of the same flower or different flower on the same plant</li> <li>Define <i>cross-pollination</i> as transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species</li> <li>Discuss the implications to a species of self-pollination and cross-pollination in terms of variation, capacity to respond to changes in the environment and reliance on pollinators</li> <li>Describe the growth of the pollen tube and its entry into the ovule followed by fertilization (details of production of endosperm and development are <b>not</b> required)</li> </ul>

## 16.4 Sexual reproduction in humans

**Core**

- Identify and name on diagrams of the male reproductive system: the testes, scrotum, sperm ducts, prostate gland, urethra and penis, and state the functions of these parts
- Identify and name on diagrams of the female reproductive system: the ovaries, oviducts, uterus, cervix and vagina, and state the functions of these parts
- Describe fertilization as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell/ovum)
- State the adaptive features of sperm, limited to flagellum and the presence of enzymes
- State the adaptive features of egg cells, limited to energy stores and a jelly coating that changes after fertilization
- State that in early development, the zygote forms an embryo which is a ball of cells that implants into the wall of the uterus
- State the functions of the umbilical cord, placenta, amniotic sac and amniotic fluid
- Outline the growth and development of the fetus in terms of increasing complexity in the early stages and increasing size towards the end of pregnancy
- Describe the ante-natal care of pregnant women, limited to special dietary needs and the harm from smoking and alcohol consumption
- Outline the processes involved in labor and birth, limited to:
  - breaking of the amniotic sac
  - contraction of the muscles in the uterus wall
  - dilation of the cervix
  - passage through the vagina
  - tying and cutting the umbilical cord
  - delivery of the afterbirth

**Supplement**

- Compare male and female gametes in terms of size, structure, motility and numbers
- Explain the adaptive features of sperm, limited to flagellum, mitochondria and enzymes in the acrosome
- Explain the adaptive features of egg cells, limited to energy stores and the jelly coat that changes at fertilization
- Describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products and providing a barrier to toxins and pathogens (structural details are **not** required)
- State that some toxins, e.g. nicotine, and pathogens, e.g. rubella virus, can pass across the placenta and affect the fetus
- Discuss the advantages and disadvantages of breast-feeding compared with bottle-feeding using formula milk

<p>16.5 Sex hormones in humans</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the roles of testosterone and estrogen in the development and regulation of secondary sexual characteristics during puberty</li> <li>Describe the menstrual cycle in terms of changes in the ovaries and in the lining of the uterus</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the sites of production of estrogen and progesterone in the menstrual cycle and in pregnancy</li> <li>Explain the role of hormones in controlling the menstrual cycle and pregnancy, limited to FSH, LH, progesterone and estrogen</li> </ul>
<p>16.6 Methods of birth control in humans</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Outline the following methods of birth control: <ul style="list-style-type: none"> <li>natural, limited to abstinence, monitoring body temperature and cervical mucus</li> <li>chemical, limited to IUD, IUS, contraceptive pill, implant and injection</li> <li>barrier, limited to condom, femidom, diaphragm</li> <li>surgical, limited to vasectomy and female sterilization</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Outline the use of hormones in contraception and fertility treatments</li> <li>Outline artificial insemination (AI)</li> <li>Outline <i>in vitro</i> fertilization (IVF)</li> <li>Discuss the social implications of contraception and fertility treatments</li> </ul>
<p>16.7 Sexually transmitted infections (STIs)</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>sexually transmitted infection</i> as an infection that is transmitted via body fluids through sexual contact</li> <li>State that human immunodeficiency virus (HIV) is an example of an STI</li> <li>Explain how the spread of STIs is controlled</li> <li>Describe the methods of transmission of HIV</li> <li>State that HIV infection may lead to AIDS</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Outline how HIV affects the immune system, limited to decreased lymphocyte numbers and reduced ability to produce antibodies</li> </ul>

17. Inheritance	
<p>17.1 Inheritance</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>inheritance</i> as the transmission of genetic information from generation to generation</li> </ul>	
<p>17.2 Chromosomes, genes and proteins</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>chromosome</i> as a thread-like structure of DNA, carrying genetic information in the form of genes</li> <li>Define <i>gene</i> as a length of DNA that codes for a protein</li> <li>Define <i>allele</i> as a version of a gene</li> <li>Describe the inheritance of sex in humans with reference to XX and XY chromosomes</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Explain that the sequence of bases in a gene is the genetic code for putting together amino acids in the correct order to make a specific protein (knowledge of the details of nucleotide structure is <b>not</b> required)</li> <li>Explain that DNA controls cell function by controlling the production of proteins (some of which are enzymes), antibodies and receptors for neurotransmitters</li> <li>Explain how a protein is made, limited to: <ul style="list-style-type: none"> <li>the gene coding for the protein remains in the nucleus</li> <li>mRNA molecules carry a copy of the gene to the cytoplasm</li> <li>the mRNA passes through ribosomes</li> <li>the ribosome assembles amino acids into protein molecules</li> <li>the specific order of amino acids is determined by the sequence of bases in the mRNA (knowledge of the details of transcription or translation is <b>not</b> required)</li> </ul> </li> <li>Explain that all body cells in an organism contain the same genes, but many genes in a particular cell are not expressed because the cell only makes the specific proteins it needs</li> </ul> <p style="text-align: right;"><i>cont.</i></p>

<p>17.2 Chromosomes, genes and proteins continued</p> <p><b>Core</b></p>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define a <i>haploid nucleus</i> as a nucleus containing a single set of unpaired chromosomes, e.g. in gametes</li> <li>Define a <i>diploid nucleus</i> as a nucleus containing two sets of chromosomes, e.g. in body cells</li> <li>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</li> </ul>
<p>17.3 Mitosis</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>mitosis</i> as nuclear division giving rise to genetically identical cells (details of stages are <b>not</b> required)</li> <li>State the role of mitosis in growth, repair of damaged tissues, replacement of cells and asexual reproduction</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State that the exact duplication of chromosomes occurs before mitosis</li> <li>State that during mitosis, the copies of chromosomes separate, maintaining the chromosome number (details of stages of mitosis are <b>not</b> required)</li> <li>Describe stem cells as unspecialized cells that divide by mitosis to produce daughter cells that can become specialized for specific functions</li> </ul>
<p>17.4 Meiosis</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>meiosis</i> as nuclear division giving rise to cells that are genetically different (details of stages are <b>not</b> required)</li> <li>State that meiosis is involved in the production of gametes</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define <i>meiosis</i> as reduction division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells (details of stages are <b>not</b> required)</li> <li>Explain how meiosis produces variation by forming new combinations of maternal and paternal chromosomes (specific details are <b>not</b> required)</li> </ul>

## 17.5 Monohybrid inheritance

**Core**

- Define *genotype* as the genetic make-up of an organism in terms of the alleles present
- Define *phenotype* as the observable features of an organism
- Define *homozygous* as having two identical alleles of a particular gene
- State that two identical homozygous individuals that breed together will be pure-breeding
- Define *heterozygous* as having two different alleles of a particular gene
- State that a heterozygous individual will not be pure-breeding
- Define *dominant* as an allele that is expressed if it is present
- Define *recessive* as an allele that is only expressed when there is no dominant allele of the gene present
- Interpret pedigree diagrams for the inheritance of a given characteristic
- Use genetic diagrams to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1:1 and 3:1 ratios
- Use Punnett squares in crosses which result in more than one genotype to work out and show the possible different genotypes

**Supplement**

- Explain how to use a test cross to identify an unknown genotype
- Explain co-dominance by reference to the inheritance of ABO blood groups – phenotypes being A, B, AB and O blood groups and alleles being  $I^A$ ,  $I^B$  and  $I^o$
- Define a *sex-linked characteristic* as a characteristic in which the gene responsible is located on a sex chromosome and that this makes it more common in one sex than in the other
- Describe color blindness as an example of sex linkage
- Use genetic diagrams to predict the results of monohybrid crosses involving co-dominance or sex linkage and calculate phenotypic ratios

## 18. Variation and selection

### 18.1 Variation

#### Core

- Define *variation* as differences between individuals of the same species
- Distinguish between phenotypic variation and genetic variation
- State that continuous variation results in a range of phenotypes between two extremes, e.g. height in humans
- State that discontinuous variation results in a limited number of phenotypes with no intermediates, e.g. tongue rolling
- Record and present the results of investigations into continuous and discontinuous variation
- Define *mutation* as genetic change
- State that mutation is the way in which new alleles are formed
- State that ionizing radiation and some chemicals increase the rate of mutation

#### Supplement

- State that phenotypic variation is caused by both genetic and environmental factors
- State that discontinuous variation is mostly caused by genes alone, e.g. A, B, AB and O blood groups in humans
- Define *gene mutation* as a change in the base sequence of DNA
- Describe the symptoms of sickle-cell anaemia
- Explain how a change in the base sequence of the gene for haemoglobin results in abnormal haemoglobin and sickle-shaped red blood cells
- Use genetic diagrams to show how sickle-cell anaemia is inherited
- State that people who are heterozygous ( $Hb^S Hb^A$ ) for the sickle-cell allele have a resistance to malaria
- Explain the distribution of the sickle-cell allele in human populations with reference to the distribution of malaria

(Teaching of human inherited conditions should be done with sensitivity at all times.)

<p>18.2 Adaptive features</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>adaptive feature</i> as an inherited feature that helps an organism to survive and reproduce in its environment</li> <li>Interpret images or other information about a species to describe its adaptive features</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define <i>adaptive feature</i> as the inherited functional features of an organism that increase its fitness</li> <li>Define <i>fitness</i> as the probability of an organism surviving and reproducing in the environment in which it is found</li> <li>Explain the adaptive features of hydrophytes and xerophytes to their environments</li> </ul>
<p>18.3 Selection</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe natural selection with reference to: <ul style="list-style-type: none"> <li>variation within populations</li> <li>production of many offspring</li> <li>competition for resources</li> <li>struggle for survival</li> <li>reproduction by individuals that are better adapted to the environment than others</li> <li>passing on of their alleles to the next generation</li> </ul> </li> <li>Describe selective breeding with reference to: <ul style="list-style-type: none"> <li>selection by humans of individuals with desirable features</li> <li>crossing these individuals to produce the next generation</li> <li>selection of offspring showing the desirable features</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe evolution as the change in adaptive features of a population over time as the result of natural selection</li> <li>Define the <i>process of adaptation</i> as the process, resulting from natural selection, by which populations become more suited to their environment over many generations</li> <li>Describe the development of strains of antibiotic resistant bacteria as an example of evolution by natural selection</li> <li>State the differences between natural and artificial selection</li> <li>Outline how selective breeding by artificial selection is carried out over many generations to improve crop plants and domesticated animals</li> </ul>

19. Organisms and their environment	
<p>19.1 Energy flow</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that the Sun is the principal source of energy input to biological systems</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the flow of energy through living organisms including light energy from the sun and chemical energy in organisms and its eventual transfer to the environment</li> </ul>
<p>19.2 Food chains and food webs</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define a <i>food chain</i> as showing the transfer of energy from one organism to the next, beginning with a producer</li> <li>State that energy is transferred between organisms in a food chain by ingestion</li> <li>Construct simple food chains</li> </ul> <ul style="list-style-type: none"> <li>Define a <i>food web</i> as a network of interconnected food chains</li> <li>Define <i>producer</i> as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis</li> <li>Define <i>consumer</i> as an organism that gets its energy by feeding on other organisms</li> <li>State that consumers may be classed as primary, secondary and tertiary according to their position in a food chain</li> </ul> <ul style="list-style-type: none"> <li>Define <i>herbivore</i> as an animal that gets its energy by eating plants</li> <li>Define <i>carnivore</i> as an animal that gets its energy by eating other animals</li> <li>Define <i>decomposer</i> as an organism that gets its energy from dead or waste organic material</li> <li>Interpret food chains and food webs in terms of identifying producers and consumers</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe how energy is transferred between trophic levels</li> <li>Define <i>trophic level</i> as the position of an organism in a food chain, food web, pyramid of numbers or pyramid of biomass</li> <li>Explain why the transfer of energy from one trophic level to another is inefficient</li> <li>Explain why food chains usually have fewer than five trophic levels</li> <li>Explain why there is a greater efficiency in supplying plants as human food, and that there is a relative inefficiency in feeding crop plants to livestock that will be used as food</li> </ul> <ul style="list-style-type: none"> <li>Identify producers, primary consumers, secondary consumers, tertiary consumers and quaternary consumers as the trophic levels in food webs, food chains, pyramids of numbers and pyramids of biomass</li> </ul> <p style="text-align: right;"><i>cont.</i></p>

<p>19.2 Food chains and food webs continued</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Use food chains and food webs to describe the impacts humans have through over-harvesting of food species and through introducing foreign species to a habitat</li> <li>• Draw, describe and interpret pyramids of numbers</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Draw, describe and interpret pyramids of biomass</li> <li>• Discuss the advantages of using a pyramid of biomass rather than a pyramid of numbers to represent a food chain</li> </ul>
<p>19.3 Nutrient cycles</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe the carbon cycle, limited to photosynthesis, respiration, feeding, decomposition, fossilization and combustion</li> <li>• Discuss the effects of the combustion of fossil fuels and the cutting down of forests on the carbon dioxide concentrations in the atmosphere</li> <li>• Describe the water cycle, limited to evaporation, transpiration, condensation and precipitation</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe the nitrogen cycle in terms of: <ul style="list-style-type: none"> <li>– decomposition of plant and animal protein to ammonium ions</li> <li>– nitrification</li> <li>– nitrogen fixation by lightning and bacteria</li> <li>– absorption of nitrate ions by plants</li> <li>– production of amino acids and proteins</li> <li>– feeding and digestion of proteins</li> <li>– deamination</li> <li>– denitrification</li> </ul> </li> <li>• State the roles of microorganisms in the nitrogen cycle, limited to decomposition, nitrification, nitrogen fixation and denitrification (generic names of individual bacteria, e.g. <i>Rhizobium</i>, are <b>not</b> required)</li> </ul>

<p>19.4 Population size</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>population</i> as a group of organisms of one species, living in the same area, at the same time</li> <li>Identify and state the factors affecting the rate of population growth for a population of an organism, limited to food supply, predation and disease</li> <li>Discuss the increase in human population size over the past 250 years and its social and environmental implications</li> <li>Interpret graphs and diagrams of human population growth</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Define <i>community</i> as all of the populations of different species in an ecosystem</li> <li>Define <i>ecosystem</i> as a unit containing the community of organisms and their environment, interacting together, e.g. a decomposing log, or a lake</li> <li>Identify the lag, exponential (log), stationary and death phases in the sigmoid population growth curve for a population growing in an environment with limited resources</li> <li>Explain the factors that lead to each phase in the sigmoid curve of population growth, making reference, where appropriate, to the role of limiting factors</li> </ul>
<p><b>20. Biotechnology and genetic engineering</b></p>	
<p>20.1 Biotechnology and genetic engineering</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that bacteria are useful in biotechnology and genetic engineering due to their rapid reproduction rate and their ability to make complex molecules</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Discuss why bacteria are useful in biotechnology and genetic engineering, limited to: <ul style="list-style-type: none"> <li>lack of ethical concerns over their manipulation and growth</li> <li>genetic code shared with all other organisms</li> <li>presence of plasmids</li> </ul> </li> </ul>

<p>20.2 Biotechnology</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the role of anaerobic respiration in yeast during production of ethanol for biofuels</li> <li>Describe the role of anaerobic respiration in yeast during bread-making</li> <li>Investigate and describe the use of pectinase in fruit juice production</li> <li>Investigate and describe the use of biological washing powders that contain enzymes</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Investigate and explain the use of lactase to produce lactose-free milk</li> <li>Describe the role of the fungus <i>Penicillium</i> in the production of the antibiotic penicillin</li> <li>Explain how fermenters are used in the production of penicillin</li> </ul>
<p>20.3 Genetic engineering</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define <i>genetic engineering</i> as changing the genetic material of an organism by removing, changing or inserting individual genes</li> <li>State examples of genetic engineering: <ul style="list-style-type: none"> <li>the insertion of human genes into bacteria to produce human insulin</li> <li>the insertion of genes into crop plants to confer resistance to herbicides</li> <li>the insertion of genes into crop plants to confer resistance to insect pests</li> <li>the insertion of genes into crop plants to provide additional vitamins</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Outline genetic engineering using bacterial production of a human protein as an example, limited to: <ul style="list-style-type: none"> <li>isolation of the DNA making up a human gene using restriction enzymes, forming sticky ends</li> <li>cutting of bacterial plasmid DNA with the same restriction enzymes, forming complementary sticky ends</li> <li>insertion of human DNA into bacterial plasmid DNA using DNA ligase to form a recombinant plasmid</li> <li>insertion of plasmid into bacteria (specific detail is <b>not</b> required)</li> <li>replication of bacteria containing recombinant plasmids which make human protein as they express the gene</li> </ul> </li> <li>Discuss the advantages and disadvantages of genetically modifying crops, such as soya, maize and rice</li> </ul>

21. Human influences on ecosystems	
<p>21.1 Food supply</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• State how modern technology has resulted in increased food production in terms of:               <ul style="list-style-type: none"> <li>– agricultural machinery to use larger areas of land and improve efficiency</li> <li>– chemical fertilizers to improve yields</li> <li>– insecticides to improve quality and yield</li> <li>– herbicides to reduce competition with weeds</li> <li>– selective breeding to improve production by crop plants and livestock, e.g. cattle, fish and poultry</li> </ul> </li> <li>• Describe the negative impacts to an ecosystem of large-scale monocultures of crop plants</li> <li>• Describe the negative impacts to an ecosystem of intensive livestock production</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Discuss the social, environmental and economic implications of providing sufficient food for an increasing human global population</li> <li>• Discuss the problems which contribute to famine including unequal distribution of food, drought and flooding, increasing population and poverty</li> </ul>
<p>21.2 Habitat destruction</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe the reasons for habitat destruction, limited to:               <ul style="list-style-type: none"> <li>– increased area for food crop growth, livestock production and housing</li> <li>– extraction of natural resources</li> <li>– marine pollution</li> </ul> </li> <li>• State that through altering food webs and food chains, humans can have a negative impact on habitats</li> <li>• List the undesirable effects of deforestation as an example of habitat destruction, to include extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Explain the undesirable effects of deforestation on the environment</li> </ul>

## 21.3 Pollution

**Core**

- State the sources and effects of pollution of land and water, e.g. rivers, lakes and the sea, by insecticides, herbicides and by nuclear fall-out
- State the sources and effects of pollution of water (rivers, lakes and the sea) by chemical waste, discarded rubbish, untreated sewage and fertilizers
- State the sources and effects of pollution of the air by methane and carbon dioxide, limited to the enhanced greenhouse effect and climate change

**Supplement**

- Explain the process of eutrophication of water in terms of:
  - increased availability of nitrate and other ions
  - increased growth of producers
  - increased decomposition after death of producers
  - increased aerobic respiration by decomposers
  - reduction in dissolved oxygen
  - death of organisms requiring dissolved oxygen in water
- Discuss the effects of nonbiodegradable plastics in the environment, in both aquatic and terrestrial ecosystems
- Discuss the causes and effects on the environment of acid rain
- State the measures that are taken to reduce sulfur dioxide pollution and reduce the impact of acid rain
- Explain how increases in carbon dioxide and methane concentrations in the atmosphere cause an enhanced greenhouse effect that leads to climate change
- Describe the negative impacts of female contraceptive hormones in water courses, limited to reduced sperm count in men and feminization of aquatic organisms

## 21.4 Conservation

**Core**

- Define a *sustainable resource* as one which is produced as rapidly as it is removed from the environment so that it does not run out
- Explain the need to conserve nonrenewable resources, limited to fossil fuels
- State that some resources can be maintained, limited to forests and fish stocks
- State that products can be reused or recycled, limited to paper, glass, plastic and metal
- Outline how sewage is treated to make the water that it contains safe to return to the environment or for human use
- Explain why organisms become endangered or extinct, limited to climate change, habitat destruction, hunting, pollution and introduced species
- Describe how endangered species can be conserved, limited to monitoring and protecting species and habitats, education, captive breeding programs and seed banks

**Supplement**

- Define the term *sustainable development* as development providing for the needs of an increasing human population without harming the environment
- Explain how forests and fish stocks can be sustained using education, legal quotas and restocking
- Explain that sustainable development requires:
  - management of conflicting demands
  - planning and co-operation at local, national and international levels
- Explain the risks to a species if the population size drops, reducing variation (knowledge of genetic drift is **not** required)
- Explain reasons for conservation programs, to include:
  - reducing extinction
  - protecting vulnerable environments
  - maintaining ecosystem functions, limited to nutrient cycling and resource provision, e.g. food, drugs, fuel and genes

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## 7. Practical Assessment

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Scientific subjects are, by their nature, experimental. It is therefore important that an assessment of a candidate's knowledge and understanding of biology should contain a practical component (see assessment objective AO3).

Schools' circumstances (e.g. the availability of resources) differ greatly, so two alternative ways of examining the practical component are provided. The alternatives are:

- Paper 5—Practical Test
- Paper 7—Coursework (internal assessment).

Whichever practical assessment route is chosen, the following points should be noted:

- the same assessment objectives apply
- the same practical skills are to be learned and developed
- the same sequence of practical activities is appropriate.

Candidates may not use textbooks in the practical component, nor any of their own records of laboratory work carried out during their course.

### 7.1 Teaching Experimental Skills

The best preparation for these papers is for candidates to pursue a course in which practical work is fully integrated so that it is a normal and natural part of the teaching.

Teachers are expected to identify suitable opportunities to embed practical techniques and investigative work throughout the course, rather than as an isolated aspect of preparation for examination. This approach will not only provide opportunities for developing experimental skills but will increase the appeal of the course, and the enjoyment of the subject. Practical work helps students to acquire a secure understanding of the syllabus topics and to appreciate how scientific theories are developed and tested. It also promotes important scientific attitudes such as objectivity, integrity, co-operation, enquiry and inventiveness.

### 7.2 Paper 5: Practical Test

This paper is based on testing experimental skills. The questions do not assess specific syllabus content from Section 6: Curriculum Content. Any information required to answer these questions is contained within the question paper or from the experimental context and skills listed below.

Questions are structured to assess across the grade range A\*—G.

#### Experimental Skills Tested in Paper 5: Practical Test

Candidates may be asked questions on the following experimental contexts:

- the recall of familiar, and unfamiliar, techniques to record observations and make deductions from them
- recall of simple chemical tests, e.g. for food substances and the use of hydrogencarbonate indicator, litmus and Universal Indicator paper
- recognize, observe, record and measure images of familiar, and unfamiliar, biological specimens
- making a clear line drawing from an image of a specimen, calculating the magnification and adding labels as required.

Questions may be set requiring candidates to:

- carefully follow a sequence of instructions
- record readings from diagrams of apparatus, including
  - reading a scale with appropriate accuracy and precision
  - interpolating between scale divisions
  - taking repeated measurements, where appropriate, to obtain an average value
- describe, explain or comment on experimental arrangements and techniques
- interpret and evaluate observations and experimental data
- complete tables of data, and process data, using a calculator where necessary
- perform simple arithmetical calculations
- plot graphs and/or interpret graphical information
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- identify sources of error and suggest possible improvements in procedures
- plan an experiment or investigation, including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

### Apparatus List

The list below details the apparatus expected to be generally available for both teaching and for examination of Paper 5. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a biology laboratory (such as Bunsen burners, ring stands, hot water-baths, etc.) are not included. The Confidential Instructions, provided to Centres prior to the examination of Paper 5, will give the detailed requirements for the examination.

- rulers capable of measuring to 1 mm
- mounted needles or seekers or long pins with large heads
- means of cutting biological materials such as scalpels, solid edged razor blades or knives
- scissors
- forceps
- means of writing on glassware
- beakers, 100 cm<sup>3</sup>, 250 cm<sup>3</sup>
- test-tubes, 125 mm × 15 mm and 150 mm × 25 mm including some hard glass test-tubes and a means of holding them (e.g. rack)
- means of measuring small and larger volumes of liquids such as syringes and graduated cylinders
- dropper
- white tile
- spotting tile
- hand lens ×6 magnification
- a thermometer, –10 °C to +110 °C at 1 °C graduations
- clock (or wall clock or wrist-watch), to measure to an accuracy of 1 s
- funnels
- Petri dishes
- syringes
- glass rods
- chemicals (e.g. for food tests, limewater)
- indicators (litmus paper, Universal Indicator paper, hydrogencarbonate indicator).

## 7.3 Paper 7: Coursework

The AO3 experimental skills and investigations are assessed as coursework (C) skills.

They are:

- C1 Using and organizing techniques, apparatus, and materials
- C2 Observing, measuring, and recording
- C3 Handling experimental observations and data
- C4 Planning and evaluating investigations

The four coursework (C) skills carry equal weighting.

All assessments must be based on experimental work carried out by the candidates.

It is expected that the teaching and assessment of experimental skills and investigations will take place throughout the course.

Teachers must ensure that they can make available to Cambridge evidence of **two** assessments of each coursework (C) skill for each candidate. For coursework (C) skills C1 to C4 inclusive, information about the tasks set and how the marks were awarded will be required. In addition, for coursework (C) skills C2, C3, and C4, the candidate's written work will also be required.

The assessment scores finally recorded for each coursework (C) skill must represent the candidate's best performances.

For candidates who miss the assessment of a given coursework (C) skill through no fault of their own, for example, because of illness, and who cannot be assessed on another occasion, Cambridge procedure for special consideration should be followed. However, candidates who for no good reason absent themselves from an assessment of a given coursework (C) skill should be given a mark of zero for that assessment.

### Criteria for Assessing Experimental Skills and Investigations

Each coursework (C) skill must be assessed on a six-point scale, level 6 being the highest level of achievement. Each of the coursework (C) skills is defined in terms of three levels of achievement at scores of 2, 4, and 6.

A score of 0 is available if there is no evidence of positive achievement for a coursework (C) skill.

For candidates who do not meet the criteria for a score of 2, a score of 1 is available if there is some evidence of positive achievement.

A score of 3 is available for candidates who go beyond the level defined by 2, but who do not meet fully the criteria for 4.

Similarly, a score of 5 is available for those who go beyond the level defined for 4, but do not meet fully the criteria for 6.

Score	Skill C1: Using and Organizing Techniques, Apparatus, and Materials
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Follows written, diagrammatic, or oral instructions to perform a single practical operation. Uses familiar apparatus and materials adequately, needing reminders on points of safety.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Follows written, diagrammatic, or oral instructions to perform an experiment involving a series of step-by-step practical operations. Uses familiar apparatus, materials, and techniques adequately and safely.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Follows written, diagrammatic, or oral instructions to perform an experiment involving a series of practical operations where there may be a need to modify or adjust one step in the light of the effect of a previous step. Uses familiar apparatus, materials, and techniques safely, correctly, and methodically.
Score	Skill C2: Observing, Measuring, and Recording
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Makes observations or readings given detailed instructions. Records results in an appropriate manner given a detailed format.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Makes relevant observations, measurements, or estimates given an outline format or brief guidelines. Records results in an appropriate manner given an outline format.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Makes relevant observations, measurements, or estimates to a degree of accuracy appropriate to the instruments or techniques used. Records results in an appropriate manner given no format.

Score	Skill C3: Handling Experimental Observations and Data
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Processes results in an appropriate manner given a detailed format. Draws an obvious qualitative conclusion from the results of an experiment.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Processes results in an appropriate manner given an outline format. Recognizes and comments on anomalous results. Draws qualitative conclusions that are consistent with obtained results and deduces patterns in data.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Processes results in an appropriate manner given no format. Deals appropriately with anomalous or inconsistent results. Recognizes and comments on possible sources of experimental error. Expresses conclusions as generalizations or patterns where appropriate.
Score	Skill C4: Planning and Evaluating Investigations
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Suggests a simple experimental strategy to investigate a given practical problem. Attempts "trial and error" modification in the light of the experimental work carried out.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Specifies a sequence of activities to investigate a given practical problem. In a situation where there are two variables, recognizes the need to keep one of them constant while the other is being changed. Comments critically on the original plan, and implements appropriate changes in the light of the experimental work carried out.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Analyzes a practical problem systematically and produces a logical plan for an investigation. In a given situation, recognizes there are a number of variables and attempts to control them. Evaluates chosen procedures, suggests/implements modifications where appropriate, and shows a systematic approach in dealing with unexpected results.

## Guidance on Candidate Assessment

The following notes are intended to provide teachers with information to help them make valid and reliable assessments of the coursework (C) skills and investigations of their candidates.

- The assessments should be based on the principle of positive achievement: candidates should be given opportunities to demonstrate what they understand and can do.
- It is expected that candidates will have had opportunities to acquire a given skill before assessment takes place.
- It is not expected that all of the practical work undertaken by a candidate will be assessed.
- Assessments can be carried out at any time during the course. However, at whatever stage assessments are done, the standards applied must be those expected at the end of the course, as exemplified in the criteria for the skills.
- Assessments should normally be made by the person responsible for teaching the candidates.
- A given practical task is unlikely to provide opportunities for all aspects of the criteria at a given level for a particular skill to be satisfied; for example, there may not be any anomalous results (Skill C3). However, by using a range of practical work, teachers should ensure that opportunities are provided for all aspects of the criteria to be satisfied during the course.
- Extended experimental investigations are of great educational value. If such investigations are used for assessment purposes, teachers should make sure that the candidates have ample opportunity for displaying the skills and abilities required by the scheme of assessment.
- It is not necessary for all candidates within a teaching group, or within a Center, to be assessed on exactly the same practical work, although teachers can use work that is undertaken by all of their candidates.
- When assessing group work, teachers must ensure that each candidate's individual contribution is assessed.
- Skill C1 may not generate a written product from the candidates; it will often be assessed by watching the candidates carrying out practical work.
- Skills C2, C3, and C4 will usually generate a written product from the candidates; this will provide evidence for moderation.
- Raw scores for coursework must be recorded on the Individual Candidate Record Card produced by Cambridge. These forms, and the instructions for completing them, may be downloaded from [www.cie.org.uk/samples](http://www.cie.org.uk/samples). The database will ask you for the syllabus code (i.e. 0438) and your Center number, after which it will take you to the correct forms. Follow the instructions when completing each form.
- Raw scores for individual practical assessments may be given to candidates as part of the normal feedback from the teacher. The final, internally moderated, total score should **not** be given to the candidate.

## Moderation

### Internal Moderation

When several teachers in a Center are involved in internal assessment, arrangements must be made within the Center for all candidates to be assessed to the same standard. It is essential that the marks for each coursework (C) skill assigned within different teaching groups (or classes) are moderated internally for the whole Center entry. The Center assessments will then be moderated externally by Cambridge.

The internally moderated marks for all candidates must be recorded on the Coursework Assessment Summary Form. This form, and the instructions for completing it, may be downloaded from [www.cie.org.uk/samples](http://www.cie.org.uk/samples). The database will ask you for the syllabus code (i.e. 0438) and your Center number, after which it will take you to the correct form. Follow the instructions when completing the form.

### External Moderation

External moderation of internal assessment is carried out by Cambridge. Centers must submit candidates' internally assessed marks to Cambridge. The deadlines and methods for submitting internally assessed marks are in the *Cambridge Administrative Guide* available on our website.

Once it has received the marks, Cambridge will draw up a list of sample candidates whose work will be moderated (a further sample may also be requested) and will ask the Center to immediately send every piece of work which has contributed toward these candidates' final marks. Individual Candidate Record Cards and Coursework Assessment Summary Forms must also be sent with the coursework. All remaining coursework and records should be kept by the Center until results are published.

Ideally, Centers should use loose-leaf letter-size filler paper for practical written work, as this is cheaper to send by mail. Original work is preferred for moderation, but authenticated photocopies can be sent if absolutely necessary.

Pieces of work for each coursework (C) skill should **not** be stapled together. Each piece of work should be clearly and securely labeled with:

- the skill being assessed
- the Center number
- the candidate's name and number
- the title of the experiment
- a copy of the mark scheme used
- the mark awarded.

## 8. Appendix

### 8.1 Safety in the Laboratory

Responsibility for safety matters rests with Centres. Further information can be found from the following UK association, publications and regulations.

#### Associations

CLEAPSS is an advisory service providing support in practical science and technology.

**<http://www.cleapss.org.uk>**

#### Publications

*CLEAPSS Laboratory Handbook*, updated 2009 (available to CLEAPSS members only)

*CLEAPSS Hazcards*, 2007 update of 1995 edition (available to CLEAPSS members only)

### 8.2 Glossary of Terms Used in Science Papers

This glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, but it is neither exhaustive nor definitive. The glossary has been deliberately kept brief, not only with respect to the number of terms included, but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend, in part, on its context.

1. *Define* (the term(s)...) is intended literally, only a formal statement or equivalent paraphrase being required.
2. *What do you understand by/What is meant by* (the term(s)...) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *State* implies a concise answer with little or no supporting argument (e.g. a numerical answer that can readily be obtained 'by inspection').
4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified this should not be exceeded.
5. (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons. The candidate needs to leave the examiner in no doubt why something happens.  
(b) *Give a reason/Give reasons* is another way of asking candidates to explain why something happens.
6. *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points. *Describe* and *explain* may be coupled, as may *state* and *explain*.
7. *Discuss* requires the candidate to give a critical account of the points involved.
8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).
9. *Predict* implies that the candidate is expected to make a prediction not by recall but by making a logical connection between other pieces of information.
10. *Deduce* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information.

11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in biology there are a variety of factors that might limit the rate of photosynthesis of a plant in a greenhouse), or to imply that candidates are expected to apply their general knowledge of the subject to a 'novel' situation, one that may be formally 'not in the syllabus' – many data response and problem solving questions are of this type.
12. *Find* is a general term that may variously be interpreted as *calculate*, *measure*, *determine*, etc.
13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length using a rule, or mass using a balance).
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained from a graph or by calculation.
16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept).  
In diagrams, *sketch* implies that simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

### 8.3 Mathematical Requirements

Calculators may be used in all parts of the examination.

Candidates should be able to:

- add, subtract, multiply and divide
- use averages, decimals, fractions, percentages, ratios and reciprocals
- use standard notation, including both positive and negative indices
- understand significant figures and use them appropriately
- recognize and use direct and inverse proportion
- use positive, whole number indices in algebraic expressions
- draw charts and graphs from given data
- interpret charts and graphs
- determine the slope and intercept of a graph
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recall and use equations for the areas of a rectangle, triangle and circle and the volumes of a rectangular block and a cylinder
- use mathematical instruments (ruler, compasses, protractor and set square)
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and diagonal
- solve equations of the form  $x = y + z$  and  $x = yz$  for any one term when the other two are known.

## 8.4 Presentation of Data

The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts, e.g. time/s for time in seconds.

### (a) Tables

- Each column of a table should be headed with the physical quantity and the appropriate unit, e.g. time/s.
- The column headings of the table can then be directly transferred to the axes of a constructed graph.

### (b) Graphs

- 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).
- Each axis should be labeled with the physical quantity and the appropriate unit, e.g. time/s.
- 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.
- The graph is the whole diagrammatic presentation, including the best-fit line when appropriate. It may have one or more sets of data plotted on it.
- Points on the graph should be clearly marked as crosses (x) or encircled dots (⊙).
- Large 'dots' are penalized. Each data point should be plotted to an accuracy of better than one half of each of the smallest squares on the grid.
- A best-fit line (trend line) should be a single, thin, smooth straight line or curve. 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.

### (c) Numerical results

- Data should be recorded so as to reflect the precision of the measuring instrument.
- The number of significant figures given for calculated quantities should be appropriate to the least number of significant figures in the raw data used.

### (d) Pie charts

- These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie charts should preferably contain no more than six sectors.

### (e) Bar charts

- These should be drawn when one of the variables is not numerical. They should be made up of narrow blocks of equal width that do **not** touch.

### (f) Histograms

- These should be drawn when plotting frequency graphs with continuous data. The blocks should be drawn in order of increasing or decreasing magnitude and they **should** touch.

## 8.5 ICT Opportunities

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This syllabus provides candidates with a wide range of opportunities to use ICT in their study of biology.

Opportunities for ICT include:

- gathering information from the internet, DVDs and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualize scientific ideas
- using software to present ideas and information on paper and on screen.

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## 9. Other Information

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### Equality and Inclusion

Cambridge International Examinations has taken great care in the preparation of this syllabus and assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), Cambridge has designed this qualification with the goal of avoiding direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. Arrangements can be put in place for these candidates to enable them to access the assessments and receive recognition of their attainment. Access arrangements will not be agreed to if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is found in the *Cambridge Handbook*, which can be downloaded from the website [www.cie.org.uk/examsOfficers](http://www.cie.org.uk/examsOfficers)

### Language

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

### Grading and Reporting

Cambridge IGCSE results are shown by one of the grades A\*, A, B, C, D, E, F, or G indicating the standard achieved, A\* being the highest and G the lowest. "Ungraded" indicates that the candidate's performance fell short of the standard required for grade G. "Ungraded" will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no results), and Y (to be issued) may also appear on the statement of results but not on the certificate.

### Entry Codes

To maintain the security of our examinations, we produce question papers for different areas of the world, known as "administrative zones." Where the component entry code has two digits, the first digit is the component number given in the syllabus. The second digit is the location code, specific to an administrative zone. Information about entry codes can be found in the *Cambridge Guide to Making Entries*.

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