CAMBRIDGE
International Examinations

Cambridge
O Level

SYLLABUS

Cambridge O Level
Biology
5090

For examination in June and November 2017, 2018 and 2019

Cambridge Secondary 2

Version 1

Changes to syllabus for 2017, 2018 and 2019

This syllabus has been updated, but there are no significant changes.

You are advised to read the whole syllabus before planning your teaching programme.

Contents

1. Introduction

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 recognised by the world's best universities and employers, giving students a wide range of options in their education and career. As a not-for-profit organisation, we devote our resources to delivering high-quality educational programmes that can unlock learners' potential.

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

Cambridge learners

Cambridge programmes and qualifications develop not only subject knowledge but also skills. We encourage Cambridge learners 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 learners, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

Recognition

Cambridge O Level is internationally recognised by schools, universities and employers as equivalent in demand to Cambridge IGCSE® (International General Certificate of Secondary Education). There are over 700 000 entries a year in nearly 70 countries. Learn more at **www.cie.org.uk/recognition**

Support for teachers

A wide range of materials and resources is available to support teachers and learners 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**

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**

Our systems for managing the provision of international qualifications and education programmes for learners aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at **www.cie.org.uk/ISO9001**

1.2 Why choose Cambridge O Level?

Cambridge O Levels have been designed for an international audience and are sensitive to the needs of different countries. These qualifications are designed for learners whose first language may not be English and this is acknowledged throughout the examination process. The Cambridge O Level syllabus also allows teaching to be placed in a localised context, making it relevant in varying regions.

Our aim is to balance knowledge, understanding and skills in our programmes 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 O Levels, we provide the tools to enable teachers to prepare learners to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge O Levels 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 programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge O Levels at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge O Level syllabuses are designed on the assumption that learners 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 learners' prior experience of the subject.

1.3 Why choose Cambridge O Level Biology?

Cambridge O Levels are established qualifications that keep pace with educational developments and trends. The Cambridge O Level curriculum places emphasis on broad and balanced study across a wide range of subject areas. The curriculum is structured so that students attain both practical skills and theoretical knowledge.

Cambridge O Level Biology is recognised by universities and employers throughout the world as proof of knowledge and understanding. Successful Cambridge O Level Biology candidates gain lifelong skills, including:

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

Candidates may also study for a Cambridge O Level in a number of other science subjects including physics and chemistry. In addition to Cambridge O Levels, Cambridge also offers Cambridge IGCSE and

Cambridge International AS and A Levels for further study in biology as well as other science subjects. See **www.cie.org.uk** for a full list of the qualifications available.

Prior learning

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

Progression

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

Candidates who are awarded grades C to A* in Cambridge O Level Biology are well prepared to follow courses leading to Cambridge International AS and A Level Biology, or the equivalent.

1.4 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**

If you are not yet a Cambridge school

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**. Email us at **info@cie.org.uk** to find out how your organisation can register to become a Cambridge school.

2. Teacher support

2.1 Support materials

We send Cambridge syllabuses, 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/olevel** to download current and future syllabuses 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 syllabuses is available online from Teacher Support, our secure online support for Cambridge teachers. Go to **http://teachers.cie.org.uk** (username and password required).

2.2 Endorsed resources

We work with publishers providing a range of resources for our syllabuses 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 which can be filtered to show all resources, or just those which 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** for further information.

3. Assessment at a glance

For the Cambridge O Level in biology, candidates take **three** components: Paper 1 **and** Paper 2 and either Paper 3 **or** Paper 6.

Paper 1: Multiple Choice	**1 hour**
40 compulsory multiple choice questions. The questions involve four response options. 40 marks	

Paper 2: Theory	**1 hour 45 minutes**
This paper has three sections. Section A carries 50 marks and consists of a small number of compulsory, structured questions. Section B carries 20 marks and consists of two compulsory questions. Each question is worth 10 marks. Section C carries 10 marks and candidates must choose **one** from a choice of two questions. 80 marks	

Paper 3: Practical Test	**1 hour 15 minutes**	**Paper 6: Alternative to Practical**	**1 hour**
This paper consists of two or three compulsory, practical questions. 40 marks		A written paper of questions designed to test past experience of practical work. 40 marks	

Availability

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

This syllabus is available to private candidates. However, it is expected that private candidates learn in an environment where practical work is an integral part of the course. Candidates will not be able to perform well in this assessment or progress successfully to further study without this necessary and important aspect of science education.

Detailed timetables are available from **www.cie.org.uk/examsofficers**

Cambridge O Levels are available to Centres in Administrative Zones 3, 4 and 5. Centres in Administrative Zones 1, 2 or 6 wishing to enter candidates for Cambridge O Level examinations should contact Cambridge Customer Services.

Combining this with other syllabuses

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

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

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

4. Syllabus aims and assessment objectives

4.1 Syllabus aims

The aims provide the educational purposes of following a course in this subject. Some of these aims are reflected in the assessment objectives; others are not because they cannot readily be translated into objectives that can be assessed. The aims are not listed in any order of priority.

The aims are to:

1. provide, through well designed studies of experimental and practical biological science, a worthwhile educational experience for all students, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to
   - 1.1 become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific import
   - 1.2 recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life
   - 1.3 be suitably prepared and stimulated for studies beyond Cambridge O Level in pure sciences, in applied sciences or in science-dependent vocational courses.
2. develop abilities and skills that
   - 2.1 are relevant to the study and practice of science
   - 2.2 are useful in everyday life
   - 2.3 encourage efficient and safe practice
   - 2.4 encourage effective communication.
3. develop attitudes relevant to science such as
   - 3.1 concern for accuracy and precision
   - 3.2 objectivity
   - 3.3 integrity
   - 3.4 enquiry
   - 3.5 initiative
   - 3.6 inventiveness.
4. stimulate interest in and care for the local and global environment.
5. promote an awareness that
   - 5.1 the study and practice of science are co-operative and cumulative activities that are subject to social, economic, technological, ethical and cultural influences and limitations
   - 5.2 the applications of science may be both beneficial and detrimental to the individual, the community and the environment
   - 5.3 science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal.

4.2 Assessment objectives

The assessment objectives describe the knowledge, skills and abilities that candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims that are assessed.

AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, 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 quantities and their determination
5. scientific and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these objectives will often begin with one of the following words: *define, state, name, describe, explain (using your knowledge and understanding)* or *outline* (see the glossary of terms in section 7.1).

AO2 Handling information and solving problems

Candidates should be able – using oral, written, symbolic, graphical and numerical forms of presentation – to:

1. locate, select, organise 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 propose hypotheses
7. solve problems.

These assessment objectives cannot be precisely specified in the syllabus content because questions testing such skills may be based on information that is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *discuss, predict, suggest, calculate, explain (give reasoned explanations and explain the processes of using information and solving problems)* or *determine* (see the glossary of terms in section 7.1).

AO3 Experimental skills and investigations

Candidates should be able to:

1. follow a sequence of instructions
2. use techniques, apparatus, measuring devices and materials effectively and safely
3. make and record observations, measurements, calculations and estimates with due regard to precision, accuracy and units
4. interpret, evaluate and report upon observations and experimental data
5. identify problems, design/plan and carry out investigations, including the selection of techniques, apparatus, measuring devices and materials
6. evaluate methods and suggest possible improvements.

4.3 Weighting of assessment objectives

Theory papers (Papers 1 and 2)

AO1 Knowledge with understanding, approximately 55% of the marks for each paper

AO2 Handling information and solving problems, approximately 45% of the marks for each paper

Practical assessment (Papers 3 and 6)

This is designed to test appropriate skills in assessment objective AO3 and carries 25% of the marks for the qualification.

4.4 Nomenclature, units and significant figures

Nomenclature

The proposals in 'Signs, Symbols and Systematics (The Association for Science Education Companion to 16–19 Science, 2000)' and the recommendations on terms, units and symbols in 'Biological Nomenclature (2009)' published by the Institute of Biology, in conjunction with the ASE, will generally be adopted.

To avoid difficulties arising out of the use of *l* as the symbol for litre, use of dm^3 in place of *l* or litre will be made.

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.

Units, significant figures

In practical work, candidates will be expected to use SI units or, where appropriate, units approved by the BIPM for use with the SI (e.g. minute). A list of SI units and units approved for use with the SI may be found in the SI brochure at **http://www.bipm.org**. The use of imperial/customary units such as the inch and degree Fahrenheit is not acceptable and should be discouraged. In all examinations, where data is supplied for use in questions, candidates will be expected to use the units supplied, and should not attempt conversion to other systems of units unless this is a requirement of the question.

Candidates should be aware that misuse of units and/or significant figures, e.g. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.

5. Syllabus content

It is expected that any course in biology will be based on experimental work. Teachers are encouraged to develop appropriate practical work for candidates to facilitate a greater understanding of the subject. Candidates should be aware of the hazards and appropriate safety precautions to follow when handling equipment and reagents in experimental work.

1. Cell structure and organisation

Content

1.1 Plant and animal cells

1.2 Specialised cells, tissues and organs

Learning outcomes

Candidates should be able to:

(a) examine under the microscope an animal cell (e.g. from fresh liver) and a plant cell (e.g. from *Elodea,* a moss, onion epidermis, or any suitable, locally available material), using an appropriate temporary staining technique, such as iodine or methylene blue

(b) draw diagrams to represent observations of the plant and animal cells examined above

(c) identify, from fresh preparations or on diagrams or photomicrographs, the cell membrane, nucleus and cytoplasm in an animal cell

(d) identify, from diagrams or photomicrographs, the cellulose cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts in a plant cell

(e) compare the visible differences in structure of the animal and the plant cells examined

(f) state the function of the cell membrane in controlling the passage of substances into and out of the cell

(g) state the function of the cell wall in maintaining turgor (turgidity) within the cell

(h) state, in simple terms, the relationship between cell function and cell structure for the following:

- absorption – root hair cells
- conduction and support – xylem vessels
- transport of oxygen – red blood cells

(i) identify these cells from preserved material under the microscope, from diagrams and from photomicrographs

(j) differentiate *cell, tissue, organ* and *organ system* as illustrated by examples covered in sections 1 to 12, 15 and 16.

2. Diffusion and osmosis

Content

2.1 Diffusion

2.2 Osmosis

2.3 Active transport

Learning outcomes

Candidates should be able to:

(a) define *diffusion as* the movement of molecules from a region of their higher concentration to a region of their lower concentration, down a concentration gradient

(b) define *osmosis* as the passage of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane

(c) describe the importance of a water potential gradient in the uptake of water by plants and the effects of osmosis on plant and animal tissues

(d) define *active transport* as the movement of ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration against a concentration gradient, using energy released during respiration

(e) discuss the importance of active transport as an energy-consuming process by which substances are transported against a concentration gradient, as in ion uptake by root hairs and glucose uptake by cells in the villi.

3. Enzymes

Content

3.1 Enzyme action

3.2 Effects of temperature and pH

Learning outcomes

Candidates should be able to:

(a) define *catalyst* as a substance that speeds up a chemical reaction and is not changed by the reaction

(b) define *enzymes* as proteins that function as biological catalysts

(c) explain enzyme action in terms of the 'lock and key' hypothesis

(d) investigate and describe the effects of temperature and of pH on enzyme activity.

4. Plant nutrition

Content

4.1 Photosynthesis

4.2 Leaf structure

4.3 Mineral nutrition

Learning outcomes

Candidates should be able to:

(a) understand that photosynthesis is the fundamental process by which plants manufacture carbohydrates from raw materials

(b) investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls

(c) state the equation (in words or symbols) for photosynthesis

(d) investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)

(e) understand the concept of limiting factors in photosynthesis

(f) describe the intake of carbon dioxide and water by plants

(g) understand that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage

(h) explain why most forms of life are completely dependent on photosynthesis

(i) identify and label the cuticle, cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope, and describe the significance of these features in terms of function, i.e.

- distribution of chloroplasts – photosynthesis
- stomata and mesophyll cells – gas exchange
- vascular bundles – transport

(j) understand the effect of a lack of nitrate and magnesium ions on plant growth.

5. Animal nutrition

Content

5.1 Nutrients
5.2 Diet
5.3 World food supplies
5.4 Human alimentary canal
5.5 Chemical digestion
5.6 Absorption and assimilation

Learning outcomes

Candidates should be able to:

(a) list the chemical elements that make up:
- carbohydrates
- fats
- proteins

(b) describe tests for:
- starch (iodine in potassium iodide solution)
- reducing sugars (Benedict's solution)
- protein (biuret test)
- fats (ethanol emulsion test)

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

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

(e) understand the concept of a balanced diet

(f) explain why diet, especially energy intake, should be related to age, sex and activity of an individual

(g) state the effects of malnutrition in relation to starvation, heart disease, constipation and obesity

(h) discuss the problems that contribute to famine (unequal distribution of food, drought and flooding, increasing population)

(i) identify the main regions of the alimentary canal and the associated organs: mouth (buccal) cavity, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum and anus

(j) describe the main functions of these parts in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate

(k) identify the different types of human teeth and describe their structure and functions

(l) state the causes of dental decay and describe the proper care of teeth

(m) describe peristalsis

(n) explain why most foods must be digested

(o) describe:
- digestion in the alimentary canal
- the functions of a typical amylase, protease and lipase, listing the substrates and end-products

(p) describe the structure of a villus, including the roles of capillaries and lacteals

(q) describe the significance of villi in increasing the internal surface area

(r) state the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestine

(s) state:

- that large molecules are synthesised from smaller basic units:

  glycogen from glucose

  proteins from amino acids

  lipids (fats and oils) from glycerol and fatty acids
- the role of the liver in the metabolism of glucose and amino acids
- the role of fat as a storage substance
- that the formation of urea and the breakdown of alcohol occur in the liver.

6. Transport in flowering plants

Content

6.1 Water and ion uptake

6.2 Transpiration and translocation

Learning outcomes

Candidates should be able to:

(a) relate the structure and functions of root hairs to their surface area and to water and ion uptake

(b) state that transpiration is the evaporation of water at the surfaces of the mesophyll cells followed by the loss of water vapour from the leaves through the stomata

(c) describe:

- how water vapour loss is related to cell surfaces, air spaces and stomata
- the effects of air currents (wind), and the variation of temperature, humidity and light intensity on transpiration rate
- how wilting occurs

(d) investigate, using a suitable stain, the pathway of water in a cut stem

(e) explain the movement of water through the stem in terms of transpiration pull

(f) identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves

(g) state the functions of xylem and phloem.

7. Transport in humans

Content

7.1 Circulatory system

Learning outcomes

Candidates should be able to:

(a) describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood

(b) describe the double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits

(c) name the main blood vessels that carry blood to and from the heart, lungs, liver and kidneys

(d) describe the structure and function of the heart in terms of muscular contraction and the working of valves

(e) compare the structure and function of arteries, veins and capillaries

(f) investigate and state the effect of physical activity on pulse rate

(g) describe coronary heart disease in terms of the occlusion of coronary arteries and state the possible causes (diet, stress and smoking) and preventive measures

(h) identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs

(i) list the components of blood as red blood cells, white blood cells, platelets and plasma

(j) state the functions of blood:

- red blood cells – haemoglobin and oxygen transport
- white blood cells – phagocytosis, antibody formation and tissue rejection
- platelets – fibrinogen to fibrin, causing clotting
- plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins and plasma proteins

(k) describe the transfer of materials between capillaries and tissue fluid.

8. Respiration

Content

8.1 Aerobic respiration

8.2 Anaerobic respiration

8.3 Human gas exchange

Learning outcomes

Candidates should be able to:

(a) define *respiration* as the release of energy from food substances in all living cells

(b) define *aerobic respiration* as the release of a relatively large amount of energy by the breakdown of food substances in the presence of oxygen

(c) state the equation (in words or symbols) for aerobic respiration

(d) state the uses of energy in the human body: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature

(e) define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen

(f) state the equation (in words or symbols) for anaerobic respiration in humans and in yeast

(g) describe the effect of lactic acid production in muscles during exercise

(h) know the percentages of the gases in atmospheric air and investigate and state the differences between inspired and expired air

(i) investigate and state the effect of physical activity on rate and depth of breathing

(j) identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries

(k) state the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange

(l) describe the role of cilia, diaphragm, ribs and intercostal muscles (external and internal) in breathing.

9. Excretion

Content

9.1 Structure and function of kidneys

9.2 Kidney dialysis

Learning outcomes

Candidates should be able to:

(a) define *excretion* as the removal of toxic materials and the waste products of metabolism from organisms

(b) describe the removal of carbon dioxide from the lungs

(c) identify on diagrams and name the kidneys, ureters, bladder, urethra and state the function of each (the function of the kidney should be described simply as removing urea and excess salts and water from the blood; details of kidney structure and nephron are **not** required)

(d) describe dialysis in kidney machines as the diffusion of waste products and salts (small molecules) through a membrane; large molecules (e.g. protein) remain in the blood.

10. Homeostasis

Content

10.1 Structure and function of the skin

Learning outcomes

Candidates should be able to:

(a) define *homeostasis* as the maintenance of a constant internal environment

(b) explain the concept of control by negative feedback

(c) identify, on a diagram of the skin, hairs, sweat glands, temperature receptors, blood vessels and fatty tissue

(d) describe the maintenance of a constant body temperature in humans in terms of insulation and the role of temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the coordinating role of the brain.

11. Coordination and response

Content

11.1 Nervous system

11.2 Receptors

11.3 Reflex action

11.4 Hormones

Learning outcomes

Candidates should be able to:

(a) state that the nervous system (brain, spinal cord and nerves) serves to coordinate and regulate bodily functions

(b) identify, on diagrams of the central nervous system, the cerebrum, cerebellum, pituitary gland and hypothalamus, medulla, spinal cord and nerves

(c) describe the principal functions of the above structures in terms of coordinating and regulating bodily functions

(d) describe the gross structure of the eye as seen in front view and in horizontal section

(e) state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina

(f) describe the pupil reflex in response to bright and dim light

(g) outline the functions of sensory neurones, relay neurones and motor neurones

(h) discuss the function of the brain and spinal cord in producing a coordinated response as a result of a specific stimulus (reflex action)

(i) define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver

(j) state the role of the hormone adrenaline in boosting the blood glucose concentration and give examples of situations in which this may occur

(k) state the role of the hormone insulin in controlling blood glucose concentration

(l) describe the signs (increased blood glucose concentration and glucose in urine) and treatment (administration of insulin) of diabetes mellitus.

12. Support, movement and locomotion

Content

12.1 Bones

12.2 Joints

12.3 Antagonistic muscles

Learning outcomes

Candidates should be able to:

(a) identify and describe, from diagrams, photographs and real specimens, the main bones of the forelimb (humerus, radius, ulna and scapula) of a mammal

(b) describe the type of movement permitted by the ball and socket joint and the hinge joint of the forelimb

(c) describe the action of the antagonistic muscles at the hinge joint.

13. The use and abuse of drugs

Content

13.1 Antibiotics

13.2 Effects of heroin

13.3 Effects of alcohol

13.4 Effects of tobacco smoke

Learning outcomes

Candidates should be able to:

(a) define a *drug* as any externally administered substance that modifies or affects chemical reactions in the body

(b) describe the medicinal use of antibiotics for the treatment of bacterial infection

(c) describe the effects of the abuse of heroin: a powerful depressant, problems of addiction, severe withdrawal symptoms and associated problems such as crime and infection, e.g. AIDS

(d) describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications

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

(f) recognise the fact that many people regard smoking as no longer socially acceptable.

14. Microorganisms and biotechnology

Content

14.1 Microorganisms
14.2 Food biotechnology
14.3 Industrial biotechnology

Learning outcomes

Candidates should be able to:

(a) list the main characteristics of the following groups: viruses, bacteria and fungi
(b) outline the role of microorganisms in decomposition
(c) explain the role of yeast in the production of bread and alcohol
(d) outline the role of bacteria in yoghurt and cheese production
(e) describe the use of fermenters for large-scale production of antibiotics and single cell protein
(f) describe the role of the fungus *Penicillium* in the production of penicillin.

15. Relationships of organisms with one another and with the environment

Content

15.1 Energy flow
15.2 Food chains and food webs
15.3 Carbon cycle
15.4 Nitrogen cycle
15.5 Parasitism
15.6 Effects of humans on the ecosystem
15.7 Pollution
15.8 Conservation

Learning outcomes

Candidates should be able to:

(a) state that the Sun is the principal source of energy input to biological systems
(b) describe the non-cyclical nature of energy flow
(c) define the following terms and establish the relationship of each in food webs:
- *producer* – an organism that makes its own organic nutrients, usually using energy from sunlight through photosynthesis
- *consumer* – an organism that gets its energy by feeding on other organisms
- *herbivore* – an animal that obtains its energy by eating plants
- *carnivore* – an animal that obtains its energy by eating other animals
- *decomposer* – an organism that obtains its energy from dead or waste organic matter
- *food chain* – a chart showing the flow of energy (food) from one organism to the next, beginning with the producer (e.g. mahogany tree → caterpillar → songbird → hawk)

(d) describe energy losses between trophic levels and infer the advantages of short food chains
(e) describe and interpret pyramids of numbers and of biomass
(f) describe and state the importance of the carbon cycle

(g) describe the nitrogen cycle in making available nitrogen for plant and animal protein, including the role of bacteria in nitrogen fixation, decomposition and nitrification (details of denitrification and the names of individual bacteria are **not** required)

(h) understand the role of the mosquito as a vector of disease

(i) describe the malarial pathogen as an example of a parasite and describe the transmission and control of the malarial pathogen (details of the life cycle of the pathogen are **not** required)

(j) describe the effects of humans on the ecosystem with emphasis on examples of international importance (tropical rainforests, oceans and important rivers)

(k) describe the consequences of deforestation in terms of its effects on soil stability, climate and local human populations

(l) evaluate the effects of:

water pollution by sewage, by inorganic waste and by nitrogen-containing fertilisers

air pollution by greenhouse gases (carbon dioxide and methane), contributing to global warming

air pollution by acidic gases (sulfur dioxide and oxides of nitrogen), contributing to acid rain

pollution due to insecticides

(m) discuss reasons for conservation of species with reference to maintenance of biodiversity, management of fisheries and management of timber production

(n) discuss reasons for recycling materials, with reference to **named** examples.

16. Development of organisms and continuity of life

Content

16.1 Asexual reproduction

16.2 Sexual reproduction in plants

16.3 Sexual reproduction in humans

16.4 Sexually transmitted diseases

Learning outcomes

Candidates should be able to:

(a) define *mitosis* as cell division giving rise to genetically identical cells in which the chromosome number is maintained and state the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction

(b) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent and describe **one named**, commercially important application of asexual reproduction in plants

(c) define *meiosis* as a reduction division in which the chromosome number is halved from diploid to haploid

(d) state that gametes are the result of meiosis (reduction division)

(e) define *sexual reproduction* as the process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring

(f) identify and draw, using a hand lens if necessary, the sepals, petals, stamens and carpels of **one**, locally available, **named**, insect-pollinated, dicotyledonous flower, and examine the pollen grains under a light microscope

(g) state the functions of the sepals, petals, anthers and carpels

(h) use a hands lens to identify and describe the anthers and stigmas of **one**, locally available, **named**, wind-pollinated flower, and examine the pollen grains under a light microscope

(i) outline the process of pollination and distinguish between self-pollination and cross-pollination

(j) compare, using fresh specimens, an insect-pollinated and a wind-pollinated flower

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

(l) investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and testa, protected by the pericarp (fruit wall)

(m) state that seed and fruit dispersal by wind and by animals provides a means of colonising new areas

(n) describe the external features of **one**, locally available, **named** example of a wind-dispersed fruit or seed and of **one named** example of an animal-dispersed fruit or seed

(o) investigate and state the environmental conditions that affect germination of seeds: suitable temperature, water and oxygen

(p) describe the uses of enzymes in the germination of seeds

(q) identify on diagrams of the male reproductive system and state the functions of the testes, scrotum, sperm ducts, prostate gland, urethra and penis

(r) identify on diagrams of the female reproductive system and state the functions of the ovaries, oviducts, uterus, cervix and vagina

(s) compare male and female gametes in terms of size, numbers and mobility

(t) describe the menstrual cycle, with reference to the alternation of menstruation and ovulation, the natural variation in its length and the fertile and infertile phases of the cycle

(u) explain the role of hormones in controlling the menstrual cycle (including FSH, LH, progesterone and oestrogen)

(v) describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells that becomes implanted in the wall of the uterus

(w) state the function of the amniotic sac and the amniotic fluid

(x) describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (**no** structural details are required)

(y) describe the special dietary needs of pregnant women

(z) describe the advantages of breast milk compared with bottle milk

(aa) describe the following methods of birth control:
natural, chemical (spermicides), mechanical, hormonal and surgical

(bb) explain that syphilis is caused by a bacterium that is transmitted during sexual intercourse

(cc) describe the symptoms, signs, effects and treatment of syphilis

(*dd*) discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled.

17. Inheritance

Content

17.1 Variation
17.2 Chromosomes and DNA
17.3 Monohybrid inheritance
17.4 Selection
17.5 Genetic engineering

Learning outcomes

Candidates should be able to:

(a) describe the difference between *continuous* and *discontinuous variation* and give examples of each
(b) state that a chromosome includes a long molecule of DNA
(c) state that DNA is divided up into sections called genes
(d) explain that genes may be copied and passed on to the next generation
(e) define a gene as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*
(f) describe complete dominance using the terms *dominant, recessive, phenotype* and *genotype*
(g) describe *mutation* as a change in the structure of a gene (e.g. sickle cell anaemia) or in the chromosome number (e.g. 47 in Down's syndrome instead of 46)
(h) name radiation and chemicals as factors that may increase the rate of mutation
(i) predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms *homozygous, heterozygous, F_1 generation* and *F_2 generation*
(j) explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny
(k) explain *codominance* by reference to the inheritance of the ABO blood group (phenotypes A, B, AB, O, gene alleles I^A, I^B and I^O)
(l) describe the determination of sex in humans (XX and XY chromosomes)
(m) describe *variation* and state that competition leads to differential survival of organisms, and reproduction by those organisms best fitted to the environment
(n) assess the importance of natural selection as a possible mechanism for evolution
(o) describe the role of artificial selection in the production of economically important plants and animals
(p) explain that DNA controls the production of proteins
(q) state that each gene controls the production of one protein
(r) explain that genes may be transferred between cells (reference should be made to transfer between organisms of the same or different species)
(s) explain that the gene that controls the production of human insulin can be inserted into bacterial DNA
(t) understand that such genetically engineered bacteria can be used to produce human insulin on a commercial scale
(u) discuss potential advantages and dangers of genetic engineering.

6. Practical assessment

6.1 Paper 3 and Paper 6

Experimental skills are assessed in Paper 3, *Practical Test* and Paper 6, *Alternative to Practical.*

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 benefits to theoretical understanding come from all practical work
- the same motivational effect, enthusiasm and enjoyment should be experienced
- the same sequence of practical activities is appropriate.

6.2 Laboratory conditions

Adequate bench space (at least 1 m × 1 m for each candidate)
Water supply – not necessarily mains supply
Gas supply (for heating) – mains/cylinder
Electrical supply – mains/batteries/generator
Secure area for preparation and storage of items made for practical lessons and tests

6.3 Laboratory equipment

The following is a list of the conditions, materials and equipment that are considered appropriate for the teaching of Cambridge O Level Biology.

In accordance with the COSHH (Control of Substances Hazardous to Health) Regulations operative in the UK, a hazard appraisal of the list has been carried out. The following codes are used where relevant.

C = corrosive substance
F = highly flammable substance
H = harmful or irritating substance
O = oxidizing substance
T = toxic substance
N = dangerous for the environment

Apparatus and materials

Safety equipment appropriate to the work being planned, but at least including eye protection such as safety spectacles or goggles

Chemical reagents

- hydrogencarbonate indicator (bicarbonate indicator)
- iodine in potassium iodide solution (iodine solution)
- Benedict's solution (or an alternative such as Fehling's)
- [**C**] biuret reagent(s) (sodium or potassium hydroxide solution and copper sulfate solution)
- [**F**] ethanol/methylated spirit
- cobalt chloride paper
- pH indicator paper or universal indicator solution or pH probes
- litmus paper
- glucose
- sodium chloride
- aluminium foil or black paper

Instruments

- rulers capable of measuring to 1 mm
- mounted needles or seekers or long pins with large heads
- means of cutting biological materials, e.g. scalpels, solid-edged razor blades or knives
- scissors
- forceps
- means of writing on glassware, e.g. wax pencil, water-resistant marker, small self-adhesive labels and pencils

Glassware and other apparatus (some of which may be glass, plastic or metal)

- beakers or other containers
- test-tubes, test-tube racks and test-tube holders
- funnels
- droppers or teat pipettes or plastic or glass dispensing bottles
- dishes such as Petri dishes or tin lids
- means of measuring small and larger volumes such as syringes, graduated pipettes or measuring cylinders
- glass rods
- capillary tubes
- glass slides and coverslips
- thermometers covering at least the range 0–100 °C (any range starting below 0 and ending above 100 °C is suitable)
- means of heating such as Bunsen or other gas burner or spirit burner
- white tile or other suitable cutting surface
- visking tube or other selectively permeable membrane material
- hand lens (at least ×6)

Desirable apparatus and materials

- microscope with mirror and lamp or with built in light, at least low-power (×10) objective, optional high-power (×40) objective will greatly increase the range of cellular detail that can be resolved
- mortar and pestle or blender
- chemical reagents in addition to those listed above
- copper(II) sulfate (blue crystals)
- dilute (1 mol dm^{-3}) hydrochloric acid
- a source of distilled or deionised water
- eosin/red ink
- limewater
- methylene blue
- [**C**] potassium hydroxide
- sodium hydrogencarbonate (sodium bicarbonate)
- Vaseline/petroleum jelly (or similar)

6.4 Paper 3: Practical Test

1. The practical test is designed to test candidates' abilities:
   (a) to follow carefully a sequence of instructions within a set time allowance
   (b) to use familiar, and unfamiliar, techniques to record their observations and make deductions from them
   (c) to recognise and observe features of familiar and unfamiliar biological specimens, record their observations and make deductions about functions of whole specimens or their parts
   (d) to make clear line drawings of the specimens provided, indicate magnification and to label familiar structures
   (e) to interpret unfamiliar data and draw conclusions from their interpretations
   (f) to design/plan an investigation to solve a problem
   (g) to comment on a procedure used in an experiment and suggest an improvement.
   In addition, the practical test is designed to test candidates' abilities:
   (h) to employ manipulative skills in assembling apparatus, in using chemical reagents and in using such instruments as mounted needles, scalpels and razor blades, forceps and scissors
   (i) to observe reactions, read simple measuring instruments and perform simple arithmetical calculations
   (j) to measure to an accuracy of 1 mm, using a ruler.
2. Candidates may be asked to carry out simple physiological experiments, involving tests for food substances (see 5*(b)*), enzyme reactions, hydrogencarbonate indicator solution, cobalt chloride paper, etc. It is expected that glassware and instruments normally found in a laboratory, e.g. beakers, test-tube racks, funnels, thermometers, droppers and so on, should be available for these experiments.
3. Candidates may be asked to carry out simple physiological experiments involving the use of the items mentioned above in 1*(h)* on plant or animal materials. Accurate observations of these specimens will need a hand lens of not less than ×6 magnification for each candidate.
4. The material set will be closely related to the subject matter of the syllabus, but will not necessarily be limited to the particular types mentioned therein. In order to assist their own practical work, and to supply possible examination specimens, schools are asked to build up a reference collection of material.
5. When planning practical work, teachers should make sure that they do not contravene any school, education authority or government regulations that restrict the sampling, in educational establishments, of urine, saliva, blood or other bodily secretions and tissues.

6.5 Paper 6: Alternative to Practical

1. The Alternative to Practical is designed to test candidates' abilities:
   (a) to follow carefully a sequence of instructions
   (b) to describe familiar and suggest unfamiliar techniques to record observations and make deductions from them
   (c) to recognise and observe features of photographs and drawings of familiar and unfamiliar biological specimens, record their observations and make deductions about functions of whole specimens or their parts
   (d) to make clear line drawings of the images of specimens, indicate magnification and to label familiar structures
   (e) to interpret unfamiliar data and draw conclusions from their interpretations
   (f) to design/plan an investigation to solve a problem
   (g) to comment on a procedure used in an experiment and suggest an improvement
   (h) to observe images of reactions; read from photographs, diagrams and simple measuring instruments, and perform simple arithmetical calculations
   (i) to measure to an accuracy of 1 mm, using a ruler.
2. Candidates may be asked to describe simple physiological experiments, involving tests for food substances (see 5*(b)*), enzyme reactions, hydrogencarbonate indicator solution, cobalt chloride paper, and other materials listed in this syllabus. It is expected that candidates will have experience of the use of glassware and instruments normally found in a laboratory, e.g. beakers, test-tube racks, funnels, thermometers, droppers and other apparatus listed in this syllabus, so that they can describe their use in such experiments.
3. Candidates may be asked to describe simple physiological experiments, involving the use of the items mentioned above in 1*(h)* involving plant or animal materials. Accurate observations of life-sized and magnified images of such specimens will be expected.
4. The material set will be closely related to the subject matter of the syllabus, but will not necessarily be limited to the particular types mentioned in it. In order to assist their own practical work, schools are recommended to build up a reference collection of material with which candidates can practise.
5. When planning practical work, teachers should make sure that they do not contravene any school, education authority or government regulations that restrict the sampling, in educational establishments, of urine, saliva, blood or other bodily secretions and tissues.

7. Appendix

7.1 Glossary of terms used in science papers

During the moderation of a question paper, care is taken to ensure that the paper and its individual questions are, in relation to the syllabus, fair as regards balance, overall difficulty and suitability. Attention is also paid to the wording of questions to ensure that it is as concise and as unambiguous as possible. In many instances, Examiners are able to make appropriate allowance for an interpretation that differs, but acceptably so, from the one intended.

It is hoped that the glossary (which is relevant only to biology, human and social biology and agriculture) will prove helpful to candidates as a guide (i.e. 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 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 for something. 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. (a) *Describe* the data or information given in a graph, table or diagram requires the candidate to state the key points that can be seen in the stimulus material. Where possible, reference should be made to numbers drawn from the stimulus material.

   (b) *Describe* a process requires the candidate to give a step-by-step written statement of what happens during the process.

   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 in the topic.
8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).
9. *Predict* 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. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

   Predict also implies a concise answer, with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required (e.g. reference to a law/principle, or the necessary reasoning is to be included in the answer).

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 in a plant kept in a glasshouse) or to imply that candidates are expected to apply their general knowledge and understanding of biology 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 ruler, or mass, using a balance).
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula (e.g. the Young modulus, relative molecular mass).
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, asymptote or discontinuity at a particular value).

    In diagrams, *sketch* implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

In all questions, the number of marks allocated are shown on the examination paper and should be used by candidates as a guide to how much detail is required. In describing a process, the mark allocation should guide the candidate about how many steps to include. In explaining why something happens, the mark allocation is a guide to how many reasons to give, or how much detail to give for each reason.

8. Other information

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 aim 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 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**

Language

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

Grading and reporting

Cambridge O Level results are shown by one of the grades A*, A, B, C, D or E, indicating the standard achieved, A* being the highest and E the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade E. '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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