GCSE

WJEC GCSE in BIOLOGY

APPROVED BY QUALIFICATIONS WALES

SPECIFICATION

Teaching from 2016
For award from 2018

This Qualifications Wales regulated qualification is not available to centres in England.

WJEC GCSE in BIOLOGY

For teaching from 2016
For award from 2018

This specification meets the GCSE Qualification Principles which set out the requirements for all new or revised GCSE specifications developed to be taught in Wales from September 2016.

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GCSE BIOLOGY (Wales)

SUMMARY OF ASSESSMENT

There are two tiers of entry for this qualification:
Higher Tier – Grades A* - D
Foundation Tier – Grades C - G

This GCSE qualification in Biology offers assessment at foundation and higher tier. In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

Unit 1: CELLS, ORGAN SYSTEMS and ECOSYSTEMS Written examination : 1 hour 45 minutes 45% of qualification — 80 marks
A mix of short answer questions, structured questions, extended writing and data response questions with some set in a practical context. A tiered assessment.
Unit 2: VARIATION, HOMEOSTASIS and MICRO-ORGANISMS **Written examination: 1 hour 45 minutes** **45% of qualification — 80 marks**
A mix of short answer questions, structured questions, extended writing and data response questions with some set in a practical context. A tiered assessment.
Unit 3: PRACTICAL ASSESSMENT **10% of qualification — 30 marks**
Practical assessment that will be carried out in centres, but will be externally marked by WJEC. It will take place in the first half of the spring term (January – February). It is recommended that this should be in the final year of study. An untiered assessment

This unitised qualification will be available in the summer series each year. It will be awarded for the first time in Summer 2018.

Qualification Number listed on The Register: 601/8233/7

Qualifications Wales Approval Number listed on QiW: C00/0779/8

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GCSE BIOLOGY

1 INTRODUCTION

1.1 Aims and objectives

This WJEC GCSE Biology specification provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, science and to recognise its importance in their own lives and to society.

Studying GCSE Biology provides the foundations for understanding the material world. Scientific understanding is changing our lives and is vital to the world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, processes and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are of universal application. These key ideas include:

- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause
- that change is driven by differences between different objects and systems when they interact
- that many such interactions occur over a distance without direct contact
- that science progresses through a cycle of hypothesis, practical experimentation, observation, theory development and review
- that quantitative analysis is a central element both of many theories and of scientific methods of inquiry.

This specification is intended to promote a variety of styles of teaching and learning so that the course is enjoyable for all participants. Learners will be introduced to a wide range of scientific principles which will allow them to enjoy a positive learning experience. Practical work is an intrinsic part of science. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

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1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the school/college's discretion.

This specification builds on subject content which is typically taught at key stage 3 and provides a suitable foundation for the study of Biology at either AS or A level. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications.*

This document is available on the JCQ website (www.jcq.org.uk). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

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1.4 Welsh Baccalaureate

In following this specification, learners should be given opportunities, where appropriate, to develop the skills that are being assessed through the Core of the Welsh Baccalaureate:

- Literacy
- Numeracy
- Digital Literacy
- Critical Thinking and Problem Solving
- Planning and Organisation
- Creativity and Innovation
- Personal Effectiveness.

1.5 Welsh perspective

In following this specification, learners must consider a Welsh perspective if the opportunity arises naturally from the subject matter and if its inclusion would enrich learners' understanding of the world around them as citizens of Wales as well as the UK, Europe and the world.

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2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying GCSE Biology.

Learners should be prepared to apply the knowledge, understanding and skills specified in a range of theoretical, practical, industrial and environmental contexts. Practical work is an intrinsic part of this specification. It is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of science. The practical skills developed are also fundamentally important to learners going on to further study in science and related subjects, and are transferable to many careers.

All of the content present in the Biology units of the Science (Double Award) specification (i.e. Units 1 and 4) is covered in this specification. In addition some of the content covered in Unit 1 of this specification (i.e. Biology 1 (Separate Science)) overlaps with the content of Unit 1 of the Applied Science (Double Award) specification. This will allow learners if necessary to transfer between the different qualifications on offer in the GCSE Science suite in the first term of study.

This section includes specified practical work that must be undertaken by learners in order that they are suitably prepared for all assessments. The completion of this practical work will develop the practical skills listed in Appendix A.

Appendix B lists the mathematical requirements.

Some areas of content have been selected for assessment at higher tier only. This content is shown in bold type in the relevant content sections. All content may therefore be examined at higher tier but that in bold will not be examined on foundation tier papers.

All content in the specification should be introduced in such a way that it develops learners' ability to:

- understand scientific concepts through the specific discipline of biology
- understand the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- apply observational, practical, modelling, enquiry and problem-solving skills, both in the laboratory, in the field and in other learning environments
- evaluate claims based on science through critical analysis of the methodology, evidence and conclusions, both qualitatively and quantitatively.

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2.1 Unit 1

CELLS, ORGAN SYSTEMS and ECOSYSTEMS

Written examination: 1 hour 45 minutes
45% of qualification

This unit includes the following topics:

1.1 Cells and movement across membranes

1.2 Respiration and the respiratory system in humans

1.3 Digestion and the digestive system in humans

1.4 Circulatory system in humans

1.5 Plants and photosynthesis

1.6 Ecosystems, nutrient cycles and human impact on the environment

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1.1 CELLS AND MOVEMENT ACROSS CELL MEMBRANES

Overview

The fundamental units of living organisms are cells, which may be part of highly adapted structures including tissues, organs and organ systems, enabling living processes to be performed effectively. This topic explores the structure and function of cells, how they transport materials and some metabolic processes that occur within them.

Working Scientifically

This topic contains opportunities for learners to understand how scientific methods and theories develop over time by considering the understanding of cell structure in relation to the development of the microscope. It gives learners the opportunity to make and record observations when examining plant and animal cells. It presents the opportunity for learners to carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations when investigating factors affecting enzyme action.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data which is available on the content of this topic. This could include the translation of information between graphical and numerical forms, the construction and interpretation of frequency tables and diagrams, bar charts and histograms and the use of a scatter diagram to identify a correlation between two variables.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the structure of animal and plant cells, including drawing and labelling diagrams and the function of the following parts: cell membrane, cytoplasm, nucleus, mitochondria, cell wall, chloroplast, vacuole

(b) the use of a light microscope to view animal and plant cells

(c) the differentiation of cells in multicellular organisms to become adapted for specific functions - specialised cells

(d) the levels of organisation within organisms: tissues are groups of similar cells with a similar function and organs may comprise several tissues performing specific functions; organs are organised into organ systems, which work together to form organisms

(e) diffusion as the movement of substances down a concentration gradient; the role of the cell membrane in diffusion; Visking tubing as a model of living material; the results of Visking tubing experiments in terms of membrane pore and particle size

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(f) diffusion as a passive process, allowing only certain substances to pass through the cell membrane in this way, most importantly oxygen and carbon dioxide

(g) osmosis as the diffusion of water through a selectively permeable membrane from a region of high water (low solute) concentration to a region of low water (high solute) concentration

(h) **active transport as an active process whereby substances can enter cells against a concentration gradient**

(i) enzyme control of chemical reactions in cells; enzymes are proteins made by living cells, which speed up/catalyse the rate of chemical reactions

(j) **how different enzymes are composed of different amino acids linked to form a chain which is then folded into a specific shape**

(k) how the specific shape of the active site of an enzyme enables it to function, a simple understanding of 'lock and key' modelling and be able to interpret enzyme activity in terms of molecular collisions **resulting in the formation of enzyme-substrate complexes**

(l) the effect of temperature and pH on enzyme activity including the effect of boiling which denatures most enzymes

SPECIFIED PRACTICAL WORK

- Examination of animal and plant cells using a light microscope and production of labelled scientific diagrams from observation

- Investigation into factors affecting enzyme action

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1.2 RESPIRATION AND THE RESPIRATORY SYSTEM IN HUMANS

Overview

Organic compounds are used as fuels in respiration within cells to allow the chemical reactions necessary for life. This topic examines the processes of aerobic and anaerobic respiration, along with the respiratory system which enables the oxygen required for respiration to be taken to the tissues and the carbon dioxide produced to be removed.

Working Scientifically

This topic contains opportunities for learners to understand how models can be used to develop understanding of inspiration and expiration using the bell jar model. It gives learners the opportunity to discuss the controversy between the sometimes conflicting evidence about the effects of smoking from independent studies and those of vested interest groups and the need for unbiased interpretation of investigations, scientific validation of data and peer review. The evaluation of risks can also be developed in relation to how attitudes to smoking have changed over time as evidence about its effects has been validated by scientists including the conflict between regulation and personal freedom and the cost–benefit considerations. The use of limewater to indicate the presence of carbon dioxide enables learners to carry out experiments appropriately with due regard to health and safety considerations.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data which is available on the content of this topic. This could include the translation of information between graphical and numerical forms; using data regarding smoking related illnesses, using ratios, fractions and percentages of different gases in inspired and expired air; understand the principles of sampling as related to health data.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) aerobic respiration as a process that occurs in cells when oxygen is available; respiration as a series of enzyme-controlled reactions within the cell, that use glucose and oxygen to release energy and produce carbon dioxide and water; **energy is released in the form of ATP** and be able to state the word equation to describe aerobic respiration

(b) anaerobic respiration as a process that occurs in the absence of oxygen; glucose being broken down to release energy and lactic acid; oxygen debt as a result of anaerobic respiration; **anaerobic respiration as a less efficient process than aerobic respiration because of the incomplete breakdown of glucose; less ATP is produced per molecule of glucose in anaerobic respiration than in aerobic respiration** and be able to state the word equation for anaerobic respiration in human cells

(c) the need for and purpose of the respiratory system and be able to label the following structures on a diagram of a vertical section of the human respiratory system: nasal cavity, trachea, bronchi, bronchioles, alveoli, lungs, diaphragm, ribs and intercostal muscles

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(d) the function of mucus and cilia in the respiratory system

(e) the mechanisms of inspiration and expiration, in terms of changes in thoracic volume and pressure brought about by movements of the diaphragm and rib cage; movement of air takes place due to differences in pressure between the lungs and outside the body

(f) the use of a bell jar model to illustrate inspiration and expiration and the limitations of this model

(g) the structure of an alveolus and its blood supply and be able to label the following structures on a diagram: end of bronchiole, wall of alveolus, moist lining of alveolus, wall of capillary, red blood cells and plasma

(h) the percentage composition of inspired and expired air and the reasons for the differences; how gases diffuse between alveolar air and capillaries; the adaptations of alveoli for gas exchange; the use of lime water to indicate the presence of carbon dioxide

(i) the effects of smoking on cilia and mucus in the respiratory system and the consequences for the individual; the link between cigarette smoking and lung cancer and emphysema and the consequences of these conditions

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1.3 DIGESTION AND THE DIGESTIVE SYSTEM IN HUMANS

Overview

This topic covers the need for digestion, the structure of the digestive system in humans and the mechanisms by which larger molecules are broken down into smaller soluble molecules which can be absorbed into the blood. There is also consideration of a balanced diet and the effects of excess sugar and fat in the diet.

Working Scientifically

The use of Visking tubing as a model of absorption enables learners to develop scientific explanations regarding digestion and absorption. There are a number of opportunities for practical work in this topic. The carrying out of experiments to test for starch, glucose and protein enables learners to develop skills in recording observations using a range of methods and to show due regard to health and safety considerations. The investigation into the energy content of different foods will allow learners to plan experiments to make observations. It also provides opportunity to carry out mathematical analysis and present reasoned explanation including relating their data to a hypothesis. There will also be opportunities to analyse data from food labelling regarding sugar, fat and salt content in foods.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data generated within the investigation into the energy content of foods. This would include finding arithmetic means; constructing and interpreting tables; using expressions in decimal form; translating information between graphical and numerical form; plotting data from experimental data.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the need for digestion; the breakdown of large molecules into smaller molecules so they can be absorbed for use by body cells

(b) the digestion of larger insoluble molecules into their soluble products which can then be absorbed: fats made up of fatty acids and glycerol; proteins made up of amino acids; starch (a carbohydrate) made up of a chain of glucose molecules

(c) the tests for the presence of: starch using iodine solution; glucose using Benedict's reagent; protein using biuret solution

(d) the role of the following enzymes in digestion: carbohydrase; protease; lipase

(e) the structure of the human digestive system and associated structures: the mouth, oesophagus, stomach, liver, gall bladder, bile duct, pancreas, small intestine, large intestine, anus and be able to label these on a diagram

(f) the role of the following organs in digestion and absorption: mouth, stomach, pancreas, small intestine, large intestine, liver

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(g) how food is moved by peristalsis

(h) the function of bile, secreted by the liver and stored in the gall bladder, in the breakdown of fats

(i) how soluble substances can be absorbed through the wall of the small intestine and eventually into the bloodstream and how Visking tubing can be used as a model gut, including the limitations of the model

(j) the fate of the digested products of fats, carbohydrates and proteins: fatty acids and glycerol from fats provide energy; glucose from carbohydrate provides energy or is stored as glycogen; amino acids from digested proteins are needed to build proteins in the body

(k) the need for a balanced diet, including: protein, carbohydrates and fats, minerals (iron),vitamins (vitamin C), fibre and water

(l) the fact that different foods have different energy contents and that energy from food, when it is in excess, is stored as fat by the body

(m) the implications, particularly for health, of excess sugar, fat and salt in foods

SPECIFIED PRACTICAL WORK

- Investigation of the energy content of foods

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1.4 CIRCULATORY SYSTEM IN HUMANS

Overview

This topic covers the structure and function of the circulatory system and blood in humans. The differences between the different types of blood vessel are covered along with an evaluation of the different treatments for cardiovascular disease.

Working Scientifically

The content on the evaluation of different methods of treating cardiovascular disease will allow learners to explain the technological applications of science and consider the ethical issues which may arise. Microscope work could be used in the observation of blood vessels to develop the use of scientific terminology and the idea of order of magnitude. A heart dissection could be used to develop the use of a range of apparatus and instruments.

Mathematical skills

There are a number of opportunities for the development of mathematical skills using data generated within this topic. This would include health data regarding cardiovascular disease; blood flow rate through arteries, veins and capillaries; effect of exercise on heart rate. The skills developed could include: interpreting tables and diagrams; translating information between graphical and numerical form; using expressions in decimal form; finding arithmetic means.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the structure of a phagocyte and a red blood cell; be able to draw and label these cells

(b) the functions of the four main parts of the blood: red cells, platelets, plasma, white cells

(c) the fact that the heart is made of muscle, which contracts to pump blood around the body

(d) the role of the coronary vessels in supplying the heart muscle with blood

(e) the flow of blood to the organs through arteries and return to the heart through veins

(f) the structure of the heart: the left and right atria and ventricles, tricuspid and bicuspid valves, semi-lunar valves, pulmonary artery, pulmonary vein, aorta and vena cava and be able to label these on a diagram

(g) the passage of blood through the heart including the functions of the valves in preventing backflow of blood

(h) a double circulatory system: involving one system for the lungs – pulmonary and one for the other organs of the body – systemic

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(i) the fact that in the organs, blood flows through very small blood vessels called capillaries; substances needed by cells pass/diffuse out of the blood to the tissues, and substances produced by the cells pass/diffuse into the blood, through the walls of the capillaries; the thin walls of the capillaries are an advantage for diffusion; capillaries form extensive networks so that every cell is near to a capillary carrying blood

(j) the structure of arteries, veins and capillaries and relate this to their function

(k) risk factors for cardiovascular disease and the effects of cardiovascular disease

(l) the advantages and disadvantages of the following treatments for cardiovascular disease:

- statins
- angioplasty
- changes to lifestyle diet/exercise

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1.5 PLANTS AND PHOTOSYNTHESIS

Overview

Life on Earth is dependent on photosynthesis in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen. This topic covers the process of photosynthesis and factors which affect the rate of photosynthesis. Learners will then go on to cover the transport systems in plants, transpiration and factors which affect transpiration.

Working Scientifically

The investigations into factors affecting photosynthesis and transpiration allow many skills to be developed. These include: the use of scientific theories to develop hypotheses; the planning experiments to make observations and test hypotheses; selection of apparatus; carrying out of experiments having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations; making and recording observations and measurements using a range of apparatus and methods; evaluating methods and suggesting possible improvements and further investigations.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills within the investigations. These skills include the understanding and use of simple compound measures such as the rate of a reaction; translating information between graphical and numerical form; plotting and drawing appropriate graphs, selecting appropriate scales for axes; extracting and interpreting information from graphs, charts and tables. **Higher tier learners should be able to understand and use inverse proportion – the inverse square law and light intensity in the context of factors affecting photosynthesis.**

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the importance of photosynthesis, whereby green plants and other photosynthetic organisms use chlorophyll to absorb light energy and convert carbon dioxide and water into glucose, producing oxygen as a by-product and be able to state the word equation for photosynthesis

(b) the conditions needed for photosynthesis to take place and the factors which affect its rate, including temperature, carbon dioxide and light intensity; **these as limiting factors of photosynthesis**

(c) the practical techniques used to investigate photosynthesis: the use of sodium hydroxide to absorb carbon dioxide; how to test a leaf for the presence of starch; how oxygen and carbon dioxide sensors and data loggers could be used

(d) the uses made by plant cells of the glucose produced in photosynthesis: respired to release energy; converted to starch for storage; used to make cellulose, proteins and oils

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(e) the structure of a leaf and be able to label the following structures: cuticle, epidermis, stomata, palisade layer, spongy layer, xylem and phloem; the structure of stomata to include guard cells and stoma; the fact that stomata can open and close to regulate transpiration and allow gas exchange

(f) the importance of water to plants: use in photosynthesis, transport of minerals and support

(g) the significance of root hairs in increasing the area for absorption in a root; the role of osmosis in the uptake and movement of water through a plant;

(h) **the uptake of mineral salts by root hairs by active transport**

(i) the role of xylem in transport of water within plants; the role of transpiration in the movement of water through a plant

(j) the effect of different environmental conditions on the rate of transpiration from a plant / plant cutting

(k) the role of phloem in carrying sucrose from the photosynthetic areas to other parts of the plant for use in respiration or converted into starch for storage

(l) the effects of plant nutrient deficiencies on plant growth: lack of nitrates results in poor growth; deficiency of potassium results in yellowing of the leaf; deficiency of phosphate results in poor root growth; the use of NPK fertilisers

SPECIFIED PRACTICAL WORK

- Investigation of the factors affecting photosynthesis
- Investigation into factors affecting transpiration

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1.6 ECOSYSTEMS, NUTRIENT CYCLES AND HUMAN IMPACT ON THE ENVIRONMENT

Overview

Living organisms may form populations of single species, communities of many species and ecosystems, interacting with each other, with the environment and with humans in many different ways. The chemicals within these ecosystems are continually cycling through the natural world. This topic comprises coverage of the levels of organisation within an ecosystem, the principles of material cycling and issues surrounding sustainability. Opportunities are given to look in detail at the factors affecting communities and how the numbers of organisms and biomass within each level can be represented. The carbon cycle and nitrogen cycle are covered in material cycling, along with how human activity affects them.

Working Scientifically

The topics discussing the advantages and disadvantages of intensive farming methods and the need to balance the human requirement for food with the needs of wildlife will allow learners to develop skills in evaluating social, economic and environmental applications based on the evaluation of evidence and arguments. There are also a number of opportunities to develop skills in analysis and evaluation within the data generated from work on food chains and food webs. These would include: presentation of data, translating data from one form to another; carrying out and representing mathematical analysis; representing distributions of results and making estimations of uncertainty.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills within the data in this topic. These would include the calculation of rate changes in the decay of biological material, the calculation of the percentage efficiency in biomass transfer between trophic levels, the calculation of arithmetic means, being able to understand and use percentiles, plotting and drawing appropriate graphs and selecting appropriate scales for the axes and extracting and interpreting information from charts, graphs and tables.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) food chains and food webs showing the transfer of energy between organisms and involving producers; first, second and third stage consumers; herbivores and carnivores; decomposers

(b) the fact that at each stage in the food chain energy is used in repair and in the maintenance and growth of cells whilst energy is lost in waste materials and respiration

(c) pyramids of numbers and biomass

(d) **how to calculate the efficiency of energy transfers between trophic levels and how this affects the number of organisms at each trophic level**

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(e) the importance of micro-organisms, bacteria and fungi in decay: micro-organisms feed on waste materials from organisms, when plants and animals die their bodies are broken down by micro-organisms bringing about decay, micro-organisms respire and release carbon dioxide into the atmosphere

(f) the fact that nutrients are released in decay, e.g. nitrates and phosphates, and that these nutrients are then taken up by other organisms resulting in nutrient cycles and in a stable community the processes which remove materials are balanced by processes which return materials

(g) the carbon cycle: carbon is constantly cycled in nature by photosynthesis which incorporates it and by respiration which releases it; the combustion of fossil fuels releases carbon dioxide

(h) **the nitrogen cycle: nitrogen is also recycled through the activity of soil bacteria and fungi acting as decomposers, converting proteins and urea into ammonia; the conversion of ammonia to nitrates which are taken up by plant roots and used to make new protein; nitrogen fixation, by which nitrogen from the air is converted to nitrates; the factors which could lead to denitrification**

(i) the issues surrounding the need to balance the human requirements for food and economic development with the needs of wildlife

(j) the advantages and disadvantages of intensive farming methods, such as using fertilisers, pesticides, disease control and battery methods to increase yields

(k) how indicator species and changes in pH and oxygen levels may be used as signs of pollution in a stream and how lichens can be used as indicators of air pollution

(l) the fact that some heavy metals, present in industrial waste and pesticides, enter the food chain, accumulate in animal bodies and may reach a toxic level

(m) the fact that untreated sewage and fertilisers may run into water and cause rapid growth of plants and algae; these then die and are decomposed; the microbes, which break them down, increase in number and use up the dissolved oxygen in the water; animals which live in the water may suffocate

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2.2 Unit 2

VARIATION, HOMEOSTASIS and MICRO-ORGANISMS

Written examination: 1 hour 45 minutes
45% of qualification

This unit includes the following topics:

2.1 Classification and biodiversity

2.2 Cell division and stem cells

2.3 DNA and inheritance

2.4 Variation and evolution

2.5 Response and regulation

2.6 Kidneys and homeostasis

2.7 Micro-organisms and their applications

2.8 Disease, defence and treatment

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2.1 CLASSIFICATION AND BIODIVERSITY

Overview

This topic covers an overview of the need for classification and how different organisms show adaptations which enable them to compete successfully for resources within their habitat. The term biodiversity is also covered, along with factors which affect it and how it can be measured.

Working Scientifically

There are a number of opportunities to develop skills in analysis and evaluation within the investigation into the abundance and distribution of a species. These would include: presentation of data, translating data from one form to another; carrying out and representing mathematical analysis; representing distributions of results and making estimations of uncertainty and communicating the methods used, findings and conclusions through written or electronic reports. Learners should also be able to apply sampling techniques within the fieldwork to any ensure any samples collected are representative. There is also opportunity to evaluate risk when considering the use of biological control agents.

Mathematical skills

There are a number of opportunities for the development of mathematical skills within the investigation in this topic. These include planning experiments to make observations; recognising when to apply knowledge of sampling techniques, to ensure representative samples; evaluating methods; carrying out statistical analysis; interpreting observations and evaluating in terms of accuracy, precision, repeatability and reproducibility.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) living organisms showing a range of sizes, features and complexity; the broad descriptive grouping into plants - non-flowering and flowering; animals - invertebrates and vertebrates

(b) the means by which organisms which have similar features and characteristics are classified into groups; the need for a scientific system for identification and the need for scientific as opposed to 'common' names

(c) the fact that organisms have morphological and behavioural adaptations which enable them to survive in their environment

(d) individual organisms needing resources from their environment e.g. food, water, light and minerals; how the size of a population may be affected by competition for these resources along with predation, disease and pollution

(e) the term biodiversity: the variety of different species and numbers of individuals within those species in an area; why biodiversity is important; the ways in which biodiversity and endangered species can be protected including issues surrounding the use of legislation

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(f) how quadrats can be used to investigate the abundance of species

(g) the principles of sampling; the need to collect sufficient data

(h) **the principles of capture/recapture techniques including simple calculations on estimated population size**

(i) the use of biological control agents and possible issues surrounding this; the introduction of alien species and their effects on local wildlife

SPECIFIED PRACTICAL WORK

- Investigation into factors affecting the distribution and abundance of a species

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2.2 CELL DIVISION AND STEM CELLS

Overview

Cells need to divide to grow and also to provide cells for sexual reproduction. This topic covers the processes by which these occur. There is also consideration of how uncontrolled mitosis can result in cancer. The use of stem cells in replacing damaged tissue is also discussed.

Working Scientifically

There are opportunities within this topic to explain technological applications of science in the use of stem cells. This can also be used to consider the ethical issues arising from the use of embryos in obtaining stem cells.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) chromosomes as linear arrangements of genes, found in pairs in body cells

(b) the functions of cell division by mitosis and meiosis

(c) the outcomes of mitotic and meiotic divisions and be able to compare these

(d) the fact that if mitosis is uncontrolled, cancer can occur

(e) stem cells: the cells in mature tissues have generally lost the ability to differentiate; some cells, in both plants and animals, do not lose this ability and these are called stem cells

(f) the potential of both adult and embryonic stem cells to replace damaged tissue

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2.3 DNA AND INHERITANCE

Overview

This topic covers the structure of DNA and how it acts as a code for the production of proteins and therefore produces the differences seen between different individuals. The application of genetic profiling as an application for looking at differences between individuals is studied. The mechanisms of inheritance are also covered, including the use of Punnett squares.

Working Scientifically

There are opportunities within this topic to discuss the methods by which scientific theories develop over time when teaching the structure of DNA. The discussion of genetic profiling also raises issues with regard to the ethical issues which may arise regarding the ownership of this information and also lead to a discussion regarding evaluating the personal and social implications of this. The topic of transfer of genes can also lead to the development of explanations of the technological applications of science.

Mathematical skills

There are a number of opportunities for the development of mathematical skills within this topic. These include being able to understand and use direct proportions and simple ratios in the study of genetic crosses, understanding and using the concept of probability in predicting the outcome of genetic crosses and extracting and interpreting information from charts, graphs and tables.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the structure of DNA as two long chains of alternating sugar and phosphate connected by bases; the chains are twisted to form a double helix; there are four types of base, A **(adenine)**, T**(thymine),** C **(cytosine)** and G **(guanine);** the order of bases forms a code for making proteins; the code determines the order in which different amino acids are linked together to form different proteins

(b) complementary base pairing between A and T, C and G **and the role of the triplet code during protein synthesis**

(c) the process of ‘genetic profiling’ which involves cutting the DNA into short pieces which are then separated into bands

(d) how 'genetic profiling' can be used to show the similarity between two DNA samples, the pattern of the bands produced can be compared to show the similarity between two DNA samples, for instance in criminal cases, paternity cases and in comparisons between species for classification purposes

(e) the benefits of DNA profiling, for example to identify the presence of certain genes which may be associated with a particular disease

(f) genes as sections of DNA molecules that determine inherited characteristics and that genes have different forms, called alleles, which are in pairs

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(g) the following terms: gamete, chromosome, gene, allele, dominant, recessive, homozygous, heterozygous, genotype, phenotype, F1, F2, selfing

(h) single gene inheritance; be able to complete Punnett squares to show this; how to predict the outcomes of monohybrid crosses including ratios

(i) the fact that most phenotypic features are the result of multiple genes rather than single gene inheritance

(j) sex determination in humans: in human body cells, one of the pairs of chromosomes, XX or XY, carries the genes which determine sex, these separate and combine randomly at fertilisation

(k) the artificial transfer of genes from one organism to another; the potential advantages, disadvantages and issues involved with this technology

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2.4 VARIATION AND EVOLUTION

Overview

The characteristics of a living organism are influenced by its genes and its interaction with the environment. Living organisms are interdependent and show adaptations to their environment. These adaptations are a result of evolution. Evolution occurs by a process of natural selection and accounts both for biodiversity and how organisms are all related to varying degrees. Learners will acquire an understanding of evolution and how it has resulted in the biodiversity seen on Earth.

Working Scientifically

The discussion of the potential for the human genome gives opportunities to explain the technological applications of science and also to evaluate the risks and ethics of such information being more widely available. The study of the work of Charles Darwin and Alfred Wallace allows learners to understand how scientific theories develop over time and also the importance of peer review and communicating results. The investigation into the variation in organisms will allow many practical skills to be developed.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the variation in individuals of the same species having environmental or genetic causes; **variation being continuous or discontinuous**

(b) sexual reproduction leading to offspring being genetically different from the parents, unlike asexual reproduction where genetically identical offspring called clones are produced from a single parent; sexual reproduction therefore giving rise to variation

(c) the facts that new genes result from changes, mutations, in existing genes; mutations occur at random; most mutations have no effect but some can be beneficial or harmful; mutation rates can be increased by ionising radiation

(d) some mutations causing conditions which may be passed on in families, as is shown by the mechanism of inheritance of cystic fibrosis; the interpretation of family trees showing this; the issues surrounding the development and use of gene therapy in cystic fibrosis sufferers

(e) heritable variation as the basis of evolution

(f) how individuals with characteristics adapted to their environment are more likely to survive and breed successfully; the use and limitations of a model to illustrate the effect of camouflage colouring in predator and prey relationships

(g) how the genes which have enabled these better adapted individuals to survive are then passed on to the next generation; natural selection as proposed by Alfred Russell Wallace and Charles Darwin; how the process of natural selection is sometimes too slow for organisms to adapt to new environmental conditions and so organisms may become extinct

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(h) how evolution is ongoing as illustrated by antibiotic resistance in bacteria, pesticide resistance and warfarin resistance in rats

(i) the potential importance for medicine of our increasing understanding of the human genome

SPECIFIED PRACTICAL WORK

- Investigation into variation in organisms

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2.5 RESPONSE AND REGULATION

Overview

This topic comprises response and regulation in both humans and plants. Within the content of the nervous system in humans, reflex actions and the structure and function of the eye are covered. Regulation is discussed with regard to blood glucose and temperature. There is consideration of the effect of plant hormones on plant growth.

Working Scientifically

The work on the treatment of diabetes allows learners to appreciate the power of science and explain the application of science. The lifestyle choices section allows the discussion of the personal and social implications of alcohol and drug abuse. The investigation into reaction time will allow the development of investigative skills in the cycle of collecting, presenting and analysing data.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data which is available on the content of this topic. This includes the extraction and interpretation of data from graphs, charts and tables and the translation of information between numerical and graphical forms.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) sense organs as groups of receptor cells which respond to specific stimuli: light, sound, touch, temperature, chemicals and then relay this information as electrical impulses along neurones to the central nervous system

(b) the brain, spinal cord and nerves forming the nervous system; the central nervous system consisting of the brain and spinal cord

(c) the properties of reflex actions: fast, automatic and some are protective, as exemplified by the withdrawal reflex, blinking and pupil size

(d) **the components of a reflex arc: stimulus, receptor, coordinator and effector; be able to label a diagram of a reflex arc to show: receptor, sensory neurone, relay neurone in spinal cord, motor neurone, effector and synapses**

(e) the structure and function of the following parts of the eye: sclera, cornea, pupil, iris, lens, choroid, retina, blind spot and optic nerve and be able to label these on a diagram

(f) the reasons why animals need to regulate the conditions inside their bodies to keep them relatively constant and protected from harmful effects – homeostasis

(g) hormones as chemical messengers, carried by the blood, which control many body functions

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(h) the need to keep blood glucose levels within a constant range, so that when the blood glucose level rises, the pancreas releases the hormone insulin, a protein, into the blood, which causes the liver to reduce the blood glucose level by converting glucose to insoluble glycogen and then storing it

(i) diabetes as a common disease in which a person has a high blood glucose level; type 1 diabetes caused by the body not producing insulin; type 2 diabetes caused by the body cells not properly responding to the insulin that is produced; the causes of both types of diabetes; treatments for diabetes

(j) the structure of a section through the skin: hair, erector muscle, sweat gland, sweat duct, sweat pore, blood vessels; be able to label these structures on a diagram

(k) the role of these structures in temperature regulation: change in diameter of blood vessels, sweating, erection of hairs; shivering as a means of generating heat

(l) **the principles of negative feedback mechanisms to maintain optimum conditions inside the body as illustrated by the control of blood glucose levels by insulin and glucagon and by the control of body temperature**

(m) the fact that some conditions are affected by lifestyle choices; the effects that alcohol and drug abuse have on the chemical processes in people's bodies the incidence of diabetes (type 2) and the possible relationship with lifestyle

(n) the positive response of plant shoots to light, phototropism, and plant roots to gravity, gravitropism; phototropism being due to a plant hormone, called auxin

SPECIFIED PRACTICAL WORK

- Investigation into factors affecting reaction time

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2.6 ROLE OF KIDNEY IN HOMEOSTASIS

Overview

This topic covers the structure and function of the kidney and its role in the regulation of the water content of the blood. The detail of the nephron is required along with the role of ADH. The treatment for kidney failure is also considered.

Working Scientifically

Discussion of the advantages of the use of dialysis and kidney transplants in the treatment of kidney failure can develop the consideration of ethical issues. The dialysis machine is also useful to use as a representational model of the kidney to show its function.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data which is available on the content of this topic. This includes the interpretation of data about the changes in the level of substances present in the filtrate due to passage through the kidney allowing learners to present reasoned explanations and carry out mathematical analysis.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the functions of the kidneys: to regulate the water content of the blood and remove waste products from the blood and why this is necessary

(b) the structure of the human excretory system to show kidneys, renal arteries, renal veins, aorta, vena cava, ureters, bladder, urethra; be able to label a diagram to show these and indicate the direction of blood flow in the blood vessels

(c) the structure of a section through a kidney to include: renal artery, renal vein, cortex, medulla, pelvis, ureter

(d) **the structure of a nephron and its associated blood supply to show: capillary knot, Bowman's capsule, tubule, collecting duct, capillary network, arteriole to and from capillary knot and be able to label these on a diagram**

(e) **why the level of substances present in the filtrate changes as it passes through the kidney; the process of filtration under pressure; the selective reabsorption of glucose, some salts and much of the water**

(f) the fact that the waste, a solution containing urea and excess salts called urine, passes from the kidneys in the ureters to the bladder where it is stored before being passed out of the body; the presence of blood or cells in the urine indicates disease in the kidney; the presence of glucose in the urine can indicate diabetes

(g) how the kidneys regulate the water content of the blood: producing dilute urine if there is too much water in the blood or concentrated urine if there is a shortage of water in the blood; **the role of anti-diuretic hormone (ADH)**

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(h) the fact that dialysis can be used to treat kidney failure; **how a dialysis machine works**

(i) the fact that a diseased kidney may be replaced by a healthy one by transplant from a donor of a similar 'tissue type' to the recipient; how the donor kidney may be rejected by the body and attacked by the immune system, unless drugs are taken which suppress the immune response

(j) the advantages and disadvantages of the use of dialysis and transplants

SPECIFIED PRACTICAL WORK

- Test artificial urine samples for the presence of protein and glucose

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2.7 MICRO-ORGANISMS AND THEIR APPLICATIONS

Overview

This topic covers the techniques used in the culture of micro-organisms and factors which affect this. The industrial use of *Penicillium* in the production of penicillin is also considered.

Working Scientifically

The investigation into the effect of antibiotics on bacterial growth allows a number of practical skills to be developed. These include using a range of apparatus; having due regard to health and safety considerations; interpreting observations; presenting reasoned explanations; communicating the report through paper based and electronic reports. The industrial production of penicillin will allow learners to explain the technological applications of science.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from the antibiotic investigation. These include plotting variables; making order of magnitude calculations; finding arithmetic means. Learners should develop their skills in geometry by calculating the cross-sectional areas of bacterial cultures and clear agar jelly using πr^2.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the safe use of basic aseptic techniques involved in inoculating, plating and incubating micro-organisms

(b) the link between the number of bacterial colonies on the agar and the number of bacteria in the original sample

(c) the effect of temperature on the growth of bacteria and understand its application in food storage

(d) the factors which influence its growth of the fungus *Penicillium* when grown industrially in a fermenter; how the penicillin is extracted from the surrounding medium

SPECIFIED PRACTICAL WORK

- Investigation into the effect of antibiotics on bacterial growth

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2.8 DISEASE, DEFENCE AND TREATMENT

Overview

This topic explores the relationship between health and disease. It includes the different causes of disease, how communicable diseases can be spread and how disease can be prevented. Natural defence mechanisms are covered along with how diseases can be treated and how new medicines are developed.

Working Scientifically

This topic provides many opportunities to explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. There are also a number of topics where learners will appreciate the power and limitations of science and consider any ethical issues which may arise. The understanding of the development of medicines will also develop the learners' skills in evaluating risks in the wider societal context, including perception of risk in relation to data and consequences. The discussion of factors influencing parental decision with regard to vaccination will also develop the skills of recognising the importance of peer review of results and of communicating results to a range of audiences.

Mathematical skills

There are a number of opportunities for the development of mathematical skills from data which is available on the content of this topic. This could include the translation of information between graphical and numerical forms, the construction and interpretation of frequency tables and diagrams, bar charts and histograms, the use of a scatter diagram to identify a correlation between two variables. When considering health data, learners should understand the principles of sampling.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the harmless nature of most micro-organisms, many performing vital functions; some micro-organisms called pathogens, cause disease

(b) the fact that pathogens include micro-organisms such as bacteria, viruses, protists and fungi; the basic structure of a bacterial cell and virus

(c) the types of organisms which can cause communicable diseases: viruses, bacteria and fungi; the means by which they can be spread: by contact, aerosol, body fluids, water, insects, contaminated food

(d) the following diseases: HIV / AIDS, Chlamydia and Malaria, this should include the causative agent, the effect on the infected organism and how they can be prevented from spreading

(e) the means by which the body defends itself from disease: intact skin forming a barrier against micro-organisms; blood clots to seal wounds; phagocytes in the blood ingesting micro-organisms; lymphocytes producing antibodies and antitoxins

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(f) an antigen as a molecule that is recognised by the immune system; foreign antigens triggering a response by lymphocytes, which secrete antibodies specific to the antigens; the function of antibodies

(g) how vaccination can be used to protect humans from infectious disease; the factors influencing parents in decisions about whether to have children vaccinated or not

(h) **the fact that a vaccine contains antigens derived from a disease-causing organism; how a vaccine will protect against infection by that organism, by stimulating the lymphocytes to produce antibodies to that antigen; how vaccines may be produced which protect against bacteria and viruses**

(i) **how after an antigen has been encountered, memory cells remain in the body and antibodies are produced very quickly if the same antigen is encountered a second time; how this memory provides immunity following a natural infection and after vaccination; the highly specific nature of this response**

(j) the fact that antibiotics, including penicillin, were originally medicines produced by living organisms, such as fungi; how antibiotics help to cure bacterial disease by killing the infecting bacteria or preventing their growth but do not kill viruses

(k) how some resistant bacteria, such as MRSA, can result from the over use of antibiotics; effective control measures for MRSA

(l) how some conditions can be prevented by treatment with drugs or by other therapies

(m) how new drug treatments may have side effects and that extensive, large scale, rigorous testing is required; the associated risks, benefits and ethical issues involved in the development of new drug treatments, including the use of animals for testing drugs and whether this is superseded by new technologies

(n) the process of discovery and development of potential new medicines, including preclinical and clinical testing: preclinical stages involve testing on human cells grown in the laboratory, then on animals and finally a group of healthy volunteers, the new medicines are then taken for clinical testing using small groups of patients

(o) **how monoclonal antibodies are produced from activated lymphocytes which are able to divide continuously, this produces very large numbers of identical antibodies, specific to one antigen**

(p) **the medical uses of monoclonal antibodies including:**

- **diagnosis of diseases including Chlamydia and HIV**
- **tissue typing for transplants**
- **monitoring the spread of malaria**
- **supporting chemotherapy for cancers**

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2.3 Unit 3

PRACTICAL ASSESSMENT

10% of qualification

This assessment gives learners the opportunity to demonstrate their ability to work scientifically. This will include experimental skills and strategies and skills in analysis and evaluation.

The practical assessment is untiered and will take place in the first half of the spring term (January – February). It is recommended that this should be in the final year of study. Each year, WJEC will provide two tasks based on the content of GCSE Biology. Learners are only required to submit **one** task so centres can select which one they wish to use with their learners.

The tasks will be externally marked by WJEC and will change on an annual basis.

The details required for the planning and administration of the practical assessment will be provided to centres at appropriate times prior to the assessment.

Each task comprises two sections:

Section A - Obtaining results (6 marks)

Learners will be permitted to work in groups of no more than three, to obtain results from a given experimental method. This will be carried out under a limited level of control i.e. learners may work with others to obtain results but they must provide their own responses to the questions set. Teacher assistance should not normally be required, but may be given if equipment failure occurs. Section A will be completed in one session of 60 minutes duration.

Section B - Analysing and evaluating results (24 marks)

Learners will be assessed on their ability to analyse and evaluate the data obtained in section A. They will require access to their section A assessment in order to complete this. Section B will be carried out under a high level of control i.e. learners must work individually. This section is to be completed with no teacher feedback or assistance allowed and under formal supervision. Section B will be completed in one session of 60 minutes duration.

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3 ASSESSMENT

3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must:

AO1
Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures

AO2
Apply knowledge and understanding of scientific ideas, processes, techniques and procedures

AO3
Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to:

- make judgements and reach conclusions
- develop and refine practical design and procedures

The table below shows the weighting of each assessment objective for each unit and for the qualification as a whole.

	AO1	AO2	AO3
Unit 1	18%	18%	9%
Unit 2	18%	18%	9%
Unit 3	4%	4%	2%
Overall weighting	**40%**	**40%**	**20%**

For each series:
- the weighting for the assessment of mathematical skills will be a minimum of 10%
- the weighting for the assessment of practical skills will be a minimum of 15%.

The ability to select, organise and communicate information and ideas coherently using scientific convention and vocabulary will be tested across the assessment objectives.

For each series, writing accurately will be assessed in specified questions that require extended writing (i.e. QER questions) in Units 1 and 2.
Writing accurately takes into account the candidate's use of specialist language. It also takes into account the candidate's spelling, punctuation and grammar.

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4 TECHNICAL INFORMATION

4.1 Making entries

This is a unitised qualification which allows for an element of staged assessment.

Assessment opportunities will be available in the summer assessment period each year, until the end of the life of the specification.

Unit 1 will be available in 2017 (and each year thereafter). Unit 2 and Unit 3 will be available in 2018 (and each year thereafter) and the qualification will be awarded for the first time in Summer 2018.

There are two tiers of entry available for this qualification: Higher Tier (Grades A* - D) and Foundation Tier (Grades C - G). Unit 3 (practical assessment) is untiered. In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

At least 40% of the assessment must be taken at the end of the course to satisfy the requirement for terminal assessment and the results from the terminal assessment must contribute to the subject award.

Candidates may re-sit units ONCE ONLY prior to certification for the qualification, with the better result contributing to the qualification. Individual unit results, prior to the certification of the qualification, have a shelf-life limited only by that of the qualification.

A candidate may retake the whole qualification more than once.

The entry codes appear below.

	Title	Entry codes	
		English-medium	**Welsh-medium**
Unit 1	Cells, Organ Systems and Ecosystems (Foundation Tier)	3400U1	3400N1
	Cells, Organ Systems and Ecosystems (Higher Tier)	3400UA	3400NA
Unit 2	Variation, Homeostasis and Micro-organisms (Foundation Tier)	3400U2	3400N2
	Variation, Homeostasis and Micro-organisms (Higher Tier)	3400UB	3400NB
Unit 3	Practical Assessment	3400U3	3400N3
GCSE Qualification cash-in		3400QS	3400CS

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

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4.2 Grading, awarding and reporting

There are two tiers of entry available for this qualification: Higher Tier (Grades A* - D) and Foundation Tier (Grades C - G). In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

The Uniform Mark Scale (UMS) is used in unitised specifications as a device for reporting, recording and aggregating candidates' unit assessment outcomes. The UMS is used so that candidates who achieve the same standard will have the same uniform mark, irrespective of when the unit was taken.

Individual unit results reported on UMS have the following grade equivalences:

Grade	MAX.	A*	A	B	C	D	E	F	G
Units 1 - 2	180	162	144	126	108	90	72	54	36
Unit 3	40	36	32	28	24	20	16	12	8

For Units 1 - 2, which are tiered, the maximum uniform mark available on the foundation tier of the assessment will be 125 (i.e. 1 mark less than the minimum mark needed to achieve a grade B on the unit). As Unit 3 is untiered, the full range of uniform marks is available in the unit.

GCSE qualifications are reported on an eight point scale from A*- G, where A* is the highest grade. Results not attaining the minimum standard for the award will be reported as U (unclassified) and learners will not receive a certificate.

The uniform marks obtained for each unit are added up and the subject grade is based on this total. The total results reported on UMS will have the following grade equivalences:

UMS total	A*	A	B	C	D	E	F	G
Subject Award	360	320	280	240	200	160	120	80

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APPENDIX A

Working Scientifically

1. Development of scientific thinking

- understand how scientific methods and theories develop over time
- use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts
- appreciate the power and limitations of science and consider any ethical issues which may arise
- explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments
- evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences
- recognise the importance of peer review of results and of communicating results to a range of audiences

2. Experimental skills and strategies

- use scientific theories and explanations to develop hypotheses
- plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena
- apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment
- carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative
- make and record observations and measurements using a range of apparatus and methods
- evaluate methods and suggest possible improvements and further investigations

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3. Analysis and evaluation

- apply the cycle of collecting, presenting and analysing data, including:
    - presenting observations and other data using appropriate methods
    - translating data from one form to another
    - carrying out and representing mathematical analysis
    - representing distributions of results and make estimations of uncertainty
    - interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions
    - presenting reasoned explanations including relating data to hypotheses
    - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
    - communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms

4. Scientific vocabulary, quantities, units, symbols and nomenclature

- use scientific vocabulary, terminology and definitions
- recognise the importance of scientific quantities and understand how they are determined
- use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate
- use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconvert units
- **use an appropriate number of significant figures in calculation**

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APPENDIX B

Mathematical Skills

This table shows the mathematical skills which can be assessed. Skills which will be assessed at higher tier only are shown in bold type.

	Skill
1	*Arithmetic and numerical computation*
	Recognise and use expressions in decimal form
	Recognise expressions in standard form
	Use ratios, fractions and percentages
2	*Handling data*
	Use an appropriate number of significant figures
	Find arithmetic means
	Construct and interpret tables and diagrams
	Understand the principles of sampling as applied to scientific data
	Understand simple probability
	Make order of magnitude calculations
3	*Algebra*
	Substitute numerical values into algebraic equations and solve them using appropriate units for physical quantities
4	*Graphs*
	Translate information between graphical and numeric form
	Plot two variables from experimental or other data
	Interpret the slope of a linear graph
5	*Geometry and trigonometry*
	Calculate areas of triangles and rectangles, surface areas and volumes of cubes

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