OCR
RECOGNISING ACHIEVEMENT

AS/A Level GCE

GCE Biology

OCR Advanced Subsidiary GCE in Biology H021

OCR Advanced GCE in Biology H421

specification

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Contents

Vertical black lines indicate a significant change to the previous printed version.

1 About these Qualifications

This booklet contains OCR's Advanced Subsidiary (AS) GCE and Advanced GCE specifications in Biology for teaching from September 2013.

This specification allows teachers to adopt a flexible approach to the delivery of AS and A Level Biology. The course has been designed to enable centres to deliver the designated units (F211–F216) using the framework provided or to design a customised course. There is also a choice of assessed practical tasks available to all centres.

The specification is divided into biological topics, each containing different key concepts of biology. Once the key features of a biological topic have been developed, applications are considered. For assessment purposes, knowledge and understanding of key concepts are treated separately at AS; important links between different areas of biology are largely assessed synoptically at A2. While the teaching of practical skills may be integrated with the theoretical topics, they are assessed separately. This allows skills to be developed in a way suited to each individual centre.

1.1 The Three-Unit AS GCE

The Advanced Subsidiary GCE is both a 'stand-alone' qualification and also the first half of the corresponding Advanced GCE. The AS GCE is assessed at a standard appropriate for candidates who have completed the first year of study (both in terms of teaching time and content) of the corresponding two-year Advanced GCE course, ie between GCSE and Advanced GCE.

From September 2013 the AS GCE is made up of **three** mandatory units, of which **two** are externally assessed and **one** is internally assessed and will include the assessment of practical skills. These units form 50% of the corresponding six-unit Advanced GCE.

1.2 The Six-Unit Advanced GCE

From September 2013 the Advanced GCE is made up of **three** mandatory units at AS and **three** further mandatory units at A2.

Two of the AS and **two** of the A2 units are externally assessed.

The third AS unit and the third A2 unit are internally assessed and will include the assessment of practical skills.

1.3 Qualification Titles and Levels

These qualifications are shown on a certificate as:

- OCR Advanced Subsidiary GCE in Biology.
- OCR Advanced GCE in Biology.

Both qualifications are Level 3 in the National Qualifications Framework (NQF).

1.4 Aims

The aims of these specifications are to encourage candidates to:

- develop their interest in and enthusiasm for biology, including developing an interest in further study and careers in biology;
- appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society;
- develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works*;
- develop essential knowledge and understanding of different areas of biology and how they relate to each other.

1.5 Prior Learning/Attainment

These specifications have been developed for students who wish to continue with a study of biology at Level 3 in the National Qualifications Framework (NQF). The AS specification has been written to provide progression from GCSE Science and GCSE Additional Science, or from GCSE Biology; achievement at a minimum of grade C in these qualifications should be seen as the normal requisite for entry to AS Biology. However, students who have successfully taken other Level 2 qualifications in science or applied science with appropriate biology content may also have acquired sufficient knowledge and understanding to begin the AS Biology course. Other students without formal qualifications may have acquired sufficient knowledge of biology to enable progression onto the course.

Recommended prior learning for the AS units is shown in the introduction to each AS unit. The A2 units build upon the knowledge and understanding acquired at AS.

Recommended prior learning for the A2 course is successful performance at Advanced Subsidiary Biology.

2 Summary of Content

2.1 AS Units

Unit F211: *Cells, Exchange and Transport*

- Module 1: Cells
  - 1.1.1 Cell Structure
  - 1.1.2 Cell Membranes
  - 1.1.3 Cell Division, Cell Diversity and Cellular Organisation
- Module 2: Exchange and Transport
  - 1.2.1 Exchange Surfaces and Breathing
  - 1.2.2 Transport in Animals
  - 1.2.3 Transport in Plants

Unit F212: *Molecules, Biodiversity, Food and Health*

- Module 1: Biological Molecules
  - 2.1.1 Biological Molecules
  - 2.1.2 Nucleic Acids
  - 2.1.3 Enzymes
- Module 2: Food and Health
  - 2.2.1 Diet and Food Production
  - 2.2.2 Health and Disease
- Module 3: Biodiversity and Evolution
  - 2.3.1 Biodiversity
  - 2.3.2 Classification
  - 2.3.3 Evolution
  - 2.3.4 Maintaining Biodiversity

Unit F213: *Practical Skills In Biology 1*

- Practical tasks

2.2 A2 Units

Unit F214: *Communication, Homeostasis and Energy*

- Module 1: Communication and Homeostasis

  4.1.1 Communication
  4.1.2 Nerves
  4.1.3 Hormones

- Module 2: Excretion

  4.2.1 Excretion

- Module 3: Photosynthesis

  4.3.1 Photosynthesis

- Module 4: Respiration

  4.4.1 Respiration

Unit F215: *Control, Genomes and Environment*

- Module 1: Cellular Control and Variation

  5.1.1 Cellular Control
  5.1.2 Meiosis and Variation

- Module 2: Biotechnology and Gene Technologies

  5.2.1 Cloning in Plants and Animals
  5.2.2 Biotechnology
  5.2.3 Genomes and Gene Technologies

- Module 3: Ecosystems and Sustainability

  5.3.1 Ecosystems
  5.3.2 Populations and Sustainability

- Module 4: Responding to the Environment

  5.4.1 Plant Responses
  5.4.2 Animal Responses
  5.4.3 Animal Behaviour

Unit F216 *Practical Skills in Biology 2*

- Practical tasks

3 Unit Content

Each unit is divided into a number of teaching modules. Within each module, the content is divided into two columns: **Context and Exemplification** and **Assessable Learning Outcomes**. Only the statements in the right hand column will be examined; statements in the left hand column are included to provide guidance on delivery. References to HSW (How Science Works) are to Appendix B. References to the GCSE Criteria for Science are to Appendix C.

3.1 AS Unit F211: *Cells, Exchange and Transport*

Module 1: Cells

Cells are the basic units of all living things. Organisms function because of communication and co-operation between specialised cells.

Cell division is a fundamental process, necessary for reproduction, growth and repair.

Links

GCSE Criteria for Science: 3.7(i) (c), (d); 3.9(i) (a)

1.1.1 Cell Structure

Context and exemplification	**Assessable learning outcomes**
The cell is the basic unit of all living things. An understanding of how to use a light microscope is developed along with an understanding of why electron microscopes are so important in biology. Careful observation using microscopes reveals details of cell structure and ultrastructure and provides evidence to support hypotheses regarding the roles of cells and organelles.	Candidates should be able to: (a) state the resolution and magnification that can be achieved by a light microscope, a transmission electron microscope and a scanning electron microscope; (b) explain the difference between magnification and resolution; (c) explain the need for staining samples for use in light microscopy and electron microscopy; (d) calculate the linear magnification of an image (HSW3); (e) describe and interpret drawings and photographs of eukaryotic cells as seen under an electron microscope and be able to recognise the following structures: nucleus, nucleolus, nuclear envelope, rough and smooth endoplasmic reticulum (ER), Golgi apparatus, ribosomes, mitochondria, lysosomes, chloroplasts, plasma (cell surface) membrane, centrioles, flagella and cilia; (f) outline the functions of the structures listed in (e);

	(g) outline the interrelationship between the organelles involved in the production and secretion of proteins (no detail of protein synthesis is required); (h) explain the importance of the cytoskeleton in providing mechanical strength to cells, aiding transport within cells and enabling cell movement; (i) compare and contrast, with the aid of diagrams and electron micrographs, the structure of prokaryotic cells and eukaryotic cells; (j) compare and contrast, with the aid of diagrams and electron micrographs, the structure and ultrastructure of plant cells and animal cells.

1.1.2 Cell Membranes

Context and exemplification	**Assessable learning outcomes**
Membranes are a fundamental part of the cell. The structure of the cell surface membrane allows cells to communicate with each other. Understanding this ability to communicate is important as scientists increasingly make use of membrane-bound receptors as sites for the action of medicinal drugs. Understanding how different substances enter cells is also crucial to the development of mechanisms for the administration of drugs.	Candidates should be able to: (a) outline the roles of membranes within cells and at the surface of cells; (b) state that plasma (cell surface) membranes are partially permeable barriers; (c) describe, with the aid of diagrams, the fluid mosaic model of membrane structure (HSW1); (d) describe the roles of the components of the cell membrane; phospholipids, cholesterol, glycolipids, proteins and glycoproteins; (e) outline the effect of changing temperature on membrane structure and permeability; (f) explain the term *cell signaling*; (g) explain the role of membrane-bound receptors as sites where hormones and drugs can bind; (h) explain what is meant by *passive transport* (diffusion and facilitated diffusion including the role of membrane proteins), *active transport*, *endocytosis* and *exocytosis;* (i) explain what is meant by *osmosis*, in terms of water potential. (**No** calculations of water potential will be required); (j) recognise and explain the effects that solutions of different water potentials can have upon plant and animal cells (HSW3).

Context and exemplification	Assessable learning outcomes
During the cell cycle, genetic information is copied and passed to daughter cells. Microscopes can be used to view the different stages of the cycle. In multicellular organisms, stem cells are modified to produce many different types of specialised cell. Understanding how stems cells can be modified has huge potential in medicine. To understand how a whole organism functions, it is essential to understand the importance of cooperation between cells, tissues, organs and organ systems.	Candidates should be able to: (a) state that mitosis occupies only a small percentage of the cell cycle and that the remaining percentage includes the copying and checking of genetic information; (b) describe, with the aid of diagrams and photographs, the main stages of mitosis (behaviour of the chromosomes, nuclear envelope, cell membrane and centrioles); (c) explain the meaning of the term *homologous pair of chromosomes*; (d) explain the significance of mitosis for growth, repair and asexual reproduction in plants and animals; (e) outline, with the aid of diagrams and photographs, the process of cell division by budding in yeast; (f) state that cells produced as a result of meiosis are not genetically identical (details of meiosis are not required); (g) define the term *stem cell*; (h) define the term *differentiation*, with reference to the production of erythrocytes (red blood cells) and neutrophils derived from stem cells in bone marrow, and the production of xylem vessels and phloem sieve tubes from cambium; (i) describe and explain, with the aid of diagrams and photographs, how cells of multicellular organisms are specialised for particular functions, with reference to erythrocytes (red blood cells), neutrophils, epithelial cells, sperm cells, palisade cells, root hair cells and guard cells; (j) explain the meaning of the terms *tissue*, *organ* and *organ system*; (k) explain, with the aid of diagrams and photographs, how cells are organised into tissues, using squamous and ciliated epithelia, xylem and phloem as examples; (l) discuss the importance of cooperation between cells, tissues, organs and organ systems (HSW4).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Make serial dilutions;
- Measure the effect of solutions of different water potentials on plant tissues;
- Use a colorimeter to investigate the effect of temperature on membrane permeability.

Collection and presentation of qualitative (descriptive) data:

- Produce a root tip squash;
- Use a light microscope to produce annotated drawings of the stages of mitosis.

Presentation, analysis and evaluation of quantitative data:

- Calculate rates of diffusion;
- Plot graphs of rate against temperature or mean change in mass against concentration.

Evaluation of data collection strategies:

- Identify limitations in measuring change in mass in osmosis investigations.

Module 2: Exchange and Transport

In order to survive, living cells need a supply of oxygen and nutrients. In single cells and small organisms these materials can enter by passive processes. However, once an organism reaches a critical size it requires specialised exchange surfaces and transport systems.

Links
GCSE Criteria for Science: 3.7(i) (a), (d); 3.9(i) (a)

1.2.1 Exchange Surfaces and Breathing

Context and exemplification	**Assessable learning outcomes**
The gas exchange surface in the lungs is used to exemplify the properties and functions of exchange surfaces in living things.	Candidates should be able to: (a) explain, in terms of surface area:volume ratio, why multicellular organisms need specialised exchange surfaces and single-celled organisms do not (HSW1); (b) describe the features of an efficient exchange surface, with reference to diffusion of oxygen and carbon dioxide across an alveolus; (c) describe the features of the mammalian lung that adapt it to efficient gaseous exchange; (d) describe, with the aid of diagrams and photographs, the distribution of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli of the mammalian gaseous exchange system; (e) describe the functions of cartilage, cilia, goblet cells, smooth muscle and elastic fibres in the mammalian gaseous exchange system; (f) outline the mechanism of breathing (inspiration and expiration) in mammals, with reference to the function of the rib cage, intercostal muscles and diaphragm; (g) explain the meanings of the terms *tidal volume* and *vital capacity;* (h) describe how a spirometer can be used to measure vital capacity, tidal volume, breathing rate and oxygen uptake; (i) analyse and interpret data from a spirometer.

Context and exemplification	Assessable learning outcomes
As animals become larger and more active, transport systems become essential to supply nutrients to and remove waste from individual cells. Controlling supply of nutrients and removal of waste requires the co-ordinated activity of the heart and circulatory system.	Candidates should be able to: (a) explain the need for transport systems in multicellular animals in terms of size, level of activity and surface area:volume ratio; (b) explain the meaning of the terms *single circulatory system* and *double circulatory system*, with reference to the circulatory systems of fish and mammals; (c) explain the meaning of the terms *open circulatory system* and *closed circulatory system*, with reference to the circulatory systems of insects and fish; (d) describe, with the aid of diagrams and photographs, the external and internal structure of the mammalian heart; (e) explain, with the aid of diagrams, the differences in the thickness of the walls of the different chambers of the heart in terms of their functions; (f) describe the cardiac cycle, with reference to the action of the valves in the heart; (g) describe how heart action is coordinated with reference to the sinoatrial node (SAN), the atrioventricular node (AVN) and the Purkyne tissue; (h) interpret and explain electrocardiogram (ECG) traces, with reference to normal and abnormal heart activity; (i) describe, with the aid of diagrams and photographs, the structures and functions of arteries, veins and capillaries; (j) explain the differences between blood, tissue fluid and lymph; (k) describe how tissue fluid is formed from plasma; (l) describe the role of haemoglobin in carrying oxygen and carbon dioxide; (m) describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide levels (the Bohr effect); (n) explain the significance of the different affinities of fetal haemoglobin and adult haemoglobin for oxygen.

Context and exemplification	Assessable learning outcomes
As plants become larger and more complex, transport systems become essential to supply nutrients to and remove waste from individual cells. The supply of nutrients from the soil relies upon the flow of water through a vascular system, as does the movement of the products of photosynthesis.	Candidates should be able to: (a) explain the need for transport systems in multicellular plants in terms of size and surface area:volume ratio; (b) describe, with the aid of diagrams and photographs, the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants; (c) describe, with the aid of diagrams and photographs, the structure and function of xylem vessels, sieve tube elements and companion cells; (d) define the term *transpiration*; (e) explain why transpiration is a consequence of gaseous exchange; (f) describe the factors that affect transpiration rate; (g) describe, with the aid of diagrams, how a potometer is used to estimate transpiration rates (HSW3); (h) explain, in terms of water potential, the movement of water between plant cells, and between plant cells and their environment. (**No** calculations involving water potential will be set); (i) describe, with the aid of diagrams, the pathway by which water is transported from the root cortex to the air surrounding the leaves, with reference to the Casparian strip, apoplast pathway, symplast pathway, xylem and the stomata; (j) explain the mechanism by which water is transported from the root cortex to the air surrounding the leaves, with reference to adhesion, cohesion and the transpiration stream; (k) describe, with the aid of diagrams and photographs, how the leaves of some xerophytes are adapted to reduce water loss by transpiration; (l) explain translocation as an energy-requiring process transporting assimilates, especially sucrose, between sources (eg leaves) and sinks (eg roots, meristem); (m) describe, with the aid of diagrams, the mechanism of transport in phloem involving active loading at the source and removal at the sink, and the evidence for and against this mechanism (HSW1, 7a).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Investigate surface area to volume relationships using agar blocks and dye;
- Make measurements using a spirometer;
- Use a potometer to compare xerophytes and non-xerophytes;
- Use a potometer to investigate the effects of environmental factors on water uptake.

Collection and presentation of qualitative (descriptive) data:

- Make measurements and annotated drawings during a heart dissection;
- Use a light microscope to make annotated drawings of lung tissue;
- Use a light microscope to make annotated drawings of blood vessels.

Presentation, analysis and evaluation of quantitative data:

- Calculate water uptake rates.

Evaluation of data collection strategies:

- Identify the limitations of using a potometer.

3.2 AS Unit F212: *Molecules, Biodiversity, Food and Health*

Module 1: Biological Molecules

Proteins, carbohydrates, lipids and nucleic acids are key biological macromolecules with important roles in living organisms.

Links

GCSE Criteria for Science: 3.7(i) (c), (e); 3.9(i) (a)

2.1.1 Biological Molecules

Context and exemplification	**Assessable learning outcomes**
Proteins, carbohydrates and lipids are three of the key groups of macromolecules essential for life. Understanding the structure of these macromolecules allows an understanding of their functions in living organisms.	Candidates should be able to: (a) describe how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water in living organisms (HSW1); (b) describe, with the aid of diagrams, the structure of an amino acid; (c) describe, with the aid of diagrams, the formation and breakage of peptide bonds in the synthesis and hydrolysis of dipeptides and polypeptides; (d) explain, with the aid of diagrams, the term *primary structure;* (e) explain, with the aid of diagrams, the term *secondary structure* with reference to hydrogen bonding; (f) explain, with the aid of diagrams, the term *tertiary structure*, with reference to hydrophobic and hydrophilic interactions, disulfide bonds and ionic interactions; (g) explain, with the aid of diagrams, the term *quaternary structure*, with reference to the structure of haemoglobin; (h) describe, with the aid of diagrams, the structure of a collagen molecule; (i) compare the structure and function of haemoglobin (as an example of a globular protein) and collagen (as an example of a fibrous protein); (j) describe, with the aid of diagrams, the molecular structure of alpha-glucose as an example of a monosaccharide carbohydrate; (k) state the structural difference between alpha- and beta-glucose; (l) describe, with the aid of diagrams, the formation and breakage of glycosidic bonds in the synthesis and hydrolysis of a disaccharide (maltose) and a polysaccharide (amylose);

	(m) compare and contrast the structure and functions of starch (amylose) and cellulose; (n) describe, with the aid of diagrams, the structure of glycogen; (o) explain how the structures of glucose, starch (amylose), glycogen and cellulose molecules relate to their functions in living organisms; (p) compare, with the aid of diagrams, the structure of a triglyceride and a phospholipid; (q) explain how the structures of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms; (r) describe how to carry out chemical tests to identify the presence of the following molecules: protein (biuret test), reducing and non-reducing sugars (Benedict's test), starch (iodine solution) and lipids (emulsion test); (s) describe how the concentration of glucose in a solution may be determined using colorimetry (HSW3).

2.1.2 Nucleic Acids

Context and exemplification	**Assessable learning outcomes**
Understanding the structure of nucleic acids allows an understanding of their role in the storage of genetic information and the functioning of the cell.	Candidates should be able to: (a) state that deoxyribonucleic acid (DNA) is a polynucleotide, usually double stranded, made up of nucleotides containing the bases adenine (A), thymine (T), cytosine (C) and guanine (G); (b) state that ribonucleic acid (RNA) is a polynucleotide, usually single stranded, made up of nucleotides containing the bases adenine (A), uracil (U), cytosine (C) and guanine (G); (c) describe, with the aid of diagrams, how hydrogen bonding between complementary base pairs (A to T, G to C) on two antiparallel DNA polynucleotides leads to the formation of a DNA molecule, and how the twisting of DNA produces its 'double-helix' shape (HSW1); (d) outline, with the aid of diagrams, how DNA replicates semi-conservatively, with reference to the role of DNA polymerase; (e) state that a gene is a sequence of DNA nucleotides that codes for a polypeptide (HSW3); (f) outline the roles of DNA and RNA in living organisms (the concept of protein synthesis must be considered in outline only).

2.1.3 Enzymes

Context and exemplification	Assessable learning outcomes
Cell function relies upon enzyme-controlled reactions. Knowledge of how enzymes work allows an understanding of the action of metabolic poisons and some drugs.	Candidates should be able to: (a) state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms; (b) state that enzyme action may be intracellular or extracellular; (c) describe, with the aid of diagrams, the mechanism of action of enzyme molecules, with reference to specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex and lowering of activation energy; (d) describe and explain the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity; (e) describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally; (f) explain the effects of competitive and non-competitive inhibitors on the rate of enzyme-controlled reactions, with reference to both reversible and non-reversible inhibitors; (g) explain the importance of cofactors and coenzymes in enzyme-controlled reactions; (h) state that metabolic poisons may be enzyme inhibitors, and describe the action of one named poison; (i) state that some medicinal drugs work by inhibiting the activity of enzymes (HSW6a).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Follow the progress of an enzyme-catalysed reaction;
- Measure the effect of different independent variables and independent variable ranges on an enzyme-catalysed reaction;
- Measure the effect of an inhibitor on an enzyme-catalysed reaction.

Presentation, analysis and evaluation of quantitative data:

- Calculate rates of reaction;
- Plot graphs of mean rate against time or mean rate after a specific time.

Evaluation of data collection strategies:

- Identify limitations that produce inaccurate and/or unreliable results;
- Identify anomalous data.

Module 2: Food and Health

Humans make use of a wide variety of organisms for food, whereas other organisms cause disease.
Good heath is dependent upon diet and on the control and prevention of disease.

Links

GCSE Criteria for Science: 3.7(i) (a), (e); 3.9(i) (b)

2.2.1 Diet and Food Production

Context and exemplification	**Assessable learning outcomes**
A balanced diet is essential for good health. Components of the human diet can be provided by plants, animals and microorganisms. Ensuring the availability of food for human populations is problematic and has been, and continues to be, a key area for research and development.	Candidates should be able to: (a) define the term *balanced diet*; (b) explain how consumption of an unbalanced diet can lead to malnutrition, with reference to obesity (HSW4); (c) discuss the possible links between diet and coronary heart disease (CHD); (d) discuss the possible effects of a high blood cholesterol level on the heart and circulatory system, with reference to high-density lipoproteins (HDL) and low-density lipoprotein (LDL) (HSW1); (e) explain that humans depend on plants for food as they are the basis of all food chains. (**No** details of food chains are required); (f) outline how selective breeding is used to produce crop plants with high yields, disease resistance and pest resistance (HSW6a); (g) outline how selective breeding is used to produce domestic animals with high productivity (HSW6a); (h) describe how the use of fertilisers and pesticides with plants and the use of antibiotics with animals can increase food production (HSW6a, 6b); (i) describe the advantages and disadvantages of using microorganisms to make food for human consumption; (j) outline how salting, adding sugar, pickling, freezing, heat treatment and irradiation can be used to prevent food spoilage by microorganisms.

Context and exemplification	Assessable learning outcomes
"Health is more than simply the absence of disease". Health can be compromised in many ways. Humans are surrounded by parasites and pathogens and have evolved defences against them. Medical intervention can be used to support these natural defences. Smoking is used as an example of a social/environmental factor that has an impact on health.	Candidates should be able to: (a) discuss what is meant by the terms *health* and *disease*; (b) define and discuss the meanings of the terms *parasite* and *pathogen*; (c) describe the causes and means of transmission of malaria, AIDS/HIV and TB (knowledge of the symptoms of these diseases is not required); (d) discuss the global impact of malaria, AIDS/HIV and TB (HSW4, 6a, 7c); (e) define the terms *immune response*, *antigen* and *antibody*; (f) describe the primary defences against pathogens and parasites (including skin and mucus membranes) and outline their importance. (**No** details of skin structure are required); (g) describe, with the aid of diagrams and photographs, the structure and mode of action of phagocytes; (h) describe, with the aid of diagrams, the structure of antibodies; (i) outline the mode of action of antibodies, with reference to the neutralisation and agglutination of pathogens; (j) describe the structure and mode of action of T lymphocytes and B lymphocytes, including the significance of cell signalling and the role of memory cells; (k) compare and contrast the primary and secondary immune responses; (l) compare and contrast active, passive, natural and artificial immunity; (m) explain how vaccination can control disease (HSW6a, 7c); (n) discuss the responses of governments and other organisations to the threat of new strains of influenza each year (HSW7b, 7c); (o) outline possible new sources of medicines, with reference to microorganisms and plants and the need to maintain biodiversity (HSW 6a, 6b, 7b);

(p) describe the effects of smoking on the mammalian gas exchange system, with reference to the symptoms of chronic bronchitis, emphysema (chronic obstructive pulmonary disease) and lung cancer;

(q) describe the effects of nicotine and carbon monoxide in tobacco smoke on the cardiovascular system with reference to the course of events that lead to atherosclerosis, coronary heart disease and stroke;

(r) evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death (HSW3, 6a, 7a, 7b, 7c).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection and presentation of qualitative (descriptive) data:

- Use a light microscope to identify and produce annotated drawings of white blood cells.

Module 3: Biodiversity and Evolution

Evolution has generated a very wide variety of organisms. The fact that all organisms share a common ancestry allows them to be classified.
There is increasing recognition of the need to maintain biodiversity.

Links
GCSE Criteria for Science: 3.7(i) (a), (b); 3.7(iv) (a)

2.3.1 Biodiversity

Context and exemplification	Assessable learning outcomes
Biodiversity is an important indicator in the study of habitats.	Candidates should be able to: (a) define the terms *species*, *habitat* and *biodiversity*; (b) explain how biodiversity may be considered at different levels; habitat, species and genetic; (c) explain the importance of sampling in measuring the biodiversity of a habitat (HSW7a, 7b, 7c); (d) describe how random samples can be taken when measuring biodiversity; (e) describe how to measure species richness and species evenness in a habitat; (f) use Simpson's Index of Diversity (*D*) to calculate the biodiversity of a habitat, using the formula $D = 1-(\Sigma(n/N)^2)$ (HSW3); (g) outline the significance of both high and low values of Simpson's Index of Diversity (*D*); (h) discuss current estimates of global biodiversity (HSW7a, 7b, 7c).

2.3.2 Classification

Context and exemplification	Assessable learning outcomes
Classification is an attempt to impose a hierarchy on the complex and dynamic variety of life on Earth. Classification systems have changed and will continue to change as our knowledge of the biology of organisms develops.	Candidates should be able to: (a) define the terms *classification*, *phylogeny* and *taxonomy*; (b) explain the relationship between classification and phylogeny; (c) describe the classification of species into the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species; (d) outline the characteristic features of the following five kingdoms: Prokaryotae (Monera), Protoctista, Fungi, Plantae, Animalia; (e) outline the binomial system of nomenclature and the use of scientific (Latin) names for species;

	(f) use a dichotomous key to identify a group of at least six plants, animals or microorganisms; (g) discuss the fact that classification systems were based originally on observable features but more recent approaches draw on a wider range of evidence to clarify relationships between organisms, including molecular evidence (HSW1, 7a); (h) compare and contrast the five kingdom and three domain classification systems (HSW4, 7a, 7b).

2.3.3 Evolution

Context and exemplification	**Assessable learning outcomes**
"*Nothing in biology makes sense except in the light of evolution*" Theodosius Dobzhansky, 1973.	Candidates should be able to: (a) define the term *variation*; (b) discuss the fact that variation occurs within as well as between species; (c) describe the differences between continuous and discontinuous variation, using examples of a range of characteristics found in plants, animals and microorganisms; (d) explain both genetic and environmental causes of variation; (e) outline the behavioural, physiological and anatomical (structural) adaptations of organisms to their environments; (f) explain the consequences of the four observations made by Darwin in proposing his theory of natural selection; (HSW1) (g) define the term *speciation*; (h) discuss the evidence supporting the theory of evolution, with reference to fossil, DNA and molecular evidence (HSW1, 4, 7a, 7b); (i) outline how variation, adaptation and selection are major components of evolution; (j) discuss why the evolution of pesticide resistance in insects and drug resistance in microorganisms has implications for humans (HSW6a, 7c).

2.3.4 Maintaining Biodiversity

Context and exemplification	Assessable learning outcomes
Maintaining biodiversity is important for many reasons. Actions to maintain biodiversity must be taken at local, national and global levels.	Candidates should be able to: (a) outline the reasons for the conservation of animal and plant species, with reference to economic, ecological, ethical and aesthetic reasons (HSW6b); (b) discuss the consequences of global climate change on the biodiversity of plants and animals, with reference to changing patterns of agriculture and spread of disease (HSW6a, 6b, 7a, 7b, 7c); (c) explain the benefits for agriculture of maintaining the biodiversity of animal and plant species (HSW6a, 6b, 7c); (d) describe the conservation of endangered plant and animal species, both *in situ* and *ex situ*, with reference to the advantages and disadvantages of these two approaches (HSW4, 6a, 6b); (e) discuss the role of botanic gardens in the *ex situ* conservation of rare plant species or plant species extinct in the wild, with reference to seed banks; (f) discuss the importance of international co-operation in species conservation with reference to The Convention in International Trade in Endangered Species (CITES) and the Rio Convention on Biodiversity (HSW6b, 7b, 7c); (g) discuss the significance of environmental impact assessments (including biodiversity estimates) for local authority planning decisions. (HSW6b, 7c).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Measure the species richness and species evenness in a habitat.

Presentation, analysis and evaluation of quantitative data:

- Calculate Simpson's Index (*D*) for a habitat.

Evaluation of data collection strategies:

- Investigate the limitations of data collection based on random sampling;
- Investigate the problems involved in collecting data in the field.

3.3 AS Unit F213: *Practical Skills in Biology 1*

This unit assesses practical and investigative skills developed within contexts encountered during AS Biology.

Candidates are required to carry out **three** tasks:

1. Qualitative task [10 marks]
2. Quantitative task [10 marks]
3. Evaluative task [20 marks]

Tasks will be chosen from a selection provided by OCR.

The Qualitative and Quantitative tasks will test skills of observation and measurement.

Candidates will carry out these tasks under controlled conditions.

Each task will be internally assessed using a mark scheme provided by OCR.

Candidates may attempt more than one task from each category with the best mark from each category being used to make up the overall mark. Candidates may **not** repeat a task to improve their mark.

Centres will supply OCR with a single mark out of 40.

How Science Works

5a Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.

5b Analyse and interpret data to provide evidence, recognising correlations and causal relationships.

5c Evaluate methodology, evidence and data, and resolve conflicting evidence.

The mark schemes supplied by OCR will be based on the following generic criteria:

1. Qualitative Task

Candidates carry out a practical task using instructions supplied by OCR.

(a) demonstrate skilful and safe practical techniques using suitable **qualitative** methods;

(b) make and record valid observations.

2. Quantitative Task

Candidates carry out a practical task using instructions supplied by OCR.

The data collected in one of the tasks will form the basis of the assessment in the Evaluative task.

(a) demonstrate skilful and safe practical techniques using suitable **quantitative** method;

(b) make and record accurate measurements to an appropriate degree of precision.

3. Evaluative task

This task will extend the quantitative task. Candidates will be required to analyse the data collected from any quantitative task that they have carried out, use scientific knowledge and understanding to explain the data collected (AO1 and AO2) and evaluate the quality of the data and procedures. Evaluative tasks will **not** require additional data collection to be done.

(a) process results quantitatively. Interpret the results to reach valid conclusions;

(b) use scientific knowledge and understanding to suggest explanations for trends and patterns in the data;

(c) identify and explain the main limitations of the data collection strategy. Suggest and give reasons for simple improvements to the experiment;

(d) comment upon the reliability of the data collected; discuss the validity of the conclusions.

The Tasks

Tasks, mark schemes and guidance for teachers and technicians can be downloaded from the OCR Interchange site.

Further advice and guidance on the use and marking of the tasks can be found in the Practical Skills Handbook.

3.4 A2 Unit F214: *Communication, Homeostasis and Energy*

Module 1: Communication and Homeostasis

Organisms respond to changes in their internal and external environment using responses that are controlled and coordinated electrically and/or chemically.

Links

GCSE Criteria for Science: 3.7(i) (a), (d), (e)

From other modules within this specification:

F211 Module 1, Module 2.

4.1.1 Communication

Context and exemplification	**Assessable learning outcomes**
Organisms use chemical and electrical systems to monitor and respond to any deviation from the body's steady state.	Candidates should be able to: (a) outline the need for communication systems within multicellular organisms, with reference to the need to respond to changes in the internal and external environment and to co-ordinate the activities of different organs; (b) state that cells need to communicate with each other by a process called cell signalling; (c) state that neuronal and hormonal systems are examples of cell signalling; (d) define the terms negative feedback, positive feedback and homeostasis; (e) explain the principles of homeostasis in terms of receptors, effectors and negative feedback; (f) describe the physiological and behavioural responses that maintain a constant core body temperature in ectotherms and endotherms, with reference to peripheral temperature receptors, the hypothalamus and effectors in skin and muscles.

4.1.2 Nerves

Context and exemplification	Assessable learning outcomes
In receptors, the energy of a stimulus is transferred into energy in an action potential in a neurone. Transmission between neurones takes place at synapses.	Candidates should be able to: (a) outline the roles of sensory receptors in mammals in converting different forms of energy into nerve impulses; (b) describe, with the aid of diagrams, the structure and functions of sensory and motor neurones; (c) describe and explain how the resting potential is established and maintained; (d) describe and explain how an action potential is generated; (e) describe and explain how an action potential is transmitted in a myelinated neurone, with reference to the roles of voltage-gated sodium ion and potassium ion channels; (f) interpret graphs of the voltage changes taking place during the generation and transmission of an action potential; (g) outline the significance of the frequency of impulse transmission; (h) compare and contrast the structure and function of myelinated and non-myelinated neurones; (i) describe, with the aid of diagrams, the structure of a cholinergic synapse; (j) outline the role of neurotransmitters in the transmission of action potentials; (k) outline the roles of synapses in the nervous system.

Context and exemplification	Assessable learning outcomes
The ways in which specific hormones bring about their effects are used to explain the action of hormones. Treatment of diabetes is used as an example of the use of medical technology in overcoming defects in hormonal control systems. The control of heart rate is used as an example of the integration of nervous and hormonal control.	Candidates should be able to: (a) define the terms *endocrine gland*, *exocrine gland, hormone* and *target tissue*; (b) explain the meaning of the terms *first messenger* and *second messenger*, with reference to adrenaline and cyclic AMP (cAMP); (c) describe the functions of the adrenal glands; (d) describe, with the aid of diagrams and photographs, the histology of the pancreas, and outline its role as an endocrine and exocrine gland; (e) explain how blood glucose concentration is regulated, with reference to insulin, glucagon and the liver; (f) outline how insulin secretion is controlled, with reference to potassium channels and calcium channels in beta cells; (g) compare and contrast the causes of Type 1 (insulin-dependent) and Type 2 (non-insulin-dependent) diabetes mellitus; (h) discuss the use of insulin produced by genetically modified bacteria, and the potential use of stem cells, to treat diabetes mellitus (HSW6a, 7b); (i) outline the hormonal and nervous mechanisms involved in the control of heart rate in humans.

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection and presentation of qualitative (descriptive) data:

- Use a light microscope to make annotated drawings of pancreatic tissue.

Module 2: Excretion

Metabolic processes produce waste products, many of which are toxic. Excretion is an essential process for all living things.

Links

GCSE Criteria for Science: 3.7(i) (a), (e); 3.9(i) (a)

From other modules within this specification:
F211 Module 1, Module 2;
F212 Module 1.

4.2.1 Excretion

Context and exemplification	Assessable learning outcomes
The kidneys, liver and lungs are all involved in the removal of toxic products of metabolism from the blood. The liver also metabolises toxins that have been ingested. The kidneys also play a major role in the control of the water potential of the blood.	Candidates should be able to: (a) define the term *excretion*; (b) explain the importance of removing metabolic wastes, including carbon dioxide and nitrogenous waste, from the body; (c) describe, with the aid of diagrams and photographs, the histology and gross structure of the liver; (d) describe the formation of urea in the liver, including an outline of the ornithine cycle; (e) describe the roles of the liver in detoxification; (f) describe, with the aid of diagrams and photographs, the histology and gross structure of the kidney; (g) describe, with the aid of diagrams and photographs, the detailed structure of a nephron and its associated blood vessels; (h) describe and explain the production of urine, with reference to the processes of ultrafiltration and selective reabsorption; (i) explain, using water potential terminology, the control of the water content of the blood, with reference to the roles of the kidney, osmoreceptors in the hypothalamus and the posterior pituitary gland; (j) outline the problems that arise from kidney failure and discuss the use of renal dialysis and transplants for the treatment of kidney failure (HSW6a, 6b, 7c); (k) describe how urine samples can be used to test for pregnancy and detect misuse of anabolic steroids (HSW6a, 6b).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection and presentation of qualitative (descriptive) data:

- Use a light microscope to make annotate drawings showing the distribution of tissues in the kidney.

Module 3: Photosynthesis

Photosynthesis may be the most important biological process on earth. Plants, animals and many microoganisms depend upon the carbohydrate and oxygen produced by photosynthesis.

GCSE Criteria for Science: 3.7(i) (a); 3.9(i) (b)

From other modules within this specification:

F211 Module 1, Module 2;

F212 Module 1, Module 2, Module 3.

4.3.1 Photosynthesis

Context and exemplification	**Assessable learning outcomes**
Photosynthesis is the process whereby light energy from the Sun is transformed into chemical energy and used to synthesise large organic molecules from inorganic substances. Photosynthesis forms the basis of most food chains.	Candidates should be able to: (a) define the terms *autotroph* and *heterotroph*; (b) state that light energy is used during photosynthesis to produce complex organic molecules; (c) explain how respiration in plants and animals depends upon the products of photosynthesis; (d) state that in plants photosynthesis is a two-stage process taking place in chloroplasts; (e) explain, with the aid of diagrams and electron micrographs, how the structure of chloroplasts enables them to carry out their functions; (f) define the term *photosynthetic pigment*; (g) explain the importance of photosynthetic pigments in photosynthesis; (h) state that the light-dependent stage takes place in thylakoid membranes and that the light-independent stage takes place in the stroma; (i) outline how light energy is converted to chemical energy (ATP and reduced NADP) in the light-dependent stage (reference should be made to cyclic and non-cyclic photophosphorylation, but **no** biochemical detail is required); (j) explain the role of water in the light-dependent stage;

(k) outline how the products of the light-dependent stage are used in the light-independent stage (Calvin cycle) to produce triose phosphate (TP) (reference should be made to ribulose bisphosphate (RuBP), ribulose bisphosphate carboxylase (rubisco) and glycerate 3-phosphate (GP), but **no** other biochemical detail is required);

(l) explain the role of carbon dioxide in the light-independent stage (Calvin cycle);

(m) state that TP can be used to make carbohydrates, lipids and amino acids;

(n) state that most TP is recycled to RuBP;

(o) describe the effect on the rate of photosynthesis, and on levels of GP, RuBP and TP, of changing carbon dioxide concentration, light intensity and temperature;

(p) discuss limiting factors in photosynthesis with reference to carbon dioxide concentration, light intensity and temperature;

(q) describe how to investigate experimentally the factors that affect the rate of photosynthesis (HSW3).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Investigate the effect of a limiting factor on the rate of photosynthesis.

Presentation, analysis and evaluation of quantitative data:

- Calculate rates of photosynthesis;
- Plot graphs showing the effect of a limiting factor on the rate of photosynthesis.

Evaluation of data collection strategies:

- Investigate the problems associated with uncontrollable variables when measuring rates of photosynthesis.

Module 4: Respiration

Respiration is one of the fundamental biological processes and takes place in all living things. Most definitions of “life” have respiration as a necessary criterion.

Links
GCSE Criteria for Science: 3.7(i) (a); 3.9(i) (b)

From other modules within this specification:
F211 Module 1;
F212 Module 2.

4.4.1 Respiration

Context and exemplification	Assessable learning outcomes
Respiration is the process whereby energy stored in complex organic molecules is transferred to ATP. ATP provides the immediate source of energy for biological processes.	Candidates should be able to: (a) outline why plants, animals and microorganisms need to respire, with reference to active transport and metabolic reactions; (b) describe, with the aid of diagrams, the structure of ATP; (c) state that ATP provides the immediate source of energy for biological processes; (d) explain the importance of coenzymes in respiration, with reference to NAD and coenzyme A; (e) state that glycolysis takes place in the cytoplasm; (f) outline the process of glycolysis beginning with the phosphorylation of glucose to hexose bisphosphate, splitting of hexose bisphosphate into two triose phosphate molecules and further oxidation to pyruvate, producing a small yield of ATP and reduced NAD; (g) state that, during aerobic respiration in animals, pyruvate is actively transported into mitochondria; (h) explain, with the aid of diagrams and electron micrographs, how the structure of mitochondria enables them to carry out their functions; (i) state that the link reaction takes place in the mitochondrial matrix; (j) outline the link reaction, with reference to decarboxylation of pyruvate to acetate and the reduction of NAD;

(k) explain that acetate is combined with coenzyme A to be carried to the next stage;

(l) state that the Krebs cycle takes place in the mitochondrial matrix;

(m) outline the Krebs cycle, with reference to the formation of citrate from acetate and oxaloacetate and the reconversion of citrate to oxaloacetate (names of intermediate compounds are **not** required);

(n) explain that during the Krebs cycle, decarboxylation and dehydrogenation occur, NAD and FAD are reduced and substrate level phosphorylation occurs;

(o) outline the process of oxidative phosphorylation, with reference to the roles of electron carriers, oxygen and the mitochondrial cristae;

(p) outline the process of chemiosmosis, with reference to the electron transport chain, proton gradients and ATPsynthase (HSW7a);

(q) state that oxygen is the final electron acceptor in aerobic respiration;

(r) evaluate the experimental evidence for the theory of chemiosmosis (HSW1);

(s) explain why the theoretical maximum yield of ATP per molecule of glucose is rarely, if ever, achieved in aerobic respiration;

(t) explain why anaerobic respiration produces a much lower yield of ATP than aerobic respiration;

(u) compare and contrast anaerobic respiration in mammals and in yeast;

(v) define the term *respiratory substrate*;

(w) explain the difference in relative energy values of carbohydrate, lipid and protein respiratory substrates.

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Investigate the effect of a variable on the rate of respiration of an animal or microorganism;
- Compare aerobic and anaerobic respiration in yeast.

Presentation, analysis and evaluation of quantitative data:

- Calculate rates of respiration;
- Plot graphs showing the effect of a variable on the rate of respiration.

Evaluation of data collection strategies:

- Identify and evaluate the limitations of measuring rates of respiration.

3.5 A2 Unit F215: *Control, Genomes and Environment*

Module 1: Cellular Control and Variation

Genes control the way in which cells function.

Changes within genes lead to variation and variation provides the raw material for evolution.

Links
GCSE Criteria for Science: 3.7(i) (a), (b), (c), (e); 3.7(iv) (a); 3.9(i) (a)

From other modules within this specification:
F211 Module 1;
F212 Module 1, Module 2, Module 3.

5.1.1 Cellular Control

Context and exemplification	**Assessable learning outcomes**
The way that DNA codes for proteins is central to our understanding of how cells and organisms function. The way in which cells control chemical reactions determines the ways in which organisms, grow, develop and function.	Candidates should be able to: (a) state that genes code for polypeptides, including enzymes; (b) explain the meaning of the term *genetic code*; (c) describe, with the aid of diagrams, the way in which a nucleotide sequence codes for the amino acid sequence in a polypeptide; (d) describe, with the aid of diagrams, how the sequence of nucleotides within a gene is used to construct a polypeptide, including the roles of messenger RNA, transfer RNA and ribosomes; (e) state that mutations cause changes to the sequence of nucleotides in DNA molecules; (f) explain how mutations can have beneficial, neutral or harmful effects on the way a protein functions; (g) state that cyclic AMP activates proteins by altering their three-dimensional structure; (h) explain genetic control of protein production in a prokaryote using the *lac* operon; (i) explain that the genes that control development of body plans are similar in plants, animals and fungi, with reference to homeobox sequences (HSW1); (j) outline how apoptosis (programmed cell death) can act as a mechanism to change body plans.

5.1.2 Meiosis and Variation

Context and exemplification	Assessable learning outcomes
Variation generated by meiosis and mutation provides the raw material for natural selection. Isolating mechanisms can lead to the accumulation of different genetic information in populations, potentially leading to new species. Over a prolonged period of time, organisms have changed and become extinct. The theory of evolution explains these changes. Humans use artificial selection to produce similar changes in plants and animals.	Candidates should be able to: (a) describe, with the aid of diagrams and photographs, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles. (Names of the main stages are expected, but **not** the subdivisions of prophase); (b) explain the terms *allele, locus, phenotype, genotype, dominant, codominant and recessive*; (c) explain the terms *linkage* and *crossing-over*; (d) explain how meiosis and fertilisation can lead to variation through the independent assortment of alleles; (e) use genetic diagrams to solve problems involving sex linkage and codominance; (f) describe the interactions between loci (epistasis). (Production of genetic diagrams is **not** required); (g) predict phenotypic ratios in problems involving epistasis; (h) use the chi-squared (χ^2) test to test the significance of the difference between observed and expected results. (The formula for the chi-squared test will be provided); (i) describe the differences between continuous and discontinuous variation; (j) explain the basis of continuous and discontinuous variation by reference to the number of genes which influence the variation; (k) explain that both genotype and environment contribute to phenotypic variation. (**No** calculations of heritability will be expected); (l) explain why variation is essential in selection; (m) use the Hardy–Weinberg principle to calculate allele frequencies in populations (HSW1); (n) explain, with examples, how environmental factors can act as stabilising or evolutionary forces of natural selection; (o) explain how genetic drift can cause large changes in small populations;

(p) explain the role of isolating mechanisms in the evolution of new species, with reference to ecological (geographic), seasonal (temporal) and reproductive mechanisms;

(q) explain the significance of the various concepts of the species, with reference to the biological species concept and the phylogenetic (cladistic/evolutionary) species concept (HSW1);

(r) compare and contrast natural selection and artificial selection;

(s) describe how artificial selection has been used to produce the modern dairy cow and to produce bread wheat (*Triticum aestivum*) (HSW6a, 6b).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Use models to investigate sex linkage and codominance;
- Collection and presentation of qualitative (descriptive) data.

Presentation, analysis and evaluation of quantitative data:

- Use the chi-squared test on data generated by models;
- Use the Hardy–Weinberg principle on data generated by models.

Module 2: Biotechnology and Gene Technologies

Natural processes have been harnessed and manipulated by humans for our benefit.

This manipulation can take place at level of the gene, the cell or the whole organism.

Links
GCSE Criteria for Science: 3.7(i) (c), (e); 3.9(i) (a)

From other modules within this specification:

F211 Module 1;

F212 Module 1, Module 2, Module 3.

5.2.1 Cloning in Plants and Animals

Context and exemplification	**Assessable learning outcomes**
Farmers and growers exploit "natural" vegetative propagation in the production of uniform crops. Artificial clones of plants and animals can now be produced.	Candidates should be able to: (a) outline the differences between reproductive and non-reproductive cloning; (b) describe the production of natural clones in plants using the example of vegetative propagation in elm trees; (c) describe the production of artificial clones of plants from tissue culture; (d) discuss the advantages and disadvantages of plant cloning in agriculture (HSW6a, 6b, 7c); (e) describe how artificial clones of animals can be produced; (f) discuss the advantages and disadvantages of cloning animals (HSW4, 6a, 6b, 7c).

5.2.2 Biotechnology

Context and exemplification	**Assessable learning outcomes**
Biotechnology uses microorganisms and enzymes to make useful products.	Candidates should be able to: (a) state that biotechnology is the industrial use of living organisms (or parts of living organisms) to produce food, drugs or other products (HSW6a); (b) explain why microorganisms are often used in biotechnological processes; (c) describe, with the aid of diagrams, and explain the standard growth curve of a microorganism in a closed culture; (d) describe how enzymes can be immobilised; (e) explain why immobilised enzymes are used in large-scale production; (f) compare and contrast the processes of continuous culture and batch culture;

	(g) describe the differences between primary and secondary metabolites; (h) explain the importance of manipulating the growing conditions in a fermentation vessel in order to maximise the yield of product required; (i) explain the importance of asepsis in the manipulation of microorganisms.

5.2.3 Genomes and Gene Technologies

Context and exemplification	**Assessable learning outcomes**
Genome sequencing gives information about the location of genes and provides evidence for the evolutionary links between organisms. Genetic engineering involves the manipulation of naturally occurring processes and enzymes. The capacity to manipulate genes has many potential benefits, but the implications of genetic techniques are subject to much public debate.	Candidates should be able to: (a) outline the steps involved in sequencing the genome of an organism; (b) outline how gene sequencing allows for genome-wide comparisons between individuals and between species (HSW7b); (c) define the term *recombinant DNA*; (d) explain that genetic engineering involves the extraction of genes from one organism, or the manufacture of genes, in order to place them in another organism (often of a different species) such that the receiving organism expresses the gene product (HSW6a); (e) describe how sections of DNA containing a desired gene can be extracted from a donor organism using restriction enzymes; (f) outline how DNA fragments can be separated by size using electrophoresis (HSW3); (g) describe how DNA probes can be used to identify fragments containing specific sequences; (h) outline how the polymerase chain reaction (PCR) can be used to make multiple copies of DNA fragments; (i) explain how isolated DNA fragments can be placed in plasmids, with reference to the role of ligase; (j) state other vectors into which fragments of DNA may be incorporated; (k) explain how plasmids may be taken up by bacterial cells in order to produce a transgenic microorganism that can express a desired gene product; (l) describe the advantage to microorganisms of the capacity to take up plasmid DNA from the environment; (m) outline how genetic markers in plasmids can be used to identify the bacteria that have

taken up a recombinant plasmid;

(n) outline the process involved in the genetic engineering of bacteria to produce human insulin;

(o) outline the process involved in the genetic engineering of 'Golden Rice™' (HSW6a);

(p) outline how animals can be genetically engineered for xenotransplantation (HSW6a, 6b);

(q) explain the term *gene therapy;*

(r) explain the differences between somatic cell gene therapy and germ line cell gene therapy;

(s) discuss the ethical concerns raised by the genetic manipulation of animals (including humans), plants and microorganisms (HSW4, 6a, 6b, 7c).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Measure the effect of changing growing conditions in a fermentation vessel.

Collection and presentation of qualitative (descriptive) data:

- Investigate different methods of immobilising enzymes.

Presentation, analysis and evaluation of quantitative data:

- Calculate yields, rates of growth and/or rates of production of secondary metabolites and present these graphically.

Evaluation of data collection strategies:

- Identify the limitations in collecting valid data in small-scale fermentation investigations.

Module 3: Ecosystems and Sustainability

Understanding how ecosystems work and how to manage them for sustainability and conservation requires knowledge of energy flows and population dynamics.

Links

GCSE Criteria for Science: 3.7(i) (a); 3.7(iv) (a); 3.9(i) (b)

From other modules within this specification:

F212 Module 2, Module 3.

5.3.1 Ecosystems

Context and exemplification	Assessable learning outcomes
Organisms do not work in isolation but form complex interactions, not just with other organisms but also with their physical environment. The efficiency of energy transfer limits the number of organisms in a particular ecosystem. Ecosystems are dynamic entities tending towards some form of climax community.	Candidates should be able to: (a) define the term *ecosystem*; (b) state that ecosystems are dynamic systems; (c) define the terms *biotic factor* and *abiotic factor*, using named examples; (d) define the terms *producer, consumer decomposer* and *trophic level*; (e) describe how energy is transferred though ecosystems; (f) outline how energy transfers between trophic levels can be measured; (g) discuss the efficiency of energy transfers between trophic levels; (h) explain how human activities can manipulate the flow of energy through ecosystems (HSW6b); (i) describe one example of primary succession resulting in a climax community; (j) describe how the distribution and abundance of organisms can be measured, using line transects, belt transects, quadrats and point quadrats (HSW3); (k) describe the role of decomposers in the decomposition of organic material; (l) describe how microorganisms recycle nitrogen within ecosystems. (Only *Nitrosomonas, Nitrobacter* and *Rhizobium* need to be identified by name).

5.3.2 Populations and Sustainability

Context and exemplification	Assessable learning outcomes
There are many factors that determine the size of a population. For economic, social and ethical reasons ecosystems may need to be carefully managed. To support an increasing human population, we must try to use biological resources in a sustainable way.	Candidates should be able to: (a) explain the significance of limiting factors in determining the final size of a population; (b) explain the meaning of the term *carrying capacity*; (c) describe predator–prey relationships and their possible effects on the population sizes of both the predator and the prey; (d) explain, with examples, the terms *interspecific* and *intraspecific* competition; (e) distinguish between the terms *conservation* and *preservation* (HSW6a, 6b); (f) explain how the management of an ecosystem can provide resources in a sustainable way, with reference to timber production in a temperate country; (g) explain that conservation is a dynamic process involving management and reclamation; (h) discuss the economic, social and ethical reasons for conservation of biological resources (HSW6b, 7c); (i) outline, with examples, the effects of human activities on the animal and plant populations in the Galapagos Islands (HSW6b).

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection of quantitative data:

- Measure the effect of a changing abiotic factor on the distribution and/or abundance of an organism.

Presentation, analysis and evaluation of quantitative data:

- Plot kite diagrams.

Evaluation of data collection strategies:

- Assess the limitations of ecological investigations.

Module 4: Responding to the Environment

Plants and animals respond to environmental stimuli. The co-ordination of responses to stimuli can vary in complexity. These responses enhance the survival of the organism.

Links

GCSE Criteria for Science: 3.7(i) (a), (d); 3.(i) (a)

From other modules within this specification:

F211 Module 1, Module 2;

F212 Module 3.

5.4.1 Plant Responses

Context and exemplification	Assessable learning outcomes
Plant responses to environmental changes are co-ordinated by hormones, some of which are commercially important.	Candidates should be able to: (a) explain why plants need to respond to their environment in terms of the need to avoid predation and abiotic stress; (b) define the term *tropism*; (c) explain how plant responses to environmental changes are co-ordinated by hormones, with reference to responding to changes in light direction; (d) evaluate the experimental evidence for the role of auxins in the control of apical dominance and gibberellin in the control of stem elongation; (e) outline the role of hormones in leaf loss in deciduous plants; (f) describe how plant hormones are used commercially (HSW6a).

5.4.2 Animal Responses

Context and exemplification	Assessable learning outcomes
In animals, responding to changes in the environment is a complex and continuous process, involving nervous, hormonal and muscular co-ordination.	Candidates should be able to: (a) discuss why animals need to respond to their environment; (b) outline the organisation of the nervous system in terms of central and peripheral systems in humans; (c) outline the organisation and roles of the autonomic nervous system; (d) describe, with the aid of diagrams, the gross structure of the human brain, and outline the functions of the cerebrum, cerebellum, medulla oblongata and hypothalamus;

	(e) describe the role of the brain and nervous system in the co-ordination of muscular movement; (f) describe how co-ordinated movement requires the action of skeletal muscles about joints, with reference to the movement of the elbow joint; (g) explain, with the aid of diagrams and photographs, the sliding filament model of muscular contraction; (h) outline the role of ATP in muscular contraction, and how the supply of ATP is maintained in muscles; (i) compare and contrast the action of synapses and neuromuscular junctions; (j) outline the structural and functional differences between voluntary, involuntary and cardiac muscle; (k) state that responses to environmental stimuli in mammals are co-ordinated by nervous and endocrine systems; (l) explain how, in mammals, the 'fight or flight' response to environmental stimuli is co-ordinated by the nervous and endocrine systems.

5.4.3 Animal Behaviour

Context and exemplification	**Assessable learning outcomes**
Animals behave in ways that enhance their survival and reproductive capacity. Behaviour patterns can be simple or complex, and can range from genetically programmed behaviour to learned behaviour that is significantly influenced by the environment.	Candidates should be able to: (a) explain the advantages to organisms of innate behaviour; (b) describe escape reflexes, taxes and kineses as examples of genetically-determined innate behaviours; (c) explain the meaning of the term *learned behaviour*; (d) describe habituation, imprinting, classical and operant conditioning, latent and insight learning as examples of learned behaviours; (e) describe, using one example, the advantages of social behaviour in primates; (f) discuss how the links between a range of human behaviours and the dopamine receptor DRD4 may contribute to the understanding of human behaviour (HSW7a);

Practical Skills (HSW5) are assessed using specific OCR-set experiments. The practical work outlined below may be carried out as part of skill development.

Collection and presentation of qualitative (descriptive) data:

- Investigate the effects of changing light direction on plant growth.

3.6 A2 Unit F216: *Practical Skills in Biology 2*

This unit assesses practical and investigative skills developed within contexts encountered during A2 Biology.

Candidates are required to carry out **three** tasks:

1. Qualitative task [10 marks]
2. Quantitative task [10 marks]
3. Evaluative task [20 marks]

Tasks will be chosen from a selection provided by OCR.

The Qualitative and Quantitative tasks will test skills of observation and measurement.

Candidates will carry out these tasks under controlled conditions.

Each task will be internally assessed using a mark scheme provided by OCR.

Candidates may attempt more than one task from each category with the best mark from each category being used to make up the overall mark. Candidates may **not** repeat a task to improve their mark.

Centres will supply OCR with a single mark out of 40.

How Science Works

5a Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.

5b Analyse and interpret data to provide evidence, recognising correlations and causal relationships.

5c Evaluate methodology, evidence and data, and resolve conflicting evidence.

The mark schemes supplied by OCR will be based on the following generic criteria:

1. Qualitative task	
Candidates carry out a practical task using instructions supplied by OCR.	(a) Demonstrate skilful and safe practical techniques using suitable **qualitative** methods; (b) Make and record valid observations.
2. Quantitative task	
Candidates carry out a practical task using instructions supplied by OCR. The data collected in one of the tasks will form the basis of the assessment in the Evaluative task.	(a) Demonstrate skilful and safe practical techniques using suitable **quantitative** methods; (b) Make and record accurate measurements to an appropriate degree of precision.
3. Evaluative task	
This task will extend the quantitative task. Candidates will be required to analyse the data collected from any of the quantitative tasks that they have carried out, use scientific knowledge and understanding to explain the data collected (AO1 and AO2) and evaluate the quality of the data and procedures. Evaluative tasks will **not** require additional data collection to be done.	(a) Process results quantitatively. Interpret the results to reach valid conclusions; (b) Use scientific knowledge and understanding to suggest explanations for trends and patterns in the data; (c) Identify and explain the main limitations of the data collection strategy; (d) Suggest and give reasons for simple improvements to the experiment; (e) Comment upon the reliability of the data collected. Discuss the validity of the conclusions.

The Tasks

Tasks, mark schemes and guidance for teachers and technicians can be downloaded from the OCR Interchange site.

Further advice and guidance on the use and marking of the tasks can be found in the Practical Skills Handbook.

4 Schemes of Assessment

4.1 AS GCE Scheme of Assessment

AS GCE Biology (H021)	
AS Unit F211: *Cells, Exchange and Transport*	
30% of the total AS GCE marks 1 h written paper 60 marks	Candidates answer all questions.
AS Unit F212: *Molecules, Biodiversity, Food and Health*	
50% of the total AS GCE marks 1 h 45 min written paper 100 marks	Candidates answer all questions.
AS Unit F213: *Practical Skills In Biology 1*	
20% of the total AS GCE marks Coursework 40 marks	Candidates complete three tasks set by OCR. Tasks are marked by the centre using mark schemes provided by OCR.

4.2 Advanced GCE Scheme of Assessment

Advanced GCE Biology (H421)	
AS Units as above, Unit F211 being 15% of the total Advanced GCE marks, Unit F212 being 25% of the Advanced GCE marks and Unit F213 being 10% of the Advanced GCE marks.	
A2 Unit F214: *Communication, Homeostasis and Energy*	
15% of the total Advanced GCE marks 1 h 15 min written paper 60 marks	Candidates answer all questions. This unit contains some synoptic assessment and Stretch and Challenge questions.
A2 Unit F215: *Control, Genomes and Environment*	
25% of the total Advanced GCE marks 2 h written paper 100 marks	Candidates answer all questions. This unit contains some synoptic assessment and Stretch and Challenge questions.
A2 Unit F216: *Practical Skills in Biology 2*	
10% of the total Advanced GCE marks Coursework 40 marks	Candidates complete three tasks set by OCR. Tasks are marked by the centre using mark schemes provided by OCR. Work is moderated by OCR. This unit is synoptic.

4.3 Unit Order

The normal order in which the unit assessments could be taken is AS Units F211, F212 and F213 in the first year of study, leading to an AS GCE award, then A2 Units F214, F215 and F216 leading to the Advanced GCE award.

Alternatively, candidates may take a valid combination of unit assessments at the end of their AS GCE or Advanced GCE course in a 'linear' fashion.

4.4 Unit Options (at AS/A2)

There are no optional units in the AS GCE specification; for AS GCE Biology candidates must take AS Units F211, F212 and F213.

There are no optional units in the Advanced GCE specification; for Advanced GCE Biology candidates take AS Units F211, F212 and F213, *and* A2 Units F214, F215 and F216.

4.5 Synoptic Assessment (A Level GCE)

Synoptic assessment tests the candidates' understanding of the connections between different elements of the subject.

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. All A2 units, whether internally or externally assessed, contain synoptic assessment.

Synoptic assessment requires candidates to make and use connections within and between different areas of biology at AS and A2, for example, by:

- applying knowledge and understanding of more than one area to a particular situation or context;
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data;
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

All A2 units (F214, F215 and F216) contain some synoptic assessment.

4.6 Assessment Availability

There is one examination series each year in June.

From 2014, both AS units and A2 units will be assessed in June only.

4.7 Assessment Objectives

Candidates are expected to demonstrate the following in the context of the content described:

AO1 Knowledge and Understanding

- recognise, recall and show understanding of scientific knowledge;
- select, organise and communicate relevant information in a variety of forms.

AO2 Application of Knowledge and Understanding

- analyse and evaluate scientific knowledge and processes;
- apply scientific knowledge and processes to unfamiliar situations including those related to issues;
- assess the validity, reliability and credibility of scientific information.

AO3 How Science Works

- demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods;
- make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy;
- analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

AO weightings in AS GCE

Unit	% of AS GCE			Total / %
	AO1	AO2	AO3	
AS Unit F211: *Cells, Exchange and Transport*	14	14	2	30
AS Unit F212: *Molecules, Biodiversity, Food and Health*	21	24	5	50
AS Unit F213: *Practical Skills In Biology 1*	3	2	15	20
	38	40	22	100

AO weightings in Advanced GCE

Unit	% of Advanced GCE			Total / %
	AO1	AO2	AO3	
AS Unit F211: *Cells, Exchange and Transport*	7	7	1	15
AS Unit F212: *Molecules, Biodiversity, Food and Health*	10.5	12	2.5	25
AS Unit F213: *Practical Skills In Biology 1*	1.5	1	7.5	10
A2 Unit F214: *Communication, Homeostasis and Energy*	5	9	1	15
A2 Unit F215: *Control, Genomes and Environment*	9	13.5	2.5	25
A2 Unit F216: *Practical Skills In Biology 2*	1	1.5	7.5	10
	34	44	22	100

4.8 Quality of Written Communication

Quality of Written Communication is assessed in all units and credit may be restricted if communication is unclear.

Candidates will:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- select and use a form and style of writing appropriate to purpose and to complex subject matter;
- organise information clearly and coherently, using specialist vocabulary when appropriate.

5 Technical Information

5.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Centres must have made an entry for a unit in order for OCR to supply the appropriate forms or moderator details for coursework.

It is essential that unit entry codes are quoted in all correspondence with OCR. See Sections 4.1 and 4.2 for these unit entry codes.

5.2 Making Qualification Entries

Candidates must enter for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Candidates may enter for:

- AS GCE certification (entry code H021).
- Advanced GCE certification (entry code H421).

A candidate who has completed all the units required for the qualification, and who did not request certification at the time of entry, may enter for certification either in the same examination series (within a specified period after publication of results) or in a later series.

AS GCE certification is available from June 2014.
Advanced GCE certification is available from June 2014.

5.3 Grading

All GCE units are awarded A to E. The Advanced Subsidiary GCE is awarded on the scale A to E. The Advanced GCE is awarded on the scale A to E with access to an A*. To be awarded an A*, candidates will need to achieve a grade A on their full A Level qualification and an A* on the aggregate of their A2 units. Grades are reported on certificates. Results for candidates who fail to achieve the minimum grade (E or e) will be recorded as *unclassified* (U or u) and this is **not** certificated.

A Uniform Mark Scale (UMS) enables comparison of candidates' performance across units and across series. The three-unit AS GCE has a total of 300 *uniform* marks and the six-unit Advanced GCE has a total of 600 *uniform* marks.

OCR converts the candidate's raw mark for each unit to a *uniform* mark. The maximum *uniform* mark for any unit depends on that unit's weighting in the specification. In these biology specifications the six units of the Advanced GCE specification have UMS weightings of 15%/25%/10%/15%/25%/10% (and the three units of the AS GCE specification have UMS weightings of 30%/50%/20%). The *uniform* mark totals are 90/150/60/90/150/60, respectively. Each unit's *raw* mark grade boundary equates to the *uniform* mark boundary at the same grade. Intermediate marks are converted on a pro-rata basis.

Uniform marks correspond to *unit* grades as follows:

(Advanced GCE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade					
		a	b	c	d	e	u
25%	150	150–120	119–105	104–90	89–75	74–60	59–0
15%	90	90–72	71–63	62–54	53–45	44–36	35–0
10%	60	60–48	47–42	41–36	35–30	29–24	23–0

OCR adds together the unit *uniform* marks and compares these to pre-set boundaries (see the table below) to arrive at *qualification* grades.

Qualification	Qualification Grade					
	A	B	C	D	E	U
AS GCE	300–240	239–210	209–180	179–150	149–120	119–0
Advanced GCE	600–480	479–420	419–360	359–300	299–240	239–0

Candidates achieving at least 480 *uniform* marks in their Advanced GCE, ie grade A, and who also gain at least 270 *uniform* marks in their three A2 units will receive an A* grade.

5.4 Result Enquiries and Appeals

Under certain circumstances, a centre may wish to query the grade available to one or more candidates or to submit an appeal against an outcome of such an enquiry. Enquiries about unit results must be made immediately following the series in which the relevant unit was taken.

For procedures relating to enquires on results and appeals, centres should consult the OCR *Administration Guide for General Qualifications* and the document *Enquiries about Results and Appeals – Information and Guidance for Centres* produced by the Joint Council. Copies of the most recent editions of these papers can be obtained from OCR.

5.5 Shelf-life of Units

Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

5.6 Unit and Qualification Re-sits

There is no restriction on the number of times a candidate may re-sit each unit before entering for certification for an AS GCE or Advanced GCE.

Candidates may enter for the full qualifications an unlimited number of times.

5.7 Guided Learning Hours

AS GCE Biology requires **180** guided learning hours in total.
Advanced GCE Biology requires **360** guided learning hours in total.

5.8 Code of Practice/Subject Criteria/Common Criteria Requirements

These specifications comply in all respects with current *GCSE, GCE, GNVQ and AEA Code of Practice* as available on the QCA website, the subject criteria for GCE Biology and *The Statutory Regulation of External Qualifications 2004*.

5.9 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Access Arrangements and Special Consideration: Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced by the Joint Council. In such cases advice should be sought from OCR as early as possible during the course.

5.10 Prohibited Qualifications and Classification Code

Candidates who enter for the OCR GCE specifications may not also enter for any other GCE specification with the certification title *Biology* in the same examination series.

Every specification is assigned to a national classification code indicating the subject area to which it belongs.

Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Achievement and Attainment Tables.

The classification code for these specifications is 1010.

5.11 Coursework Administration/Regulations

Supervision and Authentication

As with all coursework, teachers must be able to verify that the work submitted for assessment is the candidate's own work. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

Submitting marks to OCR

Centres must have made an entry for a unit (F213 and/or F216) in order for OCR to supply the appropriate forms or moderator details for coursework. Documents are sent to centres on the basis of estimated entries. Marks may be submitted to OCR either via Interchange, on the computer-printed Coursework Mark Sheets (MS1) provided by OCR (sending the top copy to OCR and the second copy to their allocated moderator) or by EDI (centres using EDI are asked to print a copy of their file and sign it before sending to their allocated moderator).

Deadline for the receipt of coursework marks is:
15 May for the June series

For regulations governing coursework, centres should consult the OCR *Administration Guide for General Qualifications.* Further copies of the coursework administration documents are available on the OCR website (www.ocr.org.uk).

Standardisation and Moderation

All internally-assessed coursework is marked by the teacher and internally standardised by the centre. Marks must be submitted to OCR by the agreed date, after which postal moderation takes place in accordance with OCR procedures.

The purpose of moderation is to ensure that the standard for the award of marks in internally-assessed coursework is the same for each centre, and that each teacher has applied the standards appropriately across the range of candidates within the centre.

The sample of work which is submitted to the moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

Minimum Coursework Required

If a candidate submits no work for a unit, then the candidate should be indicated as being absent from that unit on the coursework mark sheets submitted to OCR. If a candidate completes any work at all for that unit then the work should be assessed according to the criteria and marking instructions and the appropriate mark awarded, which may be zero.

6 Other Specification Issues

6.1 Overlap with other Qualifications

There is a degree of overlap between the content of these specifications and those for Advanced GCE Chemistry, Physics A, Science, Geography and Geology. The links between the specifications may allow for some co-teaching, particularly in the areas of biochemistry, environmental science and microbiology.

Examples of overlap include:

Chemistry

F212

Geography

F212

F215

6.2 Progression from these Qualifications

This specification provides a suitable foundation for the study of biological science or related courses in higher education.

6.3 Key Skills Mapping

These specifications provide opportunities for the development of the Key Skills of *Communication*, *Application of Number*, *Information Technology*, *Working with Others*, *Improving Own Learning and Performance* and *Problem Solving* at Levels 2 and/or 3. However, the extent to which this evidence fulfils the Key Skills criteria at these levels will be totally dependent on the style of teaching and learning adopted for each unit.

The following table indicates where opportunities *may* exist for at least some coverage of the various Key Skills criteria at Levels 2 and/or 3 for each unit.

Unit	C				AoN			IT			WwO			IOLP			PS		
	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3
F211	✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F212	✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F213				✓	✓	✓	✓	✓	✓	✓									
F214	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F215	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F216		✓	✓	✓	✓	✓	✓	✓	✓	✓									

6.4 Spiritual, Moral, Ethical, Social, Legislative, Economic and Cultural Issues

These specifications provide an opportunity for candidates to appreciate:

- a sense of awe and wonder at the scale and impact of natural processes and phenomena;
- the role of biology in describing the structure and functioning of the natural world;
- the importance of animals, plants and microorganisms to life on earth;
- the place of humankind in the natural world;
- the moral, ethical, social and cultural implications of some of the applications of biology and technology;
- legal issues relating to genetic engineering;
- economic issues relevant to discussions on the need to maintain and preserve biodiversity.

6.5 Sustainable Development, Health and Safety Considerations and European Developments

These specifications support these issues, consistent with current EU agreements, in the following topics:

- energy and mineral cycling;
- interdependence of living things;
- biodiversity;
- ecosystem management and sustainable agricultural practices;
- greenhouse effect and global warming;
- air, water and pesticide pollution;
- conservation of resources;
- environmental monitoring;
- clean technology and industrial processes;
- sustainability.

6.6 Avoidance of Bias

OCR has taken great care in the preparation of these specifications and assessment materials to avoid bias of any kind.

6.7 Language

These specifications and associated assessment materials are in English only.

6.8 Disability Discrimination Act Information Relating to these Specifications

AS/A levels often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in *Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced by the Joint Council (refer to Section 5.9 of this specification).

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they have taken and there would be an indication on their certificate that not all of the competences have been addressed. This will be kept under review and may be amended in the future.

Practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

Appendix A: Performance Descriptions

Performance descriptions have been created for all GCE subjects. They describe the learning outcomes and levels of attainment likely to be demonstrated by a representative candidate performing at the A/B and E/U boundaries for AS and A2.

In practice most candidates will show uneven profiles across the attainments listed, with strengths in some areas compensating in the award process for weaknesses or omissions elsewhere. Performance descriptions illustrate expectations at the A/B and E/U boundaries of the AS and A2 as a whole; they have not been written at unit level.

Grade A/B and E/U boundaries should be set using professional judgement. The judgement should reflect the quality of candidates' work, informed by the available technical and statistical evidence. Performance descriptions are designed to assist examiners in exercising their professional judgement. They should be interpreted and applied in the context of individual specifications and their associated units. However, performance descriptions are not designed to define the content of specifications and units.

The requirement for all AS and A level specifications to assess candidates' quality of written communication will be met through one or more of the assessment objectives.

The performance descriptions have been produced by the regulatory authorities in collaboration with the awarding bodies.

AS performance descriptions for biology

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
Assessment Objectives	**Knowledge and understanding of science and of How Science Works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge; • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How Science Works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes; • apply scientific knowledge and processes to unfamiliar situations including those related to issues; • assess the validity, reliability and credibility of scientific information.	**How Science Works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods; • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy; • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

A/B boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of most principles, concepts and facts from the AS specification; b) select relevant information from the AS specification; *c)* organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument; b) describe significant trends and patterns shown by data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly; c) comment critically on statements, conclusions or data; d) carry out accurately most of the calculations specified for AS; e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques; b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues; c) make observations and measurements with appropriate precision and record them methodically; d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.
E/U boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles and facts from the AS specification; b) select some relevant information from the AS specification; c) present information using basic terminology from the AS specification.	Candidates characteristically: a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument; b) describe some trends or patterns shown by data presented in tabular or graphical form; c) identify, when directed, inconsistencies in conclusions or data; d) carry out some steps within calculations; *e)* translate data successfully from one form to another, in some contexts.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities; b) demonstrate safe practical techniques and comment on ethical issues; c) make observations and measurements and record them; d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

A2 performance descriptions for biology

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
Assessment Objectives	**Knowledge and understanding of science and of How Science Works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge; • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How Science Works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes; • apply scientific knowledge and processes to unfamiliar situations including those related to issues; • assess the validity, reliability and credibility of scientific information.	**How Science Works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods; • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy; • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

A/B boundary Performance Descriptions	Candidates characteristically: a) demonstrate detailed knowledge and understanding of most principles, concepts and facts from the A2 specification; b) select relevant information from the A2 specification; c) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving several steps in the argument; b) describe significant trends and patterns shown by complex data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly; c) evaluate critically any statements, conclusions or data; d) carry out accurately most of the calculations specified for A2; and apply the principles of statistical analysis when directed; e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another; f) select a wide range of facts, principles and concepts from both AS and A2 specifications; g) link together appropriate facts principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques; b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues; c) make observations and measurements with appropriate precision and record these methodically; d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts; e) use an appropriate statistical technique to assess the validity of a hypothesis.
E/U boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles, concepts and facts from the A2 specification; b) select some relevant information from the A2 specification; c) present information using basic terminology from the A2 specification.	Candidates characteristically: a) apply given principles or concepts in familiar and new contexts involving a few steps in the argument; b) describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form; c) identify, when directed, inconsistencies in conclusions or data; d) carry out some steps within calculations; e) translate data successfully from one form to another, in some contexts; f) select some facts, principles and concepts from both AS and A2 specifications; g) put together some facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities; b) demonstrate safe practical techniques and comment on ethical issues; c) make observations and measurements and record them; d) interpret, explain and communicate some of the results of their own and others' experimental and investigative activities, in appropriate contexts; e) use a given statistical technique.

Appendix B: How Science Works

Incorporating Section 3.6 of the QCA criteria into the specification.

References in this specification to *How Science Works* (HSW) are to the following statements. A number of learning outcomes have been identified that exemplify these criteria, though all learning outcomes can be used to address *How Science Works*, particularly statement 2. These references have been written by rearranging the statements in Section 3.6 of the QCA Subject Criteria.

1. Use theories, models and ideas to develop and modify scientific explanations.

2. Use knowledge and understanding to pose scientific questions, define scientific problems and present scientific arguments and scientific ideas.

3. Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems.

4. Communicate information and ideas in appropriate ways using appropriate terminology.

5. Obtaining, analysing and evaluation data:

- **a.** carry out experimental and investigative activities, including appropriate risk management, in a range of contexts;
- **b.** analyse and interpret data to provide evidence, recognising correlations and causal relationships;
- **c.** evaluate methodology, evidence and data, and resolve conflicting evidence.

6. Applications, implications and ethical considerations:

- **a.** consider applications and implications of science and appreciate their associated benefits and risks;
- **b.** consider ethical issues in the treatment of humans, other organisms and the environment.

7. Scientific knowledge in its social context:

- **a.** appreciate the tentative nature of scientific knowledge;
- **b.** appreciate the role of the scientific community in validating new knowledge and ensuring integrity;
- **c.** appreciate the ways in which society uses science to inform decision-making.

Appendix C: GCSE Criteria for Science

The **Links** section at the beginning of each module contains references to the QCA GCSE Criteria for Science.

These criteria define the subject-specific essentials for **GCSE Science** (section 3.7) and **GCSE Additional Science** (section 3.9) specifications.

The specific references are:

Section 3.7

(i) **Organisms and health:**

(a) organisms are interdependent and adapted to their environments;

(b) variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified;

(c) the ways in which organisms function are related to the genes in their cells;

(d) chemical and electrical signals enable body systems to respond internal and external changes, in order to maintain the body in an optimum state;

(e) human health is affected by a range of environmental and inherited factors, by the use and misuse of drugs and by medical treatments.

(iv) **Environment, Earth and universe:**

(a) the effects of human activity on the environment can be assessed using living and non-living indicators.

Section 3.9(i)

(a) **Cells and growth:**
chemical reactions essential for life and growth take place inside cells. Differences between plant and animal cells lead to different patterns of growth and development.

(b) **Energy flows and element cycles:**
plant biomass provides energy and nutrients for other organisms. Through the consumption of organisms and decay, energy flows through the biosphere and chemical elements are recycled within it.

Appendix D: Mathematical Requirements

In order to be able to develop their skills, knowledge and understanding in biology, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated below.

1 Arithmetic and numerical computation:

- (a) recognise and use expressions in decimal and standard form;
- (b) use ratios, fractions and percentages;
- (c) make estimates of the results of calculations (without using a calculator);
- (d) use calculators to find and use power, exponential and logarithmic functions.

2 Handling data:

- (a) use an appropriate number of significant figures;
- (b) find arithmetic means;
- (c) construct and interpret frequency tables and diagrams, bar charts and histograms;
- (d) understand simple probability;
- (e) understand the principles of sampling as applied to scientific data;
- (f) understand the terms mean, median and mode;
- (g) use a scatter diagram to identify a correlation between two variables;
- (h) use a simple statistical test;
- (i) make order of magnitude calculations.

3 Algebra:

- (a) change the subject of an equation;
- (b) substitute numerical values into algebraic equations using appropriate units for physical quantities.

4 Graphs:

- (a) translate information between graphical, numerical and algebraic forms;
- (b) plot two variables from experimental or other data;
- (c) calculate rate of change from a graph showing a linear relationship.

Appendix E: Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for AS and Advanced GCE, this is likely to be the local education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at www.ase.org.uk/htm/teacher_zone/safety_in_science_education.php.

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

- *Safety in Science Education*, DfEE, 1996, HMSO, ISBN 0 11 270915 X.

  Now out of print but sections are available at:
  www.ase.org.uk/htm/teacher_zone/safety_in_science_education.php;

- *Topics in Safety*, 3rd edition, 2001, ASE ISBN 0 86357 316 9;

- *Safeguards in the School Laboratory*, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;

- CLEAPSS® *Hazcards*, 2007 edition and later updates*;

- CLEAPSS® *Laboratory Handbook**;

- *Hazardous Chemicals*, A Manual for Science Education, 1997, SSERC Limited

  ISBN 0 9531776 0 2 (see www.sserc.org.uk/public/hazcd/whats_new.htm).

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS® (or, in Scotland, SSERC).

*****These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk. In Scotland, SSERC (www.sserc.org.uk) has a similar role to CLEAPSS® and there are some reciprocal arrangements.

Appendix F: Using OCR Interchange to download Practical Skills tasks

All materials for the assessment of GCE Biology Practical Skills can be obtained from OCR Interchange.

How to use OCR Interchange

OCR Interchange is a secure extranet enabling registered users to administer qualifications on-line. Your Examinations Officer is probably using OCR Interchange to administer qualifications already. If this is not the case, then your centre will need to register.

Your Examinations Officer will be able to:*

- download the relevant documents for you by adding the role of 'Science Co-ordinator' to their other roles; or
- create a new user account for you (adding the Science Co-ordinator role) so that you can access the GCE Biology pages and download documents when you need them.

*Note that in order to assign the role of Science Coordinator to others, the Examinations Officer will need to hold the role of Centre Administrator.

The website address for Interchange is:

https://interchange.ocr.org.uk

The teacher who has downloaded these materials is responsible for ensuring that any pages labelled **confidential** are stored securely so that students do not have the opportunity to access them.

It is intended that the circulation of the Practical Tasks is limited to those students who are currently undertaking that task. These materials should be photocopied and issued to students at the start of the task. Numbering the documents may help to keep track of them.

Registering for Interchange

If your Examinations Officer is not already a registered user of Interchange then he/she will need to register before the Biology Tasks can be downloaded.

This is a straightforward process:

- Go to the website – https://interchange.ocr.org.uk
- The first page has a New User section
- Click on Sign Up to access the OCR Interchange Agreement Form 1
- Download this document and fill in your details
- Return form by post to OCR Customer Contact Centre, Westwood Way, Coventry, CV4 8JQ or fax the form back to 024 76 851633
- OCR will then contact the Head of Centre with the details needed for the Examinations Officer to access OCR Interchange.