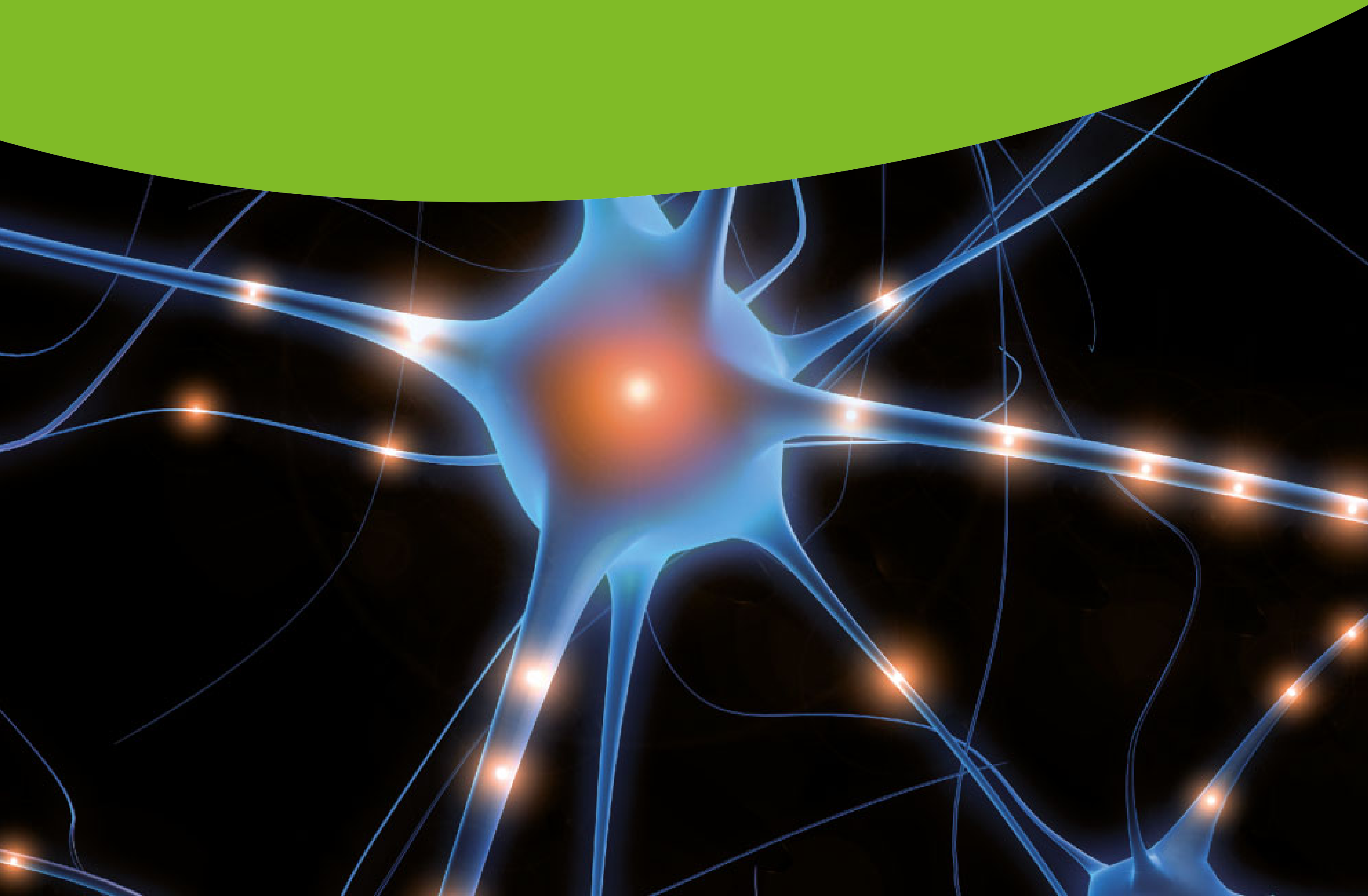
GCE

AS and A Level Specification

Biology

For exams from June 2014 onwards
For certification from June 2014 onwards



Contents

Vertical black lines indicate a significant change or addition to the previous version of this specification.

1 Introduction

1.1 Why choose AQA?

It's a fact that AQA is the UK's favourite exam board and more students receive their academic qualifications from AQA than from any other board. But why does AQA continue to be so popular?

- **Specifications**
  Ours are designed to the highest standards, so teachers, students and their parents can be confident that an AQA award provides an accurate measure of a student's achievements. And the assessment structures have been designed to achieve a balance between rigour, reliability and demands on candidates.

- **Support**
  AQA runs the most extensive programme of support meetings; free of charge in the first years of a new specification and at a very reasonable cost thereafter. These support meetings explain the specification and suggest practical teaching strategies and approaches that really work.

- **Service**
  We are committed to providing an efficient and effective service and we are at the end of the phone when you need to speak to a person about an important issue. We will always try to resolve issues the first time you contact us but, should that not be possible, we will always come back to you (by telephone, email or letter) and keep working with you to find the solution.

- **Ethics**
  AQA is a registered charity. We have no shareholders to pay. We exist solely for the good of education in the UK. Any surplus income is ploughed back into educational research and our service to you, our customers. We don't profit from education, you do.

If you are an existing customer then we thank you for your support. If you are thinking of moving to AQA then we look forward to welcoming you.

1.2 Why choose Biology?

- Designed to meet the requirements of the QCA AS and A level subject criteria, this new specification continues the best features of the two current AQA specifications, Biology A and Biology B. If you are teaching any A level Biology now, much of your teaching material will still be relevant.
- The specification builds on concepts and skills that will have been developed in the new GCSE Science specifications. It presents biology as exciting, relevant and challenging.
- The specification presents essential principles in contexts that we know students find interesting. It will stimulate the enthusiasm of students and teachers from the start.
- The specification emphasises the way in which scientists work and the contributions of science to modern society in a way that underpins the specification but is never intrusive.
- Unit 1 is smaller than Unit 2 to allow more time to develop skills alongside understanding of concepts and principles.
- The layout is transparent and clear. What you see is what you get.
- The scheme of assessment allows for stretch and challenge for the most able but still allows for the less able to show what they know and what they can do.

Internal Assessment

- There are two routes for internal assessment: centre marked or AQA marked. This provides flexibility to meet the needs of individual centres and candidates.
- Route T, centre marked, is developed from AQA's GCSE PSA/ISA assessment. The AQA set tasks are designed to be flexible and won't impose excessive demands on either time or budget.
- Route X, AQA marked, involves verification of candidates' practical skills by the teacher in the PSV and an Externally Marked Practical Assignment set and marked by AQA.

Support

- AQA's teacher support is second to none. We will continue to provide free support throughout the early years of the specification.
- Assessment Advisers will be available to support teachers in assessing practical skills and the Investigative Skills Assignments.
- We are working with Nelson Thornes to provide a blend of print and electronic resources for teaching and learning.

1.3 How do I start using this specification?

Already using the existing AQA Biology specification?

- Register to receive further information, such as mark schemes, past question papers, details of teacher support meetings, etc; at **http://www.aqa.org.uk/rn/askaqa.php** Information will be available electronically or in print, for your convenience.
- Tell us that you intend to enter candidates. Then we can make sure that you receive all the material you need for the examinations. This is particularly important where examination material is issued before the final entry deadline. You can let us know by completing the appropriate Intention to Enter and Estimated Entry forms. We will send copies to your Exams Officer and they are also available on our website **http://www.aqa.org.uk/exams-administration/entries/early-entry-information**

Not using the AQA specification currently?

- Almost all centres in England and Wales use AQA or have used AQA in the past and are approved AQA centres. A small minority are not. If your centre is new to AQA, please contact our centre approval team at **centreapproval@aqa.org.uk**

1.4 How can I find out more?

Ask AQA

You have 24-hour access to useful information and answers to the most commonly-asked questions at **http://www.aqa.org.uk/rn/askaqa.php**

If the answer to your question is not available, you can submit a query for our team. Our target response time is one day.

Teacher Support

Details of the full range of current Teacher Support and CPD courses are available on our website at **http://web.aqa.org.uk/qual/cpd/index.php**

There is also a link to our fast and convenient online booking system for all of our courses at **http://events.aqa.org.uk/ebooking/**

Latest information online

You can find out more, including the latest news, how to register to use Enhanced Results Analysis, support and downloadable resources, on our website at **http://www.aqa.org.uk/**

2 Specification at a Glance: Biology

AS Examinations

AS Award 1411

Unit 1 BIOL1 **Biology and disease**
Examination paper (60 raw marks / 100 UMS) 5 – 7 short answer questions plus 2 longer questions (a short comprehension and a structured question requiring continuous prose)
1 hour 15 minutes
33.3% of the total AS marks
16.7% of the total A Level marks Available in June only

Unit 2 BIOL2 **The variety of living organisms**
Examination paper (85 raw marks / 140 UMS) 5 – 7 short answer questions plus 2 longer questions involving the handling of data and *How Science Works*
1 hour 45 minutes
46.7% of the total AS marks
23.3% of the total A Level marks Available in June only

Unit 3 – Internal Assessment **Investigative and practical skills in AS Biology**
Either NBIO3T, Centre Marked Route T (50 raw marks/60 UMS)
Practical Skills Assessment (PSA – 6 raw marks)
Investigative Skills Assignment (ISA – 44 raw marks)
Or **NBIO3X,** Externally Marked Route X (50 raw marks/60 UMS)
Practical Skills Verification (PSV – teacher verification)
Externally Marked Practical Assignment (EMPA – 50 raw marks)
20% of total AS marks
10% of total A Level marks Available in June only

A2 Examinations

A Level Award 2411

Unit 4 BIOL4 **Populations and environment**
Examination paper (75 raw marks / 100 UMS) 6 – 9 short answer questions plus 2 longer questions involving continuous prose and *How Science Works*
1 hour 30 minutes
16.7% of the total A Level marks Available in June only

Unit 5 BIOL5 **Control in cells and in organisms**
Examination paper (100 raw marks / 140 UMS) 8 – 10 short answer questions plus 2 longer questions (a data-handling question and a synoptic essay - choice of 1 out of 2)
2 hours 15 minutes
23.3% of the total A Level marks Available in June only

Unit 6 – Internal Assessment **Investigative and practical skills in A2 Biology**
Either NBIO6T, Centre Marked Route T (50 raw marks/60 UMS)
Practical Skills Assessment (PSA – 6 raw marks)
Investigative Skills Assignment (ISA – 44 raw marks)
Or **NBIO6X,** Externally Marked Route X (50 raw marks/60 UMS)
Practical Skills Verification (PSV – teacher verification)
Externally Marked Practical Assignment (EMPA – 50 raw marks)
10% of the total A Level marks Available in June only

AS + A2 = A Level

3 Subject Content

3.1 Unit 1 BIOL1 Biology and disease

The digestive and gas exchange systems are examples of systems in which humans and other mammals exchange substances with their environment. Substances are transported from one part of the body to another by the blood system. An appreciation of the physiology of these systems requires candidates to understand basic principles including the role of enzymes as biological catalysts, and passive and active transport of substances across biological membranes.

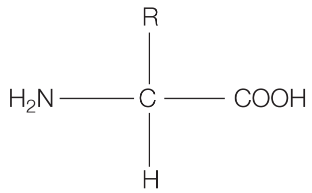
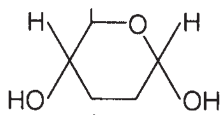
The systems described in this unit, as well as others in the body, may be affected by disease. Some of these diseases, such as cholera and tuberculosis, may be caused by microorganisms. Other non-communicable diseases such as many of those affecting heart and lung function also have a significant impact on human health. Knowledge of basic physiology allows us not only to explain symptoms but also to interpret data relating to risk factors.

The blood has a number of defensive functions which, together with drugs such as antibiotics, help to limit the spread and effects of disease.

It is anticipated that the smaller size of this unit will allow opportunity for the development of the skills of application and analysis as well as for the acquisition of the investigatory skills associated with *Investigative and practical skills* detailed in Unit 3.

3.1.1	**Disease may be caused by infectious pathogens or may reflect the effects of lifestyle.**
Pathogens	Pathogens include bacteria, viruses and fungi. Disease can result from pathogenic microorganisms penetrating any of an organism's interfaces with the environment. These interfaces include the digestive and gas-exchange systems. Pathogens cause disease by damaging the cells of the host and by producing toxins.
Lifestyle	Lifestyle can affect human health. Specific risk factors are associated with cancer and coronary heart disease. Changes in lifestyle may also be associated with a reduced risk of contracting these conditions. **Candidates should be able to** • analyse and interpret data associated with specific risk factors and the incidence of disease • recognise correlations and causal relationships.

3.1.2 The digestive system provides an interface with the environment. Digestion involves enzymic hydrolysis producing smaller molecules that can be absorbed and assimilated.

The digestive system	The gross structure of the human digestive system limited to oesophagus, stomach, small and large intestines, and rectum. The glands associated with this system limited to the salivary glands and the pancreas. Digestion is the process in which large molecules are hydrolysed by enzymes to produce smaller molecules that can be absorbed and assimilated.
Proteins	Proteins have a variety of functions within all living organisms. The general structure of an amino acid as  Condensation and the formation of peptide bonds linking together amino acids to form polypeptides. The relationship between primary, secondary, tertiary and quaternary structure, and protein function. The biuret test for proteins.
Enzyme action	Enzymes as catalysts lowering activation energy through the formation of enzyme-substrate complexes. The lock and key and induced fit models of enzyme action.
Enzyme properties	The properties of enzymes relating to their tertiary structure. Description and explanation of the effects of temperature, competitive and non-competitive inhibitors, pH and substrate concentration. **Candidates should be able to** use the lock and key model to explain the properties of enzymes. They should also recognise its limitations and be able to explain why the induced fit model provides a better explanation of specific enzyme properties.
Carbohydrate digestion	Within this unit, carbohydrates should be studied in the context of the following • starch, the role of salivary and pancreatic amylases and of maltase located in the intestinal epithelium • disaccharides, sucrase and lactase. Biological molecules such as carbohydrates and proteins are often polymers and are based on a small number of chemical elements. Monosaccharides are the basic molecular units (monomers) of which carbohydrates are composed. The structure of α-glucose as  α-glucose and the linking of α-glucose by glycosidic bonds formed by condensation to form maltose and starch. Sucrose is a disaccharide formed by condensation of glucose and fructose. Lactose is a disaccharide formed by condensation of glucose and galactose. Lactose intolerance. Biochemical tests using Benedict's reagent for reducing sugars and non-reducing sugars. Iodine/potassium iodide solution for starch.

3.1.3	Substances are exchanged between organisms and their environment by passive or active transport across exchange surfaces. The structure of plasma membranes enables control of the passage of substances across exchange surfaces.
Cells	The structure of an epithelial cell from the small intestine as seen with an optical microscope. The appearance, ultrastructure and function of • plasma membrane, including cell-surface membrane • microvilli • nucleus • mitochondria • lysosomes • ribosomes • endoplasmic reticulum • Golgi apparatus. **Candidates should be able to** apply their knowledge of these features in explaining adaptations of other eukaryotic cells. The principles and limitations of transmission and scanning electron microscopes. The difference between magnification and resolution. Principles of cell fractionation and ultracentrifugation as used to separate cell components.
Plasma membranes	Glycerol and fatty acids combine by condensation to produce triglycerides. The R-group of a fatty acid may be saturated or unsaturated. In phospholipids, one of the fatty acids of a triglyceride is substituted by a phosphate group. The emulsion test for lipids. The arrangement of phospholipids, proteins and carbohydrates in the fluid-mosaic model of membrane structure. The role of the microvilli in increasing the surface area of cell-surface membranes.
Diffusion	Diffusion is the passive movement of substances down a concentration gradient. Surface area, difference in concentration and the thickness of the exchange surface affect the rate of diffusion. The role of carrier proteins and protein channels in facilitated diffusion. **Candidates should be able to** use the fluid-mosaic model to explain appropriate properties of plasma membranes.
Osmosis	Osmosis is a special case of diffusion in which water moves from a solution of higher water potential to a solution of lower water potential through a partially permeable membrane. Candidates will **not** be expected to recall the terms hypotonic and hypertonic. Recall of isotonic will be expected.
Active transport	The role of carrier proteins and the transfer of energy in the transport of substances against a concentration gradient.
Absorption	Absorption of the products of carbohydrate digestion. The roles of diffusion, active transport and co-transport involving sodium ions.

Cholera	The cholera bacterium as an example of a prokaryotic organism. The structure of prokaryotic cells to include cell wall, cell-surface membrane, capsule, circular DNA, flagella and plasmid. Cholera bacteria produce toxins which increase secretion of chloride ions into the lumen of the intestine. This results in severe diarrhoea. The use of oral rehydration solutions (ORS) in the treatment of diarrhoeal diseases. **Candidates should be able to discuss** • the applications and implications of science in developing improved oral rehydration solutions • ethical issues associated with trialling improved oral rehydration solutions on humans.

3.1.4 The lungs of a mammal act as an interface with the environment. Lung function may be affected by pathogens and by factors relating to lifestyle.	
Lung function	The gross structure of the human gas exchange system limited to the alveoli, bronchioles, bronchi, trachea and lungs. The essential features of the alveolar epithelium as a surface over which gas exchange takes place. The exchange of gases in the lungs. Pulmonary ventilation as the product of tidal volume and ventilation rate. The mechanism of breathing.
The biological basis of lung disease	The course of infection, symptoms and transmission of pulmonary tuberculosis. The effects of fibrosis, asthma and emphysema on lung function. **Candidates should be able to** • explain the symptoms of diseases and conditions affecting the lungs in terms of gas exchange and respiration • interpret data relating to the effects of pollution and smoking on the incidence of lung disease • analyse and interpret data associated with specific risk factors and the incidence of lung disease • recognise correlations and causal relationships.

3.1.5	The functioning of the heart plays a central role in the circulation of blood and relates to the level of activity of an individual. Heart disease may be linked to factors affecting lifestyle.
Heart structure and function	The gross structure of the human heart and its associated blood vessels in relation to function. Pressure and volume changes and associated valve movements during the cardiac cycle. Myogenic stimulation of the heart and transmission of a subsequent wave of electrical activity. Roles of the sinoatrial node (SAN), atrioventricular node (AVN) and bundle of His. Cardiac output as the product of heart rate and stroke volume. **Candidates should be able to** analyse and interpret data relating to pressure and volume changes during the cardiac cycle.
The biological basis of heart disease	Atheroma as the presence of fatty material within the walls of arteries. The link between atheroma and the increased risk of aneurysm and thrombosis. Myocardial infarction and its cause in terms of an interruption to the blood flow to heart muscle. Risk factors associated with coronary heart disease: diet, blood cholesterol, cigarette smoking and high blood pressure. **Candidates should be able to** describe and explain data relating to the relationship between specific risk factors and the incidence of coronary heart disease.

3.1.6	Mammalian blood possesses a number of defensive functions.
Principles of immunology	Phagocytosis and the role of lysosomes and lysosomal enzymes in the subsequent destruction of ingested pathogens. Definition of antigen and antibody. Antibody structure and the formation of an antigen-antibody complex. The essential difference between humoral and cellular responses as shown by B cells and T cells. The role of plasma cells and memory cells in producing a secondary response. The effects of antigenic variability in the influenza virus and other pathogens on immunity. The use of vaccines to provide protection for individuals and populations against disease. The use of monoclonal antibodies in enabling the targeting of specific substances and cells. **Candidates should be able to** • evaluate methodology, evidence and data relating to the use of vaccines and monoclonal antibodies • discuss ethical issues associated with the use of vaccines and monoclonal antibodies • explain the role of the scientific community in validating new knowledge about vaccines and monoclonal antibodies, thus ensuring integrity • discuss the ways in which society uses scientific knowledge relating to vaccines and monoclonal antibodies to inform decision-making.

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Biological principles

When they have completed this unit, candidates will be expected to have an understanding of the following principles.

- Proteins and polysaccharides are made up of monomers that are linked by condensation.
- Many of the functions of proteins may be explained in terms of molecular structure and shape.
- Enzymes are proteins and their rates of reaction are influenced by a range of factors: temperature, the presence of inhibitors, pH and substrate concentration.
- Substances are exchanged by passive or active transport across exchange surfaces. The structure of plasma membranes enables control of the passage of substances across exchange surfaces.

The examiners may draw on an understanding of these principles in Units 2 and 3. This understanding may also be required in the A2 Units where it may contribute to the assessment of synoptic skills.

Investigative and practical skills

Opportunities to carry out the necessary practical work should be provided in the context of this unit. Candidates will be assessed on their understanding of *How science works* in all three AS Units. To meet this requirement, candidates are required to

- use their knowledge and understanding to pose scientific questions and define scientific problems
- carry out investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data they have collected to provide evidence
- evaluate their methodology, evidence and data, resolving conflicting evidence.

The practical work undertaken should include investigations which consider

- the effect of a specific variable on the rate of reaction of an enzyme-controlled reaction
- the effect of a specific variable on human heart rate or pulse rate
- the effect of solute concentration on the rate of uptake of water by plant issue.

3.2 Unit 2 BIOL2 The variety of living organisms

Unit 2 builds on concepts developed in Unit 1.

Although a species may be defined in terms of similarity, there is frequently considerable intraspecific variation and this is influenced by genetic and environmental factors. DNA is an information-carrying molecule, and similarities and differences in the sequence of bases in DNA result in genetic diversity.

The variety of life is extensive and is reflected in similarities and differences in its biochemical basis and cellular organisation. Factors such as size and metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems.

Classification is a means of organising the variety of life based on relationships between organisms and is built round the concept of a species. Originally, classification systems were based on observable features but more recent approaches draw on a wider range of evidence to clarify relationships between organisms. Variation that exists at the interspecific level contributes to the biodiversity of communities and ecosystems.

It is anticipated that this unit will allow opportunity for further development of the skills of application and analysis as well as for the acquisition of additional investigatory skills associated with *Investigative and practical skills*, detailed in Unit 3.

3.2.1 Living organisms vary and this variation is influenced by genetic and environmental factors.

Investigating variation	Variation exists between members of a species. The need for random sampling, and the importance of chance in contributing to differences between samples. The concept of normal distribution about a mean. Understanding mean and standard deviation as measures of variation within a sample. Candidates will not be required to calculate standard deviation in questions on written papers. **Candidates should be able to** analyse and interpret data relating to interspecific and intraspecific variation.
Causes of variation	Similarities and differences between individuals within a species may be the result of genetic factors, differences in environmental factors, or a combination of both. **Candidates should** appreciate the tentative nature of any conclusions that can be drawn relating to the causes of variation.

3.2.2 DNA is an information-carrying molecule. Its sequence of bases determines the structure of proteins, including enzymes.	
Structure of DNA	The double-helix structure of DNA, enabling it to act as a stable information-carrying molecule, in terms of • the components of DNA nucleotides: deoxyribose, phosphate and the bases adenine, cytosine, guanine and thymine • two sugar-phosphate backbones held together by hydrogen bonds between base pairs • specific base pairing.
Genes and polypeptides	A gene occupies a fixed position, called a locus, on a particular strand of DNA. Genes are sections of DNA that contain coded information as a specific sequence of bases. Genes code for polypeptides that determine the nature and development of organisms. The base sequence of a gene can change as a result of a mutation, producing one or more alleles of the same gene. A sequence of three bases, called a triplet, codes for a specific amino acid. The base sequence of a gene determines the amino acid sequence in a polypeptide. In eukaryotes, much of the nuclear DNA does not code for polypeptides. There are, for example, introns within genes and multiple repeats between genes. Differences in base sequences of alleles of a single gene may result in non-functional proteins, including non-functional enzymes.
DNA and chromosomes	In eukaryotes, DNA is linear and associated with proteins. In prokaryotes, DNA molecules are smaller, circular and are not associated with proteins.
Meiosis	The importance of meiosis in producing cells which are genetically different. Within this unit, meiosis should be studied only in sufficient detail to show • the formation of haploid cells • independent segregation of homologous chromosomes. Gametes are genetically different as a result of different combinations of maternal and paternal chromosomes • genetic recombination by crossing over.

3.2.3 Similarities and differences in DNA result in genetic diversity.	
Genetic diversity	Similarities and differences between organisms may be defined in terms of variation in DNA. Differences in DNA lead to genetic diversity. The influence of the following on genetic diversity • selection for high-yielding breeds of domesticated animals and strains of plants • the founder effect • genetic bottlenecks. **Candidates should be able to** discuss ethical issues involved in the selection of domesticated animals.

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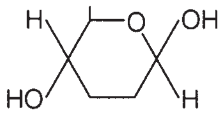
3.2.4 The variety of life is extensive and this is reflected in similarities and differences in its biochemical basis and cellular organisation.	
Haemoglobin	The haemoglobins are a group of chemically similar molecules found in many different organisms. Haemoglobin is a protein with a quaternary structure. The role of haemoglobin in the transport of oxygen. The loading, transport and unloading of oxygen in relation to the oxygen dissociation curve. The effects of carbon dioxide concentration. **Candidates should be** aware that different organisms possess different types of haemoglobin with different oxygen transporting properties. They should be able to relate these to the environment and way of life of the organism concerned.
Carbohydrates	The structure of β-glucose as  β-glucose and the linking of β-glucose by glycosidic bonds formed by condensation to form cellulose. The basic structure and functions of starch, glycogen and cellulose and the relationship of structure to function of these substances in animals and plants.
Cells	There are fundamental differences between plant cells and animal cells. The structure of a palisade cell from a leaf as seen with an optical microscope. The appearance, ultrastructure and function of • cell wall • chloroplasts. **Candidates should be able to** apply their knowledge of these and other eukaryotic features in explaining adaptations of other plant cells.

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3.2.5 During the cell cycle, genetic information is copied and passed to genetically identical daughter cells.	
Replication of DNA	The semi-conservative replication of DNA in terms of • breaking of hydrogen bonds between polynucleotide strands • attraction of new DNA nucleotides to exposed bases and base pairing • role of DNA helicase and of DNA polymerase. **Candidates should be able to** analyse, interpret and evaluate data concerning early experimental work relating to the role and importance of DNA.
Mitosis	During mitosis, the parent cell divides to produce two daughter cells, each containing an exact copy of the DNA of the parent cell. Mitosis increases the cell number in this way in growth and tissue repair. **Candidates should be able to** name and explain the events occurring during each stage of mitosis. They should be able to recognise the stages from drawings and photographs.
Cell cycle	Mitosis and the cell cycle. DNA is replicated and this takes place during interphase. **Candidates should be able to** relate their understanding of the cell cycle to cancer and its treatment.

3.2.6 In complex multicellular organisms, cells are organised into tissues, tissues into organs and organs into systems.	
Cell differentiation	The cells of multicellular organisms may differentiate and become adapted for specific functions. Tissues as aggregations of similar cells, and organs as aggregations of tissues performing specific physiological functions. Organs are organised into systems.

3.2.7	Factors such as size and metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems.
Size and surface area	The relationship between the size of an organism or structure and surface area to volume ratio. Changes to body shape and the development of systems in larger organisms as adaptations that facilitate exchange as the ratio reduces. **Candidates should be able to** explain the significance of the relationship between size and surface area to volume ratio for the exchange of substances and of heat.
Gas exchange	Gas exchange • across the body surface of a single-celled organism • in the tracheal system of an insect (tracheae and spiracles) • across the gills of a fish (gill lamellae and filaments including the countercurrent principle) • by leaves of dicotyledonous plants (mesophyll and stomata). **Candidates should be able to** use their knowledge and understanding of the principles of diffusion to explain the adaptations of gas exchange surfaces. Structural and functional compromises between the opposing needs for efficient gas exchange and the limitation of water loss shown by terrestrial insects and xerophytic plants.
Mass transport	Over large distances, efficient supply of materials is provided by mass transport.
The blood system	The general pattern of blood circulation in a mammal. Names are required only of the coronary arteries and of blood vessels entering and leaving the heart, liver and kidneys. The structure of arteries, arterioles and veins in relation to their function. The structure of capillaries and their importance in metabolic exchange. The formation of tissue fluid and its return to the circulatory system.
The passage of water through a plant	The structure of a dicotyledonous root in relation to the pathway of water from root hairs through the cortex and endodermis to the xylem. Apoplastic and symplastic pathways. Transpiration and the effects of light, temperature, humidity and air movement. The roles of root pressure and cohesion-tension in moving water through the xylem.

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3.2.8	**Classification is a means of organising the variety of life based on relationships between organisms and is built round the concept of species.**
Principles of taxonomy	The principles and importance of taxonomy. Classification systems consist of a hierarchy in which groups are contained within larger composite groups and there is no overlap. The phylogenetic groups are based on patterns of evolutionary history. A species may be defined in terms of observable similarities and the ability to produce fertile offspring. One hierarchy comprises Kingdom, Phylum, Class, Order, Family, Genus, Species. **Candidates should be able to** appreciate the difficulties of defining species and the tentative nature of classifying organisms as distinct species.

3.2.9	**Originally, classification systems were based on observable features but more recent approaches draw on a wider range of evidence to clarify relationships between organisms.**
Genetic comparisons	Genetic comparisons can be made between different species by direct examination of their DNA or of the proteins encoded by this DNA.
DNA	Comparison of DNA base sequences is used to elucidate relationships between organisms. These comparisons have led to new classification systems in plants. Similarities in DNA may be determined by DNA hybridisation.
Proteins	Comparisons of amino acid sequences in specific proteins can be used to elucidate relationships between organisms. Immunological comparisons may be used to compare variations in specific proteins. **Candidates should be able to** interpret data relating to similarities and differences in base sequences in DNA and in amino acid sequences in proteins to suggest relationships between different organisms.
Behaviour	Courtship behaviour as a necessary precursor to successful mating. The role of courtship in species recognition.

3.2.10 Adaptation and selection are major components of evolution and make a significant contribution to the diversity of living organisms.	
Antibiotics	Antibiotics may be used to treat bacterial disease. One way in which antibiotics function is by preventing the formation of bacterial cell walls, resulting in osmotic lysis.
Genetic variation in bacteria	DNA is the genetic material in bacteria as well as in most other organisms. Mutations are changes in DNA and result in different characteristics. Mutations in bacteria may result in resistance to antibiotics. Resistance to antibiotics may be passed to subsequent generations by vertical gene transmission. Resistance may also be passed from one species to another when DNA is transferred during conjugation. This is horizontal gene transmission. Antibiotic resistance in terms of the difficulty of treating tuberculosis and MRSA. **Candidates should be able to** • apply the concepts of adaptation and selection to other examples • evaluate methodology, evidence and data relating to antibiotic resistance • discuss ethical issues associated with the use of antibiotics • discuss the ways in which society uses scientific knowledge relating to antibiotic resistance to inform decision-making.

3.2.11 Biodiversity may be measured within a habitat.	
Species diversity	Diversity may relate to the number of species present in a community. The influence of deforestation and the impact of agriculture on species diversity.
Index of diversity	An index of diversity describes the relationship between the number of species and the number of individuals in a community. Calculation of an index of diversity from the formula $d = \frac{N\ (N-1)}{\Sigma\, n\ (n-1)}$ where N = total number of organisms of all species and n = total number of organisms of each species **Candidates should be able to** • calculate the index of diversity from suitable data • interpret data relating to the effects of human activity on species diversity and be able to evaluate associated benefits and risks • discuss the ways in which society uses science to inform the making of decisions relating to biodiversity.

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Biological principles

When they have completed this unit, candidates will be expected to have an understanding of the following principles.

- A species may be defined in terms of observable similarities and the ability to produce fertile offspring.
- Living organisms vary and this variation is influenced by genetic and environmental factors.
- The biochemical basis and cellular organisation of life is similar for all organisms.
- Genes are sections of DNA that contain coded information as a specific sequence of bases.
- During mitosis, the parent cell divides to produce genetically identical daughter cells.
- The relationship between size and surface area to volume ratio is of fundamental importance in exchange.

An understanding of these principles may be required in the A2 Units where it may contribute to the assessment of synoptic skills.

Investigative and practical skills

Opportunities to carry out the necessary practical work should be provided in the context of this unit. Candidates will be assessed on their understanding of *How science works* in all three AS Units. To meet this requirement, candidates are required to

- use their knowledge and understanding to pose scientific questions and define scientific problems
- carry out investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data they have collected to provide evidence
- evaluate their methodology, evidence and data, resolving conflicting evidence.

They will require specific knowledge of the following skills and areas of investigation. The practical work undertaken should include investigations which consider

- collection and analysis of data relating to intraspecific variation
- use of an optical microscope to examine temporary mounts of plant cells, tissues or organs
- measurement of the rate of water uptake by means of a simple potometer.

3.3 Unit 3 Investigative and practical skills in AS Biology

This unit will address the following aspects of the AS subject criteria. The ability to

- demonstrate and describe ethical, safe and skilful practical techniques, 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 investigatory activities in a variety of ways.

Candidates will be assessed on their understanding of investigative and practical skills in this unit and in Units 1 and 2. Guidance on Internal Assessment can be found in Section 3.8. Opportunities to carry out practical work are provided in the context of material contained in Units 1 and 2.

3.3.1 Investigating biological problems involves changing a specific factor, the independent variable, and measuring the changes in the dependent variable that result.	
Candidates should be able to • use knowledge and understanding from the AS specification to pose scientific questions and define scientific problems • identify the independent variable and describe an appropriate method of varying it in such detail that a student starting an AS course could carry out the suggested procedure without further assistance • identify other variables that might be expected to exert a significant influence on the results, use knowledge from relevant parts of the AS specification to explain why, and describe how these would be kept constant • where necessary, describe how and explain why appropriate control experiments should be established • identify the dependent variable and describe how they would collect a full range of useful quantitative data, measured to an appropriate level of accuracy and precision • distinguish between accuracy and reliability and describe precautions needed to obtain valid, accurate and reliable data.	**Practical work carried out in the context of Units 1 and 2 should enable candidates to gain experience of** • the use of water baths to change or control temperature • the use of buffers to change or control pH • producing an appropriate dilution series when provided with stock solutions of reagents.

3.3.2 Implementing involves the ability to work methodically and safely, demonstrating competence in the required manipulative skills and efficiency in managing time. Raw data should be methodically collected and recorded during the course of the investigation.	
Candidates should be able to • show full regard for safety and the ethical issues involved with the well-being of living organisms and the environment • carry out an investigation in a methodical and organised way, demonstrating competence in the required manipulative skills and efficiency in managing time • take all measurements to an appropriate level of accuracy and precision • collect and present raw data in a suitable table conforming to the conventions specified in the Institute of Biology publication, *Biological Nomenclature, Recommendations on Terms, Units and Symbols*, 3rd edition (2000) concerning organisation and presentation of units.	**Practical work carried out in the context of Units 1 and 2 should enable candidates to gain experience of** • using an optical microscope, preparing temporary mounts, staining and estimating size • collection of reliable quantitative data where – gas is evolved – colour change takes place – there are changes in mass or length.

3.3.3 Raw data may require processing. Processed data should be used to plot graphs that illustrate patterns and trends from which appropriate conclusions may be drawn. Scientific knowledge from the AS specification should be used to explain these conclusions.

Candidates should be able to	Practical work carried out in the context of Units 1 and 2 should enable candidates to gain experience of
• process data by carrying out appropriate calculations • select relevant data to present an effective summary of the results of an investigation and plot this as an appropriate graph conforming to the conventions specified in the Institute of Biology publication, *Biological Nomenclature, Recommendations on Terms, Units and Symbols*, 3rd edition (2000) concerning organisation and presentation of units • describe, concisely but fully, the trends and patterns in data collected, relating these to specific values, quantities and units • recognise correlations and causal relationships • draw valid conclusions, relating explanations to specific aspects of the data collected and applying biological knowledge and understanding from the AS specification.	• using a standard scientific calculator to calculate mean and standard deviation, rate and percentage change • plotting data as line graphs, bar charts and histograms • plotting data as scatter diagrams and using these to identify correlation.

3.3.4 Limitations are inherent in the material and apparatus used, and procedures adopted. These limitations should be identified and methods of overcoming them suggested.

Candidates should be able to	
• identify the limitations of the material, apparatus and techniques used • discuss the effects of these limitations on the reliability and precision of the data and on the conclusions that may be drawn, resolving conflicting evidence • suggest realistic ways in which the effect of these limitations may be reduced.	

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3.4 Unit 4 BIOL4 Populations and environment

Living organisms form structured communities within dynamic but essentially stable ecosystems through which energy is transferred and chemical elements are cycled. Humans are part of the ecological balance and their activities affect it both directly and indirectly. Consideration of these effects underpins the content of this unit and should lead to an understanding that sustainability of resources depends on effective management of the conflict between human needs and conservation.

It is expected that candidates will carry out fieldwork involving the collection of quantitative data from at least one habitat and will apply elementary statistical analysis to the results.

3.4.1	**The dynamic equilibrium of populations is affected by a number of factors.**
Populations and ecosystems	A population is all the organisms of one species in a habitat. Populations of different species form a community. Within a habitat a species occupies a niche governed by adaptation to both biotic and abiotic conditions.
Investigating populations	A critical appreciation of some of the ways in which the numbers and distribution of organisms may be investigated. Random sampling with quadrats and counting along transects to obtain quantitative data. The use of percentage cover and frequency as measures of abundance. The use of mark–release–recapture for more mobile species. In the context of investigating populations, **candidates should** • carry out experimental and investigative activities, including appropriate risk management • consider ethical issues arising when carrying out fieldwork, particularly those relating to the organisms involved and their environment • analyse and interpret data relating to the distribution of organisms, recognising correlations and causal relationships • appreciate the tentative nature of conclusions that may be drawn from such data.
Variation in population size	Population size may vary as a result of • the effect of abiotic factors • interactions between organisms: interspecific and intraspecific competition and predation.
Human populations	Population size and structure, population growth rate, age-population pyramids, survival rates and life expectancy. **Candidates should be able to** • interpret growth curves, survival curves and age-population pyramids • calculate population growth rates from data on birth rate and death rate. • relate changes in the size and structure of human populations to different stages in demographic transition.

3.4.2	**ATP provides the immediate source of energy for biological processes.**
ATP	The synthesis of ATP from ADP and phosphate and its role as the immediate source of energy for biological processes.

3.4.3	**In photosynthesis, energy is transferred to ATP in the light-dependent reaction and the ATP is utilised in the light-independent reaction.**
Photosynthesis	The light-independent and light-dependent reactions in a typical C3 plant.
Light-dependent reaction	The light-dependent reaction in such detail as to show that • light energy excites electrons in chlorophyll • energy from these excited electrons generates ATP and reduced NADP • the production of ATP involves electron transfer associated with the electron transfer chain in chloroplast membranes • photolysis of water produces protons, electrons and oxygen.
Light-independent reaction	The light-independent reaction in such detail as to show that • carbon dioxide is accepted by ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate (GP) • ATP and reduced NADP are required for the reduction of GP to triose phosphate • RuBP is regenerated in the Calvin cycle • Triose phosphate is converted to useful organic substances.
Limiting factors	The principle of limiting factors as applied to the effects of temperature, carbon dioxide concentration and light intensity on the rate of photosynthesis. **Candidates should be able to** explain how growers apply a knowledge of limiting factors in enhancing temperature, carbon dioxide concentration and light intensity in commercial glasshouses. They should also be able to evaluate such applications using appropriate data.

3.4.4	**In respiration, glycolysis takes place in the cytoplasm and the remaining steps in the mitochondria. ATP synthesis is associated with the electron transfer chain in the membranes of mitochondria.**
Aerobic respiration	Aerobic respiration in such detail as to show that • glycolysis takes place in the cytoplasm and involves the oxidation of glucose to pyruvate with a net gain of ATP and reduced NAD • pyruvate combines with coenzyme A in the link reaction to produce acetylcoenzyme A • in a series of oxidation-reduction reactions the Krebs cycle generates reduced coenzymes and ATP by substrate-level phosphorylation, and carbon dioxide is lost • acetylcoenzyme A is effectively a two carbon molecule that combines with a four carbon molecule to produce a six carbon molecule which enters the Krebs cycle • synthesis of ATP by oxidative phosphorylation is associated with the transfer of electrons down the electron transport chain and passage of protons across mitochondrial membranes.
Anaerobic respiration	Glycolysis followed by the production of ethanol or lactate and the regeneration of NAD in anaerobic respiration.

3.4.5 Energy is transferred through ecosystems and the efficiency of transfer can be measured.	
Energy transfer	Photosynthesis is the main route by which energy enters an ecosystem. Energy is transferred through the trophic levels in food chains and food webs and is dissipated. Quantitative consideration of the efficiency of energy transfer between trophic levels. Pyramids of numbers, biomass and energy and their relationship to their corresponding food chains and webs.
Energy and food production	Comparison of natural ecosystems and those based on modern intensive farming in terms of energy input and productivity. Net productivity as defined by the expression Net productivity = Gross productivity – Respiratory loss The ways in which productivity is affected by farming practices that increase the efficiency of energy conversion. These include • the use of natural and artificial fertilisers • the use of chemical pesticides, biological agents and integrated systems in controlling pests on agricultural crops • intensive rearing of domestic livestock. **Candidates should be able to** • apply their understanding of biological principles to present scientific arguments that explain how these and other farming practices affect productivity • evaluate economic and environmental issues involved with farming practices that increase productivity • consider ethical issues arising from enhancement of productivity.

3.4.6 Chemical elements are recycled in ecosystems. Microorganisms play a key role in recycling these elements.	
Nutrient cycles	The role of microorganisms in the carbon and nitrogen cycles in sufficient detail to illustrate the processes of saprobiotic nutrition, ammonification, nitrification, nitrogen fixation and denitrification. (The names of individual species are **not** required.)
Carbon	The importance of respiration, photosynthesis and human activity in giving rise to short-term fluctuation and long-term change in global carbon dioxide concentration. The roles of carbon dioxide and methane in enhancing the greenhouse effect and bringing about global warming. **Candidates should be able to** analyse, interpret and evaluate data relating to evidence of global warming and its effects on • the yield of crop plants • the life-cycles and numbers of insect pests • the distribution and numbers of wild animals and plants.
Nitrogen	The environmental issues arising from the use of fertilisers. Leaching and eutrophication. **Candidates should be able to** analyse, interpret and evaluate data relating to eutrophication.

3.4.7 Ecosystems are dynamic systems, usually moving from colonisation to climax communities in the process of succession.	
Succession	Succession from pioneer species to climax community. At each stage in succession, certain species may be recognised which change the environment so that it becomes more suitable for other species. The changes in the abiotic environment result in a less hostile environment and changing diversity. Conservation of habitats frequently involves management of succession. **Candidates should be able to** • use their knowledge and understanding to present scientific arguments and ideas relating to the conservation of species and habitats • evaluate evidence and data concerning issues relating to the conservation of species and habitats and consider conflicting evidence • explain how conservation relies on science to inform decision-making.

3.4.8 Genetic variation within a species and geographic isolation lead to the accumulation of different genetic information in populations and the potential formation of new species.	
Inheritance	The genotype is the genetic constitution of an organism. The phenotype is the expression of this genetic constitution and its interaction with the environment. Alleles are one or more alternative versions of the same gene. The alleles at a specific locus may be either homozygous or heterozygous. Alleles may be dominant, recessive or codominant. There may be multiple alleles of a single gene. **Candidates should be able to** use fully labelled genetic diagrams to predict the results of • monohybrid crosses involving dominant, recessive and codominant alleles • crosses involving multiple alleles and sex-linked characteristics.
The Hardy-Weinberg principle	Species exist as one or more populations. The concepts of gene pool and allele frequency. The Hardy-Weinberg principle. The conditions under which the principle applies. **Candidates should be able to** calculate allele, genotype and phenotype frequencies from appropriate data and from the Hardy-Weinberg equation, $p^2 + 2pq + q^2 = 1$ where p is the frequency of the dominant allele and q is the frequency of the recessive allele. **Candidates should understand that** the Hardy-Weinberg principle provides a mathematical model which predicts that allele frequencies will not change from generation to generation.

Selection	Differential reproductive success and its effect on the allele frequency within a gene pool. Directional and stabilising selection. **Candidates should be able to** • use both specific examples and unfamiliar information to explain how selection produces changes within a species • interpret data relating to the effect of selection in producing change within populations.
Speciation	Geographic separation of populations of a species can result in the accumulation of difference in the gene pools. The importance of geographic isolation in the formation of new species

Biological principles

When they have completed this unit, candidates will be expected to have an understanding of the following principles.

- Random sampling results in the collection of data which is unbiased and suitable for statistical analysis
- ATP is the immediate source of energy for biological processes
- Limiting factors
- Energy is transferred through ecosystems
- Chemical elements are recycled in ecosystems
- Genetic variation occurs within a species and geographic isolation leads to the accumulation of genetic difference in populations.

Understanding of these principles may be tested in Units 5 and 6. Such testing may contribute to the assessment of synoptic skills.

Investigative and practical skills

Opportunities to carry out the necessary practical work should be provided in the context of this unit. Candidates will be assessed on their understanding of *How Science Works* in all three A2 Units. To meet this requirement candidates are required to

- use their knowledge and understanding to pose scientific questions and define scientific problems
- carry out investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data they have collected to provide evidence
- evaluate their methodology, evidence and data, resolving conflicting evidence.

The practical work undertaken should include investigations which consider

- the effect of a specific limiting factor such as light intensity, carbon dioxide concentration or temperature on the rate of photosynthesis
- the effect of a specific variable such as substrate or temperature on the rate of respiration of a suitable organism
- fieldwork involving the use of frame quadrats and line transects, and the measurement of a specific abiotic factor; collection of quantitative data from at least one habitat, and the application of elementary statistical analysis to the results; the use of percentage cover and frequency as measures of abundance.

3.5 Unit 5 BIOL5 Control in cells and in organisms

Multicellular organisms are able to control the activities of different tissues and organs within their bodies. They do this by detecting stimuli and stimulating appropriate effectors: plants use specific growth factors; animals use hormones, nerve impulses or a combination of both. By responding to internal and external stimuli, animals increase their chances of survival by avoiding harmful environments and by maintaining optimal conditions for their metabolism.

Cells are also able to control their metabolic activities by regulating the transcription and translation of their genome. Although the cells within an organism carry the same genetic code, they translate only part of it. In multicellular organisms, this control of translation enables cells to have specialised functions, forming tissues and organs. The sequencing and manipulation of DNA has many medical and technological applications.

Consideration of control mechanisms underpins the content of this unit. Students who have studied it should develop an understanding of the ways in which organisms and cells control their activities. This should lead to an appreciation of common ailments resulting from a breakdown of these control mechanisms and the use of DNA technology in the diagnosis and treatment of human diseases.

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3.5.1	**Stimuli, both internal and external, are detected and lead to a response.**
Survival and response	Organisms increase their chance of survival by responding to changes in their environment. Tropisms as responses to directional stimuli that can maintain the roots and shoots of flowering plants in a favourable environment. Taxes and kineses as simple responses that can maintain a mobile organism in a favourable environment. A simple reflex arc involving three neurones. The importance of simple reflexes in avoiding damage to the body.
Control of heart rate	The role of chemoreceptors and pressure receptors, the autonomic nervous system and effectors in controlling heart rate.
Receptors	The basic structure of a Pacinian corpuscle as an example of a receptor. The creation of a generator potential on stimulation. The Pacinian corpuscle should be used as an example to illustrate the following. • Receptors only respond to specific stimuli • Stimulation of receptor membranes produces deformation of stretch-mediated sodium channels, leading to the establishment of a generator potential. Differences in sensitivity and visual acuity as explained by differences in the distribution of rods and cones and the connections they make in the optic nerve.

3.5.2	Coordination may be chemical or electrical in nature.
Principles	Nerve cells pass electrical impulses along their length. They stimulate their target cells by secreting chemical neurotransmitters directly on to them. This results in rapid, short-lived and localised responses. Mammalian hormones are substances that stimulate their target cells via the blood system. This results in slow, long-lasting and widespread responses. Histamine and prostaglandins are local chemical mediators released by some mammalian cells and affect only cells in their immediate vicinity. In flowering plants, specific growth factors diffuse from growing regions to other tissues. They regulate growth in response to directional stimuli. The role of indoleacetic acid (IAA) in controlling tropisms in flowering plants.
Nerve impulses	The structure of a myelinated motor neurone. The establishment of a resting potential in terms of differential membrane permeability, electrochemical gradients and the movement of sodium and potassium ions. Changes in membrane permeability lead to depolarisation and the generation of an action potential. The all-or-nothing principle. The passage of an action potential along non-myelinated and myelinated axons, resulting in nerve impulses. The nature and importance of the refractory period in producing discrete impulses. Factors affecting the speed of conductance: myelination and saltatory conduction; axon diameter; temperature.
Synaptic transmission	The detailed structure of a synapse and of a neuromuscular junction. **Candidates should be able to** explain • unidirectionality • temporal and spatial summation • inhibition. The sequence of events involved in transmission across a cholinergic synapse and across a neuromuscular junction. When provided with information, **candidates should be able to** predict and explain the effects of specific drugs on a synapse. Recall of the names and mode of action of individual drugs will **not** be required.

3.5.3	Skeletal muscles are stimulated to contract by nerves and act as effectors.
The sliding filament theory of muscle contraction	Gross and microscopic structure of skeletal muscle. The ultrastructure of a myofibril. The roles of actin, myosin, calcium ions and ATP in myofibril contraction. The roles of calcium ions and tropomyosin in the cycle of actinomyosin bridge formation.
Muscles as effectors	The role of ATP and phosphocreatine in providing the energy supply during muscle contraction. The structure, location and general properties of slow and fast skeletal muscle fibres.

3.5.4 Homeostasis is the maintenance of a constant internal environment.	
Principles	Homeostasis in mammals involves physiological control systems that maintain the internal environment within restricted limits. The importance of maintaining a constant core temperature and constant blood pH in relation to enzyme activity. The importance of maintaining a constant blood glucose concentration in terms of energy transfer and water potential of blood.
Temperature control	The contrasting mechanisms of temperature control in an ectothermic reptile and an endothermic mammal. Mechanisms involved in heat production, conservation and loss. The role of the hypothalamus and the autonomic nervous system in maintaining a constant body temperature in a mammal.
Control of blood glucose concentration	The factors that influence blood glucose concentration. The role of the liver in glycogenesis and gluconeogenesis. The role of insulin and glucagon in controlling the uptake of glucose by cells and in activating enzymes involved in the interconversion of glucose and glycogen. The effect of adrenaline on glycogen breakdown and synthesis. The second messenger model of adrenaline and glucagon action. Types I and II diabetes and control by insulin and manipulation of the diet.

3.5.5 Negative feedback helps maintain an optimal internal state in the context of a dynamic equilibrium. Positive feedback also occurs.	
Principles	Negative feedback restores systems to their original level. The possession of separate mechanisms involving negative feedback controls departures in different directions from the original state, giving a greater degree of control. Positive feedback results in greater departures from the original levels. Positive feedback is often associated with a breakdown of control systems, e.g. in temperature control. **Candidates should be able to** interpret diagrammatic representations of negative and positive feedback.
Control of mammalian oestrus	The mammalian oestrous cycle is controlled by FSH, LH, progesterone and oestrogen. The secretion of FSH, LH, progesterone and oestrogen is controlled by interacting negative and positive feedback loops. **Candidates should be able to** interpret graphs showing the blood concentrations of FSH, LH, progesterone and oestrogen during a given oestrous cycle. Changes in the ovary and uterus lining are **not** required.

3.5.6	The sequence of bases in DNA determines the structure of proteins, including enzymes.
The genetic code	The genetic code as base triplets in mRNA which code for specific amino acids. The genetic code is universal, non-overlapping and degenerate. The structure of molecules of messenger RNA (mRNA) and transfer RNA (tRNA). **Candidates should be able to** compare the structure and composition of DNA, mRNA and tRNA.
Polypeptide synthesis	Transcription as the production of mRNA from DNA. The role of RNA polymerase. The splicing of pre-mRNA to form mRNA in eukaryotic cells. Translation as the production of polypeptides from the sequence of codons carried by mRNA. The role of ribosomes and tRNA. **Candidates should be able to** • show understanding of how the base sequences of nucleic acids relate to the amino acid sequence of polypeptides, when provided with suitable data • interpret data from experimental work investigating the role of nucleic acids. Recall of specific codons and the amino acids for which they code, and of specific experiments, will **not** be tested.
Gene mutation	Gene mutations might arise during DNA replication. The deletion and substitution of bases. Gene mutations occur spontaneously. The mutation rate is increased by mutagenic agents. Some mutations result in a different amino acid sequence in the encoded polypeptide. Due to the degenerate nature of the genetic code, not all mutations result in a change to the amino acid sequence of the encoded polypeptide. The rate of cell division is controlled by proto-oncogenes that stimulate cell division and tumour suppressor genes that slow cell division. A mutated proto-oncogene, called an oncogene, stimulates cells to divide too quickly. A mutated tumour suppressor gene is inactivated, allowing the rate of cell division to increase.

3.5.7	Gene expression is controlled by a number of features.
Most of a cell's DNA is not translated	Totipotent cells are cells that can mature into any body cell. During development, totipotent cells translate only part of their DNA, resulting in cell specialisation. In mature plants, many cells remain totipotent. They have the ability to develop *in vitro* into whole plants or into plant organs when given the correct conditions. Totipotent cells occur only for a limited time in mammalian embryos. Multipotent cells are found in mature mammals. They can divide to form only a limited number of different cell types. Totipotent and multipotent stem cells can be used in treating some genetic disorders. **Candidates should be able to** • interpret data relating to tissue culture of plants from samples of totipotent cells • evaluate the use of stem cells in treating human disorders.

Regulation of transcription and translation	Transcription of target genes is stimulated only when specific transcriptional factors move from the cytoplasm into the nucleus. The effect of oestrogen on gene transcription. Small interfering RNA (siRNA) as a short, double-strand of RNA that interferes with the expression of a specific gene. **Candidates should be able to** • interpret data provided from investigations into gene expression • interpret information relating to the use of oncogenes and tumour suppressor genes in the prevention, treatment and cure of cancer • evaluate the effect on diagnosis and treatment of disorders caused by hereditary mutations and those caused by acquired mutations.

3.5.8 Gene cloning technologies allow study and alteration of gene function in order to better understand organism function and to design new industrial and medical processes.	
Gene cloning and transfer	Fragments of DNA can be produced by • conversion of mRNA to cDNA, using reverse transcriptase • cutting DNA at specific, palindromic recognition sequences using restriction endonucleases • the polymerse chain reaction (PCR). Fragments of DNA produced by any of the above methods can be used to clone genes by *in vivo* and *in vitro* techniques. *In vivo* cloning. The use of restriction endonucleases and ligases to insert a gene into vectors, which are then transferred into host cells. The identification and growth of transformed host cells to clone the desired DNA fragments. The importance of "sticky ends". *In vitro* cloning. The use of the polymerase chain reaction (PCR) to clone directly. The relative advantages of *in vivo* and *in vitro* cloning. The use of recombinant DNA technology to produce transformed organisms that benefit humans. **Candidates should be able to** • interpret information relating to the use of recombinant DNA technology • evaluate the ethical, moral and social issues associated with the use of recombinant technology in agriculture, in industry and in medicine • balance the humanitarian aspects of recombinant DNA technology with the opposition from environmentalists and anti-globalisation activists.
Gene therapy	The use of gene therapy to supplement defective genes. **Candidates should be able to** evaluate the effectiveness of gene therapy.

Medical diagnosis	The use of labelled DNA probes and DNA hybridisation to locate specific genes. Once located, the base sequence of a gene can be determined by • restriction mapping • DNA sequencing. Many human diseases result from mutated genes or from genes that are useful in one context but not in another, e.g. sickle cell anaemia. DNA sequencing and the PCR are used to produce DNA probes that can be used to screen patients for clinically important genes. The use of this information in genetic counselling, e.g. for parents who are both carriers of defective genes and, in the case of oncogenes, in deciding the best course of treatment for cancers. **Candidates should** understand the principles of these methods. They should be aware that methods are continuously updated and automated.
Genetic fingerprinting	An organism's genome contains many repetitive, non-coding base sequences. The probability of two individuals having the same repetitive sequences is very low. The technique of genetic fingerprinting in analysing DNA fragments, that have been cloned by PCR, and its use in determining genetic relationships and in determining the genetic variability within a population. **Candidates should be able to** • explain the biological principles that underpin genetic fingerprinting techniques • interpret data showing the results of gel electrophoresis to separate DNA fragments • explain why scientists might use genetic fingerprints in the fields of forensic science, medical diagnosis, animal and plant breeding.

Biological principles

When they have completed this unit, candidates will be expected to have an understanding of the following principles.

- Organisms regulate their internal environment and so maintain optimum conditions for their metabolism.
- Animals respond to their internal and external environment as a result of stimulus perception, chemical and electrical coordination and a response by effectors. Plants respond to their external environment as a result of specific growth factors that regulate cell growth.
- The genetic code is held in the base sequence of nucleic acids and determines the amino acid sequence of polypeptides produced by a cell.
- Regulating gene expression enables a cell to control its own activities and development.
- Scientists are able to manipulate gene expression for many agricultural, industrial and medical purposes.

Understanding of these principles, together with those established during the study of other units, will contribute to the assessment of synoptic skills in Unit 5.

Investigative and practical skills

Opportunities to carry out the necessary practical work should be provided in the context of this unit. Candidates will be assessed on their understanding of *How Science Works* in all three A2 units. To meet this requirement, candidates are required to

- use their knowledge and understanding to pose scientific questions and define scientific problems
- carry out investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data they have collected to provide evidence
- evaluate their methodology, evidence and data, resolving conflicting evidence.

They will require specific knowledge of the following skills and areas of investigation. The practical work undertaken should include investigations which consider the effect of external stimuli on taxes and kineses in suitable organisms.

3.6 Unit 6 Investigative and practical skills in A2 Biology

This unit will address the following aspects of the A2 subject criteria. The ability to

- demonstrate and describe ethical, safe and skilful practical techniques, 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 investigatory activities in a variety of ways.

Candidates will be assessed on their understanding of investigative and practical skills in this unit and in Units 4 and 5. Guidance on Internal Assessment can be found in Section 3.8. Opportunities to carry out practical work are provided in the context of material contained in Units 4 and 5.

3.6.1 Investigating biological problems involves changing a specific factor, the independent variable, and measuring the changes in the dependent variable that result.

Candidates should be able to	Practical work carried out in the context of Units 4 and 5 should enable candidates to gain experience of
• use knowledge and understanding from the A level specification to pose scientific questions and define scientific problems • identify the independent variable and describe an appropriate method of varying it in such detail that a student starting an A2 course could carry out the suggested procedure without further assistance • identify other variables that might be expected to exert a significant influence on the results, use knowledge from relevant parts of the A Level specification to explain why, and describe how they would be kept constant or monitored • where necessary, describe how and explain why appropriate control experiments should be established • identify the dependent variable and describe how they would collect a full range of useful quantitative data that could be analysed statistically, measured to an appropriate level of accuracy and precision • distinguish between accuracy and reliability and describe precautions needed to obtain valid, accurate and reliable data.	• random sampling • the use of a three-way tap in collecting gas samples • establishing anaerobic conditions.

3.6.2 Implementing involves the ability to work methodically and safely, demonstrating competence in the required manipulative skills and efficiency in managing time. Raw data should be methodically collected and recorded during the course of the investigation.

Candidates should be able to	**Practical work carried out in the context of Units 4 and 5 should enable candidates to gain experience of**
• show full regard for safety and the ethical issues involved with the well-being of living organisms and the environment • carry out an investigation in a methodical and organised way, demonstrating competence in the required manipulative skills and efficiency in managing time • take all measurements to an appropriate level of accuracy and precision • present raw data in a suitable table conforming to the conventions specified in the Institute of Biology publication, *Biological Nomenclature, Recommendations on Terms, Units and Symbols,* 3rd edition (2000) concerning organisation and presentation of units.	• collection of reliable quantitative ecological data involving a specific abiotic factor, frequency, population density and percentage cover.

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3.6.3 Data should be analysed by means of an appropriate statistical test. This allows calculation of the probability of an event being due to chance. Appropriate conclusions should be drawn and scientific knowledge from the A Level specification should be used to explain these conclusions.

Candidates should be able to	**Practical work carried out in the context of Units 4 and 5 should enable candidates to gain experience of**
• select and justify the choice of an appropriate statistical test from the following: – standard error and 95% confidence limits – Spearman rank correlation – χ^2 • construct an appropriate null hypothesis • calculate the test statistic given a standard scientific calculator • interpret the calculated test statistic in terms of the appropriate critical value at the 5% significance level, making reference to chance, probability and acceptance or rejection of the null hypothesis • draw valid conclusions, relating explanations to specific aspects of the data collected and applying biological knowledge and understanding from the A Level specification.	• selecting, using and interpreting an appropriate statistical test from the following: – standard error and 95% confidence limits – Spearman rank correlation – χ^2

3.6.4 Limitations are inherent in the material and apparatus used and procedures adopted. These limitations should be identified, evaluated and methods of overcoming them suggested.	
Candidates should be able to • identify the limitations inherent in the apparatus and techniques used • discuss and assess the relative effects of these limitations on the reliability and precision of the data and on the conclusions that may be drawn, resolving conflicting evidence • suggest realistic ways in which the effect of these limitations may be reduced • suggest further investigations which would provide additional evidence for the conclusions drawn.	

3.7 How Science Works

How Science Works is an underpinning set of concepts and is the means whereby students come to understand how scientists investigate scientific phenomena in their attempts to explain the world about us. Moreover, *How Science Works* recognises the contribution scientists have made to their own disciplines and to the wider world.

It recognises that scientists may be influenced by their own beliefs and that these can affect the way in which they approach their work. Also, it acknowledges that scientists can and must contribute to debates about the uses to which their work is put and how their work influences decision-making in society.

In general terms, it can be used to promote students' skills in solving scientific problems by developing an understanding of:

- the concepts, principles and theories that form the subject content
- the procedures associated with the valid testing of ideas and, in particular, the collection, interpretation and validation of evidence
- the role of the scientific community in validating evidence and also in resolving conflicting evidence.

As students become proficient in these aspects of *How Science Works*, they can also engage with the place and contribution of science in the wider world. In particular, students will begin to recognise

- the contribution that scientists, as scientists, can make to decision-making and the formulation of policy
- the need for regulation of scientific enquiry and how this can be achieved
- how scientists can contribute legitimately to debates about those claims which are made in the name of science.

An understanding of *How Science Works* is a requirement for this specification and is set out in the following points which are taken directly from the *GCE AS and A Level subject criteria for science subjects*. Each point is expanded in the context of Biology. The specification references given illustrate where the example is relevant and could be incorporated.

A	**Use theories, models and ideas to develop and modify scientific explanations** Scientists use theories and models to attempt to explain observations. These theories and models can form the basis for scientific experimental work. Scientific progress is made when validated evidence is found that supports a new theory or model. *Examples in this specification include:* • Theoretical models such as the mass transport of water, 3.1.3 • Physical models such as the use of the lock and key model to explain the properties of enzymes, 3.1.2 • Mathematical models, such as the Hardy-Weinberg principle, predict that allele frequencies do not change from generation to generation 3.4.8
B	**Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas** Scientists use their knowledge and understanding when observing objects and events, in defining a scientific problem and when questioning their own explanations or those of other scientists. Scientific progress is made when scientists contribute to the development of new ideas, materials and theories. *Examples in this specification include:* • pose scientific questions and define scientific problems in Investigative and practical skills 3.3.1 • presentation of logical scientific argument in the synoptic essay in Unit 5, 3.5
C	**Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems** Observations ultimately lead to explanations in the form of hypotheses. In turn, these hypotheses lead to predictions that can be tested experimentally. Observations are one of the key links between the 'real world' and the abstract ideas of science. Once an experimental method has been validated, it becomes a protocol that is used by other scientists. ICT can be used to collect, record and analyse experimental data. *Examples in this specification include:* • choice of a suitable method to measure a variable, 3.3.1 • choice and use of a suitable statistical test, 3.6.3
D	**Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts** Scientists perform a range of experimental skills that include manual and data handling skills (tabulation, graphical skills etc). Scientists should select and use equipment that is appropriate when making accurate measurements and should record these measurements methodically. Scientists carry out experimental work in such a way as to minimise the risk to themselves, to others and to the materials, including organisms, used. *Examples in this specification include:* • Many opportunities in the Investigative and practical skills units for AS and A2

E	**Analyse and interpret data to provide evidence, recognising correlations and causal relationships**
	Scientists look for patterns and trends in data as a first step in providing explanations of phenomena. The degree of uncertainty in any data will affect whether alternative explanations can be given for the data. Anomalous data are those measurements that fall outside the normal, or expected, range of measured values. Decisions on how to treat anomalous data should be made only after examination of the event. In searching for causal links between factors, scientists propose predictive theoretical models that can be tested experimentally. When experimental data confirm predictions from these theoretical models, scientists become confident that a causal relationship exists.
	Examples in this specification include: • analyse and interpret data associated with specific risk factors and the incidence of lung disease, 3.1.4 • analyse and interpret data relating to the distribution of organisms, recognising correlations and causal relationships, 3.4.1
F	**Evaluate methodology, evidence and data, and resolve conflicting evidence**
	The validity of new evidence, and the robustness of conclusions that stem from it, is constantly questioned by scientists. Experimental methods must be designed adequately to test predictions. Solutions to scientific problems are often developed when different research teams produce conflicting evidence. Such evidence is a stimulus for further scientific investigation, which involves refinements of experimental technique or development of new hypotheses
	Examples in this specification include: • evaluate methodology, evidence and data relating to the use of vaccines and monoclonal antibodies, 3.1.6 • evaluate evidence and data concerning issues relating to the conservation of species and habitats and consider conflicting evidence, 3.4.7
G	**Appreciate the tentative nature of scientific knowledge**
	Scientific explanations are those that are based on experimental evidence which is supported by the scientific community. Scientific knowledge changes when new evidence provides a better explanation of scientific observations.
	Examples in this specification include: • appreciate the tentative nature of any conclusions that can be drawn relating to the causes of variation, 3.2.1 • appreciate the tentative nature of conclusions that may be drawn from data relating to populations, 3.4.1
H	**Communicate information and ideas in appropriate ways using appropriate terminology**
	By sharing the findings of their research, scientists provide the scientific community with opportunities to replicate and further test their work, thus either confirming new explanations or refuting them. Scientific terminology avoids confusion amongst the scientific community, enabling better understanding and testing of scientific explanations.
	Examples in this specification include: • Many opportunities through assessment of questions requiring extended prose for AS and A2

I	**Consider applications and implications of science and appreciate their associated benefits and risks**
	Scientific advances have greatly improved the quality of life for the majority of people. Developments in technology, medicine and materials continue to further these improvements at an increasing rate. Scientists can predict and report on some of the beneficial applications of their experimental findings. Scientists evaluate, and report on, the risks associated with the techniques they develop and the applications of their findings.
	Examples in this specification include: • interpret data relating to the effects of human activity on species diversity and be able to evaluate associated benefits and risks, 3.2.11 • balance the humanitarian aspects of recombinant DNA technology with opposition from environmentalists and anti-globalisation activists, 3.5.8
J	**Consider ethical issues in the treatment of humans, other organisms and the environment**
	Scientific research is funded by society, either through public funding or through private companies that obtain their income from commercial activities. Scientists have a duty to consider ethical issues associated with their findings. Individual scientists have ethical codes that are often based on humanistic, moral and religious beliefs. Scientists are self-regulating and contribute to decision-making about what investigations and methodologies should be permitted.
	Examples in this specification include: • discuss ethical issues involved in the selection of domesticated animals, 3.2.3 • evaluate evidence and data concerning issues relating to the conservation of species and habitats and consider conflicting evidence, 3.4.7
K	**Appreciate the role of the scientific community in validating new knowledge and ensuring integrity**
	The findings of scientists are subject to peer review before being accepted for publication in a reputable scientific journal. The interests of the organisations that fund scientific research can influence the direction of research. In some cases, the validity of those claims may also be influenced.
	Examples in this specification include: • explain the role of the scientific community in validating new knowledge about vaccines and monoclonal antibodies thus ensuring integrity, 3.1.6 • evaluate the ethical, moral and social issues associated with the use of recombinant technology in agriculture, in industry and in medicine, 3.5.8
L	**Appreciate the ways in which society uses science to inform decision-making**
	Scientific findings and technologies enable advances to be made that have potential benefit for humans. In practice, the scientific evidence available to decision-makers may be incomplete. Decision-makers are influenced in many ways, including by their prior beliefs, their vested interests, special interest groups, public opinion and the media, as well as by expert scientific evidence.
	Examples in this specification include: • discuss the ways in which society uses scientific knowledge relating to vaccines and monoclonal antibodies to inform decision-making, 3.1.6 • explain how conservation relies on science to inform decision-making, 3.4.7

3.8 Guidance on Internal Assessment

Introduction

The GCE Sciences share a common approach to internal assessment. This is based on the belief that assessment should encourage practical work in science, and that practical work should encompass a broad range of activities. This section must be read in conjunction with information in the Teaching and learning resources web pages.

Investigative and Practical Skills are assessed in Unit 3 and Unit 6, worth, respectively, 20% of the AS Award (and 10% of the A Level Award) and 10% of the full A Level Award.

There are two routes for the assessment of Investigative and Practical Skills

Either

Route T: Practical Skills Assessment (PSA) + Investigative Skills Assignment (ISA) – Teacher-marked

Or

Route X: Practical Skills Verification (PSV) + Externally Marked Practical Assessment (EMPA) – AQA-marked.

Both routes to assessment are available at AS and A2.

Centres can not make entries for the same candidate for both assessment routes [T and X] in the same examination series.

The assessments produced for each of Unit 3 and Unit 6 are common to AQA AS/A Level Biology (2410) and AQA AS/A Level Human Biology (2405). As a result, centres entering the same candidates for both Biology and Human Biology in the same session for both unit 3s and/or both unit 6s must enter these candidates for route T for one subject and route X for the other subject. These candidates can not enter the same route for both qualifications.

3.8.1 Centre Assessed Route T (PSA/ISA)

Each centre assessed unit comprises

- Practical Skills Assessment (PSA)
- Investigative Skills Assignment (ISA).

The PSA consists of the centre's assessment of the candidate's ability at the end of the course to demonstrate practical skills; thus, candidates should be encouraged to carry out practical and investigative work throughout the course. This work should cover the skills and knowledge of How Science Works (Section 3.7) and in Sections 3.3 and 3.6.

The ISA has three stages where candidates

- undertake practical work and collect data
- process the data
- complete a written ISA test.

There are two windows of assessment for the ISA:

- one for the practical work (Stages 1 and 2)
- one for the written test (Stage 3).

Each stage of the ISA must be carried out

- under controlled conditions
- within the windows of assessment stipulated by AQA in the Instructions for Administration of the ISA http://filestore.aqa.org.uk/subjects/AQA-2410-W-TRB-ISAADMIN.PDF

All candidates at a centre must complete the written test in a single uninterrupted session on the same day.

The ISA is set externally by AQA, but internally marked, with marking guidelines provided by AQA.

In a given academic year two ISAs at each of AS and A2 will be provided.

Practical Skills Assessment (PSA)

Candidates following this route must undertake the practical activities outlined in Sections 3.3 for AS or 3.6 for A2 in order to allow candidates suitable opportunities to demonstrate safe and skilful practical techniques and to make reliable and valid observations.

Candidates are assessed throughout the course on practical skills, using a scale from 0 to 6. The mark submitted for practical skills should be judged by the teacher. Teachers may wish to use this section for formative assessment and should keep an ongoing record of each candidate's performance but the mark submitted should represent the candidate's practical abilities at the end of the course.

The nature of the assessment

Since the skills in this section involve implementation, they must be assessed while the candidate is carrying out practical work. Practical activities are not intended to be undertaken as formal tests and teachers can provide the level of guidance that would normally be given during teaching. In order to provide appropriate opportunities to demonstrate the necessary skills, the instructions provided must not be too prescriptive but should allow candidates to make decisions for themselves, particularly concerning the organisation and conduct of practical work, and the manner in which equipment is used.

The assessment criteria

In the context of material specified in the relevant AS or A2 specification, candidates will be assessed in the following skills

- following instructions
- selecting and using equipment
- organisation and safety

Descriptors for these three skills areas are provided for 0, 1 and 2 marks.

The Assessment Criteria

Following instructions	Selecting and using equipment	Organisation and safety
0 marks Able to follow instructions involving standard procedures only when guidance is given.	**0 marks** Able to select appropriate laboratory equipment only when guidance is given. Able to make measurements with assistance.	**0 marks** Works in a disorganised manner. Works safely only with constant supervision.
1 mark Able to follow instructions involving standard procedures but unable to follow instructions involving complex procedures without further guidance.	**1 mark** Able to select appropriate laboratory equipment. Able to make accurate measurements but requires guidance on making repeat measurements.	**1 mark** Works in an organised manner. Works with due regard to safety, but needs occasional guidance or reminders.
2 marks Able to follow instructions involving both standard and complex procedures without guidance.	**2 marks** Able to select appropriate laboratory equipment. Able to make accurate measurements and to recognise when it is appropriate to repeat measurements.	**2 marks** Works in an organised manner. Works with due regard to safety, showing competence in risk management.

Candidates should be awarded marks which reflect their level of performance at the end of the course.

AQA may wish to ask for further supporting evidence from centres in relation to the marks awarded for the PSA. Centres should therefore keep records of their candidates' performances in their practical activities throughout the course. (For example, a laboratory diary, log or tick sheet.)

Further guidance for the awarding of marks for the PSA will be provided in the Teaching and learning resources web pages.

Use of ICT during the PSA

Candidates are encouraged to use ICT where appropriate in the course of developing practical skills, for example in collecting and analysing data.

Investigative Skills Assignment (ISA)

The Investigative Skills Assignment carries 44 marks and has three stages.

Stage 1: Collection of data

Candidates carry out practical work following an AQA task sheet. Centres may use the task sheet as described or may make minor suitable modifications to materials or equipment, following AQA guidelines. Details of any amendments made to the task sheet must be agreed in writing with the AQA Assessment Adviser. The task may be conducted in a normal timetabled lesson but must be under controlled conditions and during the window of assessment for practical work.

For AS, candidates collect raw data and represent it in a table of their own design or make observations that are recorded on the *Candidate Result Sheet*.

The candidates' work must be handed to the teacher at the end of the session. The teacher assesses the candidates' work following AQA marking guidelines.

For A2, candidates collect raw data on the *Candidate Result Sheet.* The candidates' work must be handed to the teacher at the end of each session. The raw data is not assessed by the teacher.

There is no specified time limit for this stage.

Stage 2: Processing of data

The teacher returns the candidates' data from Stage 1 (on the *Candidate Result Sheet*).

For AS, the teacher instructs the candidates to process the data (e.g. calculate means or rates of reaction) and plot an appropriate graph. The teacher must not instruct the candidates on the presentation of the data or on the choice of graph or chart.

For A2, the teacher instructs the candidates to process the data and carry out a suitable statistical test. The teacher must not instruct the candidates on the choice, implementation and interpretation of the statistical test.

For both AS and A2, stage 2 may be done in normal lesson time and must be done in a single session under controlled conditions and during the window of assessment for practical work. Both the raw and the processed data must be handed to the teacher at the end of the session. The teacher assesses the candidates' work to AQA marking guidelines.

Stage 1 and Stage 2 may be done in the same session. There is no specified time limit for Stage 2.

Stage 3: The ISA written test

The ISA test should be taken after completion of Stage 2, under controlled conditions and during the window of assessment for the written test. All candidates at a centre must complete the written test in a single uninterrupted session on the same day. Each candidate is provided with an ISA test and their completed material from Stages 1 and 2. The teacher uses the AQA marking guidelines to assess the ISA test.

The ISA test is in two Sections.

Section A

This consists of a number of questions relating to the candidate's own data.

Section B

At the start of this section, candidates are supplied with additional data on a related topic. A number of questions relating to analysis and evaluation of the data then follow.

The number of marks allocated to each section may vary slightly with each ISA test.

Use of ICT during the ISA

ICT may be used during the ISA but teachers should note any restrictions in the ISA marking guidelines or Teachers' Notes. Use of the internet is not permitted.

Candidates absent for the practical work

A candidate absent for the practical work should be given an opportunity to carry out the practical work before they sit the ISA test. This may be with another group or at a different time. In exceptional cases when such arrangements are not possible, the teacher can supply a candidate with class data. In this case the candidate cannot be awarded marks for Stage 1, but may be awarded marks for Stage 2.

Material from AQA

For each ISA, AQA will provide:

- Teachers' Notes
- Task sheet
- ISA test
- Marking guidelines.

This material must be kept under secure conditions within the centre. The centre must ensure security of the material. Further details regarding this material will be provided.

Security of assignments

All ISA materials, including marked ISAs should be treated like examination papers and kept under secure conditions until the publication of results.

General Information

Route T

Administration

In any year a candidate may attempt either or both of the two ISAs. AQA will stipulate windows of assessment during which the ISAs (task and test) must be completed.

For each candidate, the teacher should submit a total mark to AQA comprising:

- the PSA mark
- the better ISA mark (if two have been attempted).

The ISA component of this mark must come from one ISA only, i.e. the marks awarded for individual stages of different ISAs cannot be combined.

Candidates may make only one attempt at a particular ISA. Redrafting is **not** permitted at any stage during the ISA.

The mark must be submitted by the due date in the academic year for which the ISA was published.

Only unit entry codes from the Biology specification can contribute towards an AS or A Level Award in Biology. **Human Biology unit entry codes can not be used towards a Biology qualification.**

Work to be submitted

For each candidate in the sample the following materials must be submitted to the moderator by the deadline issued by AQA.

- the candidate's data from Stage 1 and 2 (on the *Candidate Result Sheet*)
- the ISA written test, which includes the *Candidate Record Form*, showing the marks for the ISA and the PSA.

In addition each centre must provide

- *Centre Declaration Sheet*
- Details of any agreed amendments to the task sheet with information supporting the changes from the AQA Assessment Adviser.

Working in groups

For the PSA, candidates may work in groups provided that any skills being assessed are the work of individual candidates. For the ISA further guidance will be provided in the Teachers' Notes.

Other information

Section 6 outlines further guidance on the supervision and authentication of internally assessed units.

Section 6 also provides information in relation to the internal standardisation of marking for these units. Please note that the marking of both the PSA and the ISA must be internally standardised as stated in Section 6.4.

Further support

AQA supports the units in a number of ways.

- AQA holds annual standardising meetings on a regional basis for all internally assessed components. Section 6 of this specification provides further details about these meetings
- Teaching and learning resources which include Instructions for Administration of the ISA http://filestore.aqa.org.uk/subjects/AQA-2410-W-TRB-ISAADMIN.PDF
- Assessment Advisers are appointed by AQA to provide advice on internally assessed units. Every centre is allocated an Assessment Adviser.

The Assessment Advisers can provide guidance on

– issues relating to the carrying out of tasks for assessment
– application of marking guidelines.

Any amendments to the ISA task sheet must be discussed with the Assessment Adviser and confirmation of the amendments made must be submitted to the AQA moderator.

3.8.2 Externally Marked Route X (PSV/ EMPA)

The practical and investigative skills will be assessed through

- Practical Skills Verification (PSV) and
- Externally Marked Practical Assignment (EMPA).

The PSV requires teachers to verify their candidates' ability to demonstrate safe and skilful practical techniques and make valid and reliable observations

The EMPA has three stages where candidates

- undertake a themed task and collect data
- process the data
- complete a written EMPA test

There are two windows of assessment for the EMPA:

- one for the practical work - Task 1 and Task 2 (Stages 1 and 2)
- one for the written test (Stage 3).

Each stage of the EMPA must be carried out

- under controlled conditions
- within the windows of assessment stipulated by AQA in the Instructions for Administration of the EMPA http://filestore.aqa.org.uk/subjects/AQA-2410-W-TRB-EMPAADMIN.PDF

All candidates at a centre must complete the written test in a single uninterrupted session on the same day.

The EMPA is set and marked by AQA. Only one EMPA at each of AS and A2 will be provided in a given academic year.

Practical Skills Verification

Candidates following this route must undertake the practical activities outlined in sections 3.3 for AS and 3.6 for A2 in order to allow candidates suitable opportunities to demonstrate safe and skilful practical techniques and to make reliable and valid observations. The teacher will confirm, on the front cover of the EMPA written test, for each candidate that this requirement has been met. Failure to complete the tick box will lead to a mark of zero being awarded to the candidate for the whole of this unit.

In the context of material specified in the relevant AS or A2 specification, candidates will be required to demonstrate the following skills

- following instructions
- selecting and using equipment
- organisation and safety.

Practical activities must provide candidates with opportunities to develop the knowledge and skills of *How Science Works* outlined in section 3.3 and 3.6. Teachers can provide the level of guidance that would normally be given during practical activities. However, in order to provide appropriate opportunities to demonstrate the necessary skills, instructions provided must not be too prescriptive but should allow candidates to make decisions for themselves, particularly concerning the organisation and conduct of practical work, and the manner in which equipment is used.

Further guidance for conducting practical activities for the PSV will be provided in the Teaching and learning resources web pages.

ICT

Candidates may use ICT where appropriate in the course of developing practical skills, for example in collecting and analysing data.

Externally Marked Practical Assignment (EMPA)

The Externally Marked Practical Assignment carries 50 marks and has three stages.

Stage 1: Themed task and collection of data

Candidates carry out practical work following AQA task sheets. The tasks may be conducted in a normal timetabled lesson, at a time convenient to the centre, but must be under controlled conditions and in the window of assessment for practical work.

For AS, candidates collect raw data and represent it in a table of their own design on *Task Sheet 1*. The candidates' work must be handed to the teacher at the end of each session.

For A2, candidates collect raw data on *Task Sheet 1*. The candidates' work must be handed to the teacher at the end of each session.

Centres may use the task sheets, as described, or may make minor suitable modifications to materials or equipment following AQA guidelines. Any modifications made to the task sheet must be agreed with the Assessment Adviser and details must be provided to the AQA examiner. The task may be conducted in a normal timetabled session.

There is no specified time limit for this stage.

Stage 2: Processing of data

For AS, the teacher instructs the candidates to process data (e.g. calculate means or rates of reaction) and plot an appropriate graph. The teacher must not instruct the candidates on the presentation of the data or on the choice of graph or chart.

For A2, the teacher instructs the candidates to process the and carry out a suitable statistical test. The teacher must not instruct the candidates on the choice, implementation and interpretation of the statistical test.

3

For both AS and A2, stage 2 may be done in normal lesson time and must be done in a single session, under controlled conditions and in the window of assessment for practical work. Both the raw and the processed data must be handed to the teacher at the end of the session.

Stage 1 and Stage 2 may be done in the same session. There is no specified time limit for Stage 2.

Stage 3: The EMPA written test

The EMPA written test should be taken after completion of Stage 2, under controlled conditions and during the window of assessment for the written test. All candidates at a centre must complete the written test in a single uninterrupted session on the same day. Each candidate is provided with an EMPA written test and the candidate's completed Task Sheet indicated on the front cover of the EMPA written test.

The EMPA test is in two Sections.

Section A

This consists of a number of questions relating to the candidate's own data.

Section B

At the start of this section, candidates are supplied with additional data on a related topic. A number of questions relating to analysis and evaluation of the data then follow.

The number of marks allocated to each section may vary with each EMPA test.

Use of ICT during the EMPA

ICT may be used during the EMPA Stages 1 and 2 but teachers should note any restrictions in the Teachers' Notes. Use of the internet is not permitted.

Candidates absent for the practical work

A candidate absent for the practical work (Stage 1) should be given an opportunity to carry out the practical work before they sit the EMPA test. This may be with another group or at a different time. In exceptional cases, when this is not possible, the teacher can supply a candidate with class data. This must be noted on the front cover of the written test. In this case the candidate cannot be awarded marks for Stage 1, collection of data, but can still be awarded marks for Stage 2, processing of data.

Material from AQA

For each EMPA, AQA will provide:

- Teachers' Notes
- Task Sheets 1 and 2
- EMPA test.

When received, this material must be kept under secure conditions. The centre must ensure security of material. Further details regarding this material will be provided.

Security of assignments

Completed EMPAs should be treated like examination papers and kept under secure conditions until sent to the AQA examiner. All other EMPA materials should be kept under secure conditions until publication of results.

General Information

Route X

Administration

Only one EMPA will be available in any year at AS and at A2. AQA will stipulate windows of assessment during which the EMPA (themed task and written test) must be completed.

Candidates may make only one attempt at a particular EMPA and redrafting is **not** permitted at any stage during the EMPA.

Only unit entry codes from the Biology specification can contribute towards an AS or A Level Award in Biology. **Human Biology unit entry codes can not be used towards a Biology qualification.**

Work to be submitted

The material to be submitted to the AQA examiner for each candidate consists of

- the completed *Task Sheet 1* and *Task Sheet 2*
- the EMPA written test which includes the *Candidate Record Form* including the PSV verification that safe and skilful practical techniques have been demonstrated and reliable and valid observations made.

In addition each centre must provide

- *Centre Declaration Sheet*
- Details of any agreed amendments to the task sheet must be notified to the AQA examiner with information supporting the changes from the Assessment Adviser.

Working in groups

For the PSV, candidates may work in groups provided that any skills being verified are the work of individual candidates. For the EMPA further guidance will be provided but the opportunity for group work will not be a common feature.

Other information

Section 6 of this specification outlines further guidance on the supervision and authentication of Internally assessed units.

Further support

AQA supports centres in a number of ways.

- Teaching and learning resources which include Instructions for Administration of the EMPA http://filestore.aqa.org.uk/subjects/AQA-2410-W-TRB-EMPAADMIN.PDF
- Assessment Advisers appointed by AQA to provide advice on internally assessed units. Every centre is allocated an Assessment Adviser.

The Assessment Advisers can provide guidance on issues relating to the carrying out of tasks for assessment. Contact details for your Assessment Adviser can be obtained by e-mailing your centre name and number to alevelscience@aqa.org.uk.

Any amendments to the EMPA task sheet must be discussed with the AQA Assessment Adviser and confirmation of the amendments must be submitted to the AQA examiner.

3.9 Mathematical Requirements

In order to be able to develop the knowledge, understanding and skills in the specification, candidates need to have been taught, and to have acquired competence in, the areas of mathematics set out below. Material relevant to the second part of the A level (A2) only is given in bold type.

	Candidates should be able to
Arithmetic and computation	• recognise and use expressions in decimal and standard form • use ratios, fractions and percentages • make estimates of the results of calculations (without using a calculator) • understand the symbols > and < • use calculators to find and use mean, standard deviations and x^n, $^1/x$, $\sqrt{x}$
Handling data	• use an appropriate number of significant figures • find arithmetic means • construct and interpret frequency tables, bar charts and histograms • **understand the principles of sampling as applied to biological data** • **distinguish between chance and probability and understand the importance of chance and probability when interpreting data** • understand the terms mean, median and mode and standard deviation • use a scatter diagram to identify positive and negative correlation between two variables • **select and use a simple statistical test (see Teaching and learning resources for further guidance)** • **Candidates are not required to recall statistical formulae but will be provided with an appropriate data sheet when necessary.**
Algebra	• change the subject of an equation • substitute numerical values into algebraic equations using appropriate units for physical quantities • understand the use of logarithms in relation to quantities that range over several orders of magnitude.
Graphs	• translate information between graphical and numerical forms • plot two variables from experimental or other data using appropriate Institute of Biology conventions • calculate rate of change from a graph showing a linear relationship • draw and use the slope of a tangent to a curve as a measure of rate of change.
Geometry	• visualise three dimensional forms from two dimensional representations of three dimensional objects • calculate circumferences and areas of circles, surface areas and volumes of regular blocks and cylinders when provided with appropriate formulae.

4 Scheme of Assessment

4.1 Aims

AS and A level courses based on this specification should encourage candidates to:

a) develop their interest in and enthusiasm for the subject, including developing an interest in further study and careers in the subject

b) appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society

c) develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works*

d) develop essential knowledge and understanding of different areas of the subject and how they relate to each other.

4.2 Assessment Objectives (AOs)

The Assessment Objectives are common to AS and A level. The assessment units will assess the following assessment objectives in the context of the content and skills set out in Section 3 (Subject Content).

AO1: Knowledge and understanding of science and of *How Science Works*

Candidates should be able to

a) recognise, recall and show understanding of scientific knowledge

b) select, organise and communicate relevant information in a variety of forms.

AO2: Application of knowledge and understanding of science and of *How Science Works*

Candidates should be able to

a) analyse and evaluate scientific knowledge and processes

b) apply scientific knowledge and processes to unfamiliar situations including those related to issues

c) assess the validity, reliability and credibility of scientific information.

AO3: *How Science Works*

Candidates should be able to

a) demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods

b) make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy

c) analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

Quality of Written Communication (QWC)

In GCE specifications which require candidates to produce written material in English, candidates must:

- 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 where appropriate.

In this specification, QWC will be assessed in Unit 1 and Unit 2 at AS, and Unit 4 and Unit 5 at A2. Where relevant, the mark schemes for questions contain specific statements about QWC. These statements are marked "Q" in the mark scheme and relate to the clear expression of concepts (e.g. the active site of an enzyme has a complementary shape to that of its substrate, but not the same shape), correct subject-specific terminology and correct spelling where there are close alternatives to biological terms (e.g. glucose, glycogen and glucagon), as appropriate. The mark scheme for the essay in Unit 5 is divided into three sets of skills: subject content; breadth of selected material; relevance of selected material; QWC. Specific descriptors are used for allocating the marks for QWC in these essays.

Weighting of Assessment Objectives for AS

The table below shows the approximate weighting of each of the Assessment Objectives in the AS units.

Assessment Objectives	Unit Weightings (%)			Overall Weighting of AOs (%)
	Unit 1	Unit 2	Unit 3	
AO1	14	18	3	35
AO2	14	18	3	35
AO3	5	11	14	30
Overall weighting of units (%)	33	47	20	100

Weighting of Assessment Objectives for A Level

The table below shows the approximate weighting of each of the Assessment Objectives in the AS and A2 units.

Assessment Objectives	Unit Weightings (%)						Overall Weighting of AOs (%)
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	
AO1	7	9	2	5	6	1	30
AO2	7	9	1	8	13	2	40
AO3	3	5	7	4	4	7	30
Overall weighting of units (%)	17	23	10	17	23	10	100

4.3 National Criteria

This specification complies with the following.

- The Subject Criteria for Science: Biology
- The Code of Practice for GCE
- The GCE AS and A Level Qualification Criteria
- The Arrangements for the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland: Common Criteria

4.4 Prior Learning

There are no prior learning requirements. However, we recommend that candidates should have acquired the skills and knowledge associated with a GCSE Additional Science course or equivalent.

Candidates will be required to have an understanding of the following terms:

molecule, ion, compound, element, isomer, isotope, oxidation, bond, reduction, hydrolysis, condensation, wavelength.

Any requirements set for entry to a course following this specification are at the discretion of centres.

4.5 Synoptic Assessment and Stretch and Challenge

The definition of synoptic assessment in the context of science is as follows.

Synoptic assessment requires candidates to make and use connections within and between different areas of the subject 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.

Synoptic assessment in Biology is assessed in the A2 units by two types of question: structured questions carrying 15 marks and an essay question carrying 25 marks. The structured question on Unit 4 develops a *How Science Works* context and requires candidates to use subject matter and skills from Unit 4 and the AS specification. The structured question in Unit 5 tests data handling skills and requires candidates to apply knowledge, understanding and skills from the AS and A2 specification. In the essay in Unit 5, candidates are required to use knowledge and understanding from across all units.

The requirement that Stretch and Challenge is included at A2 will be met in the externally assessed units by the following

- using a variety of stems in questions to avoid a formulaic approach through the use of such words as: evaluate.
- avoiding assessments being too atomistic, connections between areas of content being used where possible and appropriate
- having some requirement for extended writing
- using a range of question types to address different skills, i.e. not just short answer/structured questions
- asking candidates to bring to bear knowledge and the other prescribed skills in answering questions rather than simply demonstrating a range of content coverage.

The requirement that Stretch and Challenge is included at A2 is met in the long, structured questions in Units 4 and 5 which are designed with an incline of difficulty such that the later sub-questions will offer a genuine challenge to the most able candidates. Differentiation by outcome will be used. The mark descriptors for the essay in Unit 5 include marks that will be gained only by those candidates who have included material beyond that expected of a good A Level candidate. This technique has been successful in rewarding the most able candidates.

4.6 Access to Assessment for Disabled Students

AS/A Levels often require assessment of a broader 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.

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 the competences had been addressed. This will be kept under review and may be amended in the future.

5 Administration

5.1 Availability of Assessment Units and Certification

After June 2013, examinations and certification for this specification are available in June only.

5.2 Entries

Please refer to the current version of Entry Procedures and Codes for up-to-date entry procedures. You should use the following entry codes for the units and for certification.

Unit 1 – BIOL1

Unit 2 – BIOL2

Unit 3 – **Either** NBIO3T **or** NBIO3X

Unit 4 – BIOL4

Unit 5 – BIOL5

Unit 6 – **Either** NBIO6T **or** NBIO6X

Centres can not make entries for the same candidate for both assessment routes [T and X] in either Unit 3 or Unit 6 in the same examination series.

The assessments produced for each of Unit 3 and Unit 6 are common to AQA AS/A Level Biology (2410) and AQA AS/A Level Human Biology (2405). As a result, centres entering the same candidates for both Biology and Human Biology in the same session for both unit 3s and/or both unit 6s must enter these candidates for route T for one subject and route X for the other subject. These candidates can not enter the same route for both qualifications.

AS certification – 1411

A Level certification – 2411

5.3 Private Candidates

This specification is available to private candidates under certain conditions. Because of the nature of the centre assessed units, candidates must be attending an AQA centre which will supervise and assess the centre assessed work. As we will no longer be providing supplementary guidance in hard copy, see our website for guidance and information on taking examinations and assessments as a private candidate;

www.aqa.org.uk/exams-administration/entries/private-candidates

Entries from private candidates can be accepted only where the candidate is registered with an AQA registered centre that will accept responsibility for:

- supervising the practical components of the PSA/ISA or PSV/EMPA
- supervising the written component of the ISA or EMPA
- prime marking the centre assessed work.

Candidates wishing to repeat or complete the AS and/or A2 components may register as private candidates only if they already have a previously moderated mark for Units 3 and 6, respectively, or if they can find a centre that will comply with the above requirements.

5.4 Access Arrangements and Special Consideration

We have taken note of the Equality Act 2010 and the interests of minority groups in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: *Access Arrangements, Reasonable Adjustments and Special Consideration.* This is published on the JCQ website (**http://www.jcq.org.uk**) or you can follow the link from our website (**http://www.aqa.org.uk**).

Section 2.14.5 of the above JCQ document states that "A practical assistant will not normally be allowed to carry out physical tasks or demonstrate physical abilities where they form part of the assessment objectives." However, in order that candidates may obtain experimental results that can be used in the Externally Marked Practical Assignment (EMPA), practical assistants may be used to carry out the manipulation under the candidate's instructions. An application for a practical assistant should be made via Access arrangements online and cases will be considered individually.

Access Arrangements

We can make arrangements so that candidates with disabilities can access the assessment. These arrangements must be made **before** the examination. For example, we can produce a Braille paper for a candidate with a visual impairment.

Special Consideration

We can give special consideration to candidates who have had a temporary illness, injury or serious problem, such as death of a relative, at the time of the examination. We can only do this **after** the examination.

The Examinations Officer at the centre should apply online for access arrangements and special consideration by following the e-AQA link from our website **www.aqa.org.uk**

5.5 Language of Examinations

We will provide units in English only.

5.6 Qualification Titles

Qualifications based on this specification are:

- AQA Advanced Subsidiary GCE in Biology, and
- AQA Advanced Level GCE in Biology.

5.7 Awarding Grades and Reporting Results

The AS qualification will be graded on a five-point scale: A, B, C, D and E. The full A Level qualification will be graded on a six-point scale: A*, A, B, C, D and E. To be awarded an A*, candidates will need to achieve a grade A on the full A Level qualification and an A* on the aggregate of the A2 units. For AS and A Level, candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate. Individual assessment unit results will be certificated.

5.8 Re-sits and Shelf-life of Unit Results

Unit results remain available to count towards certification, whether or not they have already been used, as long as the specification is still valid.

Each unit is available in June only. Candidates may re-sit a unit any number of times within the shelf-life of the specification. The best result for each unit will count towards the final qualification. Candidates who wish to repeat a qualification may do so by retaking one or more units. The appropriate subject award entry, as well as the unit entry/entries, must be submitted in order to be awarded a new subject grade.

Candidates will be graded on the basis of the work submitted for assessment.

6 Administration of Internally Assessed Units: Route T and Route X

The Head of Centre is responsible to AQA for ensuring that work for the Centre Assessed Units is conducted in accordance with AQA's instructions and JCQ instructions.

Centres can not make entries for the same candidate for both assessment routes [T and X] in either Unit 3 or Unit 6 in the same examination series.

The assessments produced for each of Unit 3 and Unit 6 are common to AQA AS/A Level Biology (2410) and AQA AS/A Level Human Biology (2405). As a result, centres entering the same candidates for both Biology and Human Biology in the same session for both unit 3s and/or both unit 6s must enter these candidates for route T for one subject and route X for the other subject. These candidates can not enter the same route for both qualifications.

6.1 Supervision and authentication of Centre Assessed Units

In order to meet the regulators' Code of Practice for GCE, AQA requires:

- **candidates** to sign the appropriate section on the front cover of the ISA or EMPA Written Test to confirm that the work submitted is their own, and
- **teachers/assessors** to confirm on the front cover of the ISA or EMPA written test that the work assessed is solely that of the candidate concerned and was conducted under the conditions laid down by the specification.

Candidates and teachers complete the front cover of the ISA or EMPA written test in place of the Candidate Record Form (CRF). Failure to sign the teacher declaration may delay the processing of the candidates' results.

In all cases, direct supervision is necessary to ensure that the work submitted can be confidently authenticated as the candidate's own.

If teachers/assessors have reservations about signing the teacher declaration, the following points of guidance should be followed.

- If it is believed that a candidate has received additional assistance and this is acceptable within the guidelines for the relevant specification, the teacher declaration should be signed and information given.
- If the teacher/assessor is unable to sign the teacher declaration for a particular candidate, then the candidate's work cannot be accepted for assessment.
- If malpractice is suspected, the Examinations Officer should be consulted about the procedure to be followed.

Route T

All teachers who have assessed the work of any candidate entered for each unit must sign the *Centre Declaration Sheet.*

The practical work for the PSA and for the ISA should be carried out in normal lesson time with a degree of supervision appropriate for candidates working in a laboratory. The practical work for the ISA should be completed during the window of assessment for practical work. The processing of raw data and the ISA written test should be taken in normal lesson time under controlled conditions and during the window of assessment for the written test.

Redrafting of answers to any stage of the ISA is not permitted. Candidates must **not** take their work away from the classroom.

Material to submit to moderator

For each candidate in the sample, the following material must be submitted to the moderator by the deadline issued by AQA:

- the candidate's data from Stages 1 and 2 (on the *Candidate Result Sheets*)
- the ISA written test which includes the *Candidate Record Form*, showing the marks for the ISA and the PSA

In addition each centre must provide

- *Centre Declaration Sheet*
- details of any amendments to the task sheet with the information supporting the changes from the Assessment Adviser, if there are any significant changes.

Route X

The practical work for the PSV and for the EMPA should be carried out in normal lesson time with a degree of supervision appropriate for candidates working in a laboratory. The practical work for the EMPA should be completed during the window of assessment for practical work. The processing of raw data and the EMPA written test should be taken in normal lesson time under controlled conditions and during the window of assessment for the written test.

Redrafting of answers to any stage of the EMPA is not permitted. Candidates must **not** take their work away from the class.

Material to submit to examiner

For each candidate, the following material must be submitted to the examiner by the deadline issued by AQA:

- the completed *Task Sheet 1* and *Task Sheet 2*
- the EMPA written test, which includes the *Candidate Record Form*, showing the PSV verification of safe and skilful practical techniques and reliable and valid observations

In addition each centre must provide

- *Centre Declaration Sheet*
- Details of any amendments to the task sheet with the information supporting the changes from the Assessment Adviser, if there are any significant changes.

6.2 Malpractice

Teachers should inform candidates of the AQA Regulations concerning malpractice.

Candidates must **not**:

- submit work which is not their own
- lend work to other candidates
- submit work typed or word-processed by a third person without acknowledgement.

These actions constitute malpractice, for which a penalty (e.g. disqualification from the examination) will be applied.

Route T

Where suspected malpractice in internally assessed work is identified by a centre after the candidate has signed the *Candidate Record Form*, the Head of Centre must submit full details of the case to AQA at the earliest opportunity. The form JCQ/M1 should be used. Copies of the form can be found on the JCQ website **(http://www.jcq.org.uk/)**.

Malpractice in internally assessed work discovered prior to the candidate signing the declaration of authentication need not be reported to AQA, but should be dealt with in accordance with the centre's internal procedures. AQA would expect centres to treat such cases very seriously. Details of any work which is not the candidate's own must be recorded on the *Candidate Record Form* or other appropriate place.

Route X

If the teacher administering the EMPA believes that a student is involved in malpractice, he/she should contact AQA.

If the examiner suspects malpractice with the EMPA, at any stage, he/she will raise the matter with the Irregularities Office at AQA. An investigation will be undertaken, in line with the JCQ's policies on Suspected Malpractice in Examinations and Assessments.

6.3 Teacher Standardisation (Route T only)

We will hold annual standardising meetings for teachers, usually in the autumn term, for the internally assessed units. At these meetings we will provide support in using the marking guidelines.

If your centre is new to this specification, you must send a representative to one of the meetings. If you have told us you are a new centre, either by submitting an estimate of entry or by contacting the subject team, we will contact you to invite you to a meeting.

We will also contact centres if

- the moderation of internally assessed work from the previous year has identified a serious misinterpretation of the requirements,
- inappropriate tasks have been set, or
- a significant adjustment has been made to a centre's marks.

In these cases, centres will be expected to send a representative to one of the meetings. For all other centres, attendance is optional. If you are unable to attend and would like a copy of the materials used at the meeting, please contact the subject team at **alevelscience@aqa.org.uk**.

6.4 Internal Standardisation of Marking (Route T only)

Centres must standardise marking within the centre to make sure that all candidates at the centre have been marked to the same standard. One person must be responsible for internal standardisation. This person should sign the *Centre Declaration Sheet* to confirm that internal standardisation has taken place.

Internal standardisation may involve

- all teachers marking some trial pieces of work and identifying differences in marking standards
- discussing any differences in marking at a training meeting for all teachers involved in the assessment
- referring to reference and archive material such as previous work or examples from AQA's teacher standardising meetings

but other approaches are permissible.

6.5 Annotation of Centre Assessed Work (Route T only)

The Code of Practice for GCE states that the awarding body must require internal assessors to show clearly how the marks have been awarded in relation to the marking criteria defined in the specification and that the awarding body must provide guidance on how this is to be done.

The annotation will help the moderator to see as precisely as possible where the teacher considers that the candidates have met the criteria in the specification.

Work could be annotated by either of the following methods:

- key pieces of evidence flagged throughout the work by annotation either in the margin or in the text;
- summative comments on the work, referencing precise sections in the work.

6.6 Submitting Marks and Sample Work for Moderation (Route T only)

The total mark for each candidate must be submitted to AQA and the moderator on the mark forms provided or by Electronic Data Interchange (EDI) by the specified date. Centres will be informed which candidates' work is required in the samples to be submitted to the moderator.

6.7 Factors Affecting Individual Candidates

Teachers should be able to accommodate the occasional absence of candidates by ensuring that the opportunity is given for them to make up missed assessments.

If work is lost, AQA should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Centres should use the JCQ form JCQ/LCW to inform AQA Candidate Services of the circumstances.

Where special help which goes beyond normal learning support is given, AQA must be informed through comments on the CRF so that such help can be taken into account when moderation takes place (see Section 6.1).

Candidates who move from one centre to another during the course sometimes present a problem for a scheme of internal assessment. Possible courses of action depend on the stage at which the move takes place. If the move occurs early in the course, the new centre should take responsibility for assessment. If it occurs late in the course, it may be possible to arrange for the moderator to assess the work through the 'Educated Elsewhere' procedure. Centres should contact AQA at the earliest possible stage for advice about appropriate arrangements in individual cases.

6.8 Retaining Evidence and Re-using Marks (Route T only)

The centre must retain the work of all candidates, with CRFs attached, under secure conditions, from the time it is assessed, to allow for the possibility of an enquiry about results. The work may be returned to candidates after the deadline for enquiries about results. If an enquiry about a result has been made, the work must remain under secure conditions in case it is required by AQA.

7 Moderation (Route T only)

7.1 Moderation Procedures

Moderation of the internally assessed work is by inspection of a sample of candidates' work, sent by post from the centre to a moderator appointed by AQA. The centre marks must be submitted to AQA and to the moderator by the specified deadline (see **http://www.aqa.org.uk/deadlines.php**). We will let centres know which candidates' work will be required in the sample to be submitted for moderation.

Following the re-marking of the sample work, the moderator's marks are compared with the centre marks to determine whether any adjustment is needed in order to bring the centre's assessments into line with standards generally. In some cases, it may be necessary for the moderator to call for the work of other candidates in the centre. In order to meet this possible request, centres must retain under secure conditions and have available the centre assessed work and the CRF of every candidate entered for the examination and be prepared to submit it on demand. Mark adjustments will normally preserve the centre's order of merit, but where major discrepancies are found, we reserve the right to alter the order of merit.

7.2 Post-moderation Procedures

On publication of the AS/A Level results, we will provide centres with details of the final marks for the centre assessed unit.

The candidates' work will be returned to the centre after moderation has taken place. The centre will receive a report with, or soon after, the dispatch of published results giving feedback on the accuracy of the assessments made and the reasons for any adjustments to the marks.

We reserve the right to retain some candidates' work for archiving or standardising purposes.

Appendices

A Performance Descriptions

These performance descriptions show the level of attainment characteristic of the grade boundaries at A Level. They give a general indication of the required learning outcomes at the A/B and E/U boundaries at AS and A2. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the Assessment Objectives (see Section 4) overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

AS Performance Descriptions for Biology

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
Assessment Objectives	**AO1 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.	**AO2 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.	**AO3 *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.

AS Performance Descriptions for Biology continued

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
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 should 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	**AO1 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.	**AO2 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.	**AO3 *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.

A2 Performance Descriptions for Biology continued

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
E/U boundary performance descriptions	Candidates should 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 should 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.

B Spiritual, Moral, Ethical, Social and other Issues

European Dimension

AQA has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen units.

The specification is designed to improve candidates' knowledge and understanding of the international debates surrounding new technology and to foster responsible attitudes to such developments.

Environmental Education

AQA has taken account of the 1988 Resolution of the Council of the European Community and the Report "Environmental Responsibility: An Agenda for Further and Higher Education" 1993 in preparing this specification and associated specimen units.

The specification is designed to improve candidates' knowledge and understanding of environmental themes which occur in AS Units 1and 2, and A2 Units 4 and 5.

Opportunities for consideration of environmental issues are indicated in the contents of the units.

Avoidance of Bias

AQA has taken great care in the preparation of this specification and specimen units to avoid bias of any kind.

Spiritual, Moral, Ethical, Social and Cultural Issues

The study of Biology lends itself to consideration of many spiritual, moral and cultural issues. The immense variety and complexity of living organisms ineluctably evoke awe and wonder, and candidates should be encouraged to appreciate and respect all forms of life.

Consideration of the evidence for evolution and natural selection may lead candidates to reflect on ultimate questions relating to the origin and meaning of life. Many of the potential applications of biological understanding raise moral and ethical issues.

Opportunities for discussion of these issues are indicated in the contents of the units. This specification encourages candidates to appreciate the importance of all aspects of the global environment and the necessity to achieve sustainability to ensure the continuation of the human race.

The following sections of the specification may be particularly apposite for analysis and discussion of the above issues:

AS specification

- Risk factors associated with the incidence of disease (3.1.1), (3.1.5)
- The development of improved oral rehydration solutions (3.1.3)
- The use of vaccines and monoclonal antibodies (3.1.6)
- Selection of domesticated animals (3.2.3)
- Tentative nature of classifying organisms as distinct species (3.2.8)

A2 specification

- Effect of farming practices on productivity (3.4.5)
- Conservation of species and habitats (3.4.7)
- Effect on diagnosis and treatment of disorders caused by hereditary mutations (3.5.7)
- Use of recombinant technology in agriculture, in industry and in medicine (3.5.8)
- Effectiveness of gene therapy (3.5.8)

Terminology

The terminology used in all the written papers will be that described in the Institute of Biology publication *Biological Nomenclature, Recommendation on Terms, Units and Symbols* (3rd edition 2000). The overriding consideration in setting papers will continue to be clarity and lack of ambiguity rather than adherence to strict rules; alternative names or units will be given whenever ambiguity might otherwise arise. The use in a candidate's answer of names, formulae or units other than those included in the above publication will be accepted, provided that the essential biological information is correctly supplied in the answer.

Health and Safety

An assessment of risks involved in all practical procedures must be made before work commences under the COSHH regulations. Attention is drawn to the hazards associated with many materials and processes associated with the specification. Detailed information may be found in pamphlets on safety issued by the Department for Education and Employment. In addition, all work involving live organisms must be legal and humane.

It is expected that all candidates will be familiar with appropriate standards of safety in all aspects of practical work; in particular the potential hazards of microbiological work.

C Overlaps with other Qualifications

AQA GCE Human Biology

The Subject Criteria for Biology require that all GCE Biology specifications will have at least fifty percentage overlap in content with each other but the depth of treatment of each topic and the assessment pattern will ensure that each specification is distinctive.

AQA GCE Chemistry

There are minimal overlaps with Chemistry although some aspects of biochemistry are covered in both specifications: for example, the structure of organic molecules, bonding and the action of enzymes.

AQA GCE Physics A Traditional

There is a marginal overlap with Medical Physics

AQA GCE Science in Society

The following topics are covered to varying depths in both specifications: Cells, Infectious Diseases, Lifestyle and Health, Genetic Diseases, Genetic Engineering, Biodiversity, Human Reproduction, Evolution, Ethical issues in Medical Research and Disease Treatment, Human Impact on the Environment, Nervous Coordination.

AQA GCE Psychology A

There is a marginal overlap with the Biological basis of sex differences and of perception, and the advantages of behavioural and sociological adaptations of humans

AQA GCE Applied Science

There are some overlaps with the following units:

Unit 2 Energy Transfer Systems

Unit 7 Planning and Carrying out a Scientific Investigation

Unit 8 Medical Physics

Unit 9 Sports Science

Unit 14 The Healthy Body

Unit 16 Ecology, Conservation and Recycling

AQA GCE Environmental Studies

There are some overlaps with all four units with respect to human impact on the environment. However, the approach, breadth and depth of coverage of related topics varies between the specifications.

AQA Applied GCE in Health and Social Care

There are some overlaps with the following units:

Unit 3 Health, Illness and Disease

Unit 5 Nutrition and Dietetics

Unit 6 Common Diseases and Disorders

Unit 13 The Role of Exercise in Maintaining Health and Well-Being

Unit 14 Diagnosis and Treatment

Unit 19 Physiological Aspects of Health

Unit 20 Environmental Health

Unit 21 Research Methods and Perspectives

D Key Skills

Key Skills qualifications have been phased out and replaced by Functional Skills qualifications in English, Mathematics and ICT from September 2010.

GCE Biology (2410) For exams from June 2014 onwards

Qualification Accreditation Number: AS 500/2352/4 - A Level 500/2339/1

For updates and further information on any of our specifications, to find answers or to ask a question: register with ASK AQA at:

http://www.aqa.org.uk/help-and-contacts/ask-aqa

For information on courses and events please visit:
http://www.aqa.org.uk/professional-development

Every specification is assigned a discounting code indicating the subject area to which it belongs for performance measure purposes.
The discount codes for this specification are:
AS RH3
A Level 1010

The definitive version of our specification will always be the one on our website, this may differ from printed versions.

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