WJEC
CBAC

GCE

Examinations from 2009

First AS Award: Summer 2009

First A Level Award: Summer 2010

Biology

Contents

WJEC AS GCE in Biology
WJEC A Level GCE in Biology

2009 & 2010

First AS Award - Summer 2009
First A level Award - Summer 2010

GCE Biology

Subject/Option Entry Codes	
Advanced Subsidiary (AS) "Cash in" entry *A Level (A)"Cash in" entry*	*2071* *3071*
BY1 : Basic Biochemistry and organisation	1071
BY2 : Biodiversity and physiology of Body Systems	1072
BY3 : AS Practical assessment	1073
BY4 : Metabolism, Microbiology and Homeostasis	1074
BY5 : Environment, Genetics and Evolution	1075
BY6 : A2 Practical assessment	1076

When making entries, the following option codes should be entered after the four digit unit or cash-in code to indicate English medium or Welsh medium entries:

	English	Welsh
BY1	01	W1
BY2	01	W1
BY3	01	W1
BY4	01	W1
BY5	01	W1
BY6	01	W1

Availability of Assessment Units				
Unit	**January 2009**	**June 2009**	**January 2010 & each subsequent year**	**June 2010 & each subsequent year**
BY1	✓	✓	✓	✓
BY2		✓	✓	✓
BY3		✓		✓
BY4			✓	✓
BY5				✓
BY6				✓

Qualification Accreditation Numbers

Advanced Subsidiary: 500/2776/1
Advanced: 500/2475/9

SUMMARY OF ASSESSMENT

This specification is divided into a total of 6 units, 3 AS units and 3 A level units. Weightings noted below are expressed in terms of the full A level qualification. Marks are given as raw and uniform marks (UM).

AS (3 units)

Biology 1	20 %	1 hour 30 min Written Paper	70 marks (120UM)
Unit title Basic Biochemistry and cell organisation Outline of paper structure – Short and longer structured questions, choice of 1 from 2 essays.			
Biology 2	20 %	1 hour 30 min Written Paper	70 marks (120UM)
Unit Title Biodiversity and physiology of Body Systems Outline of paper structure – Short and longer structured questions, choice of 1 from 2 essays.			
Biology 3	10 %	Internal assessment	44 marks (60UM)
AS Unit AS Practical assessment Experimental work set in centre, completed by candidates over 3 month period. Marked by board plus, low power plan microscope drawing.			

A LEVEL (the above plus a further 3 units)

Biology 4	20 %	1 hour 45 min Written Paper	80 marks (120UM)
Unit title Metabolism, Microbiology and Homeostasis Outline of paper structure – Short and longer structured questions, choice of 1 from 2 essays. Small % synoptic marks.			
Biology 5	20 %	1 hour 45 min Written Paper	80 marks (120UM)
Unit title Environment, Genetics and Evolution Outline of paper structure – Short and longer structured questions, choice of 1 from 2 essays. Small % synoptic marks.			
Biology 6	10 %	Internal assessment	50 marks (60UM)
A level Unit AL Practical assessment Experimental work set in centre, completed by candidates over 3 month period. Marked by board plus one microscope drawing and calibration.			

Assessment units BY1, BY2 and BY4 are available in January. All assessment units are available in June.

Synoptic aspects are assessed by a few marks in assessments for units BY 4, BY 5. Practical work, BY6 is considered to be inherently synoptic.

One theory unit at AS (BY2) and one at A2 (BY4) is a Biology/Human Biology option. One unit at each of AS and A2 is common to both courses along with the practical assessments.

Candidates' choice of units will determine whether they obtain a qualification in either Biology or Human Biology.

Biology

1 INTRODUCTION

1. 1 Criteria for AS and A Level GCE

This specification has been designed to meet the general criteria for GCE Advanced Subsidiary (AS) and A level (A) and the subject criteria for AS/A Biology as issued by the regulators [July 2006]. The qualifications will comply with the grading, awarding and certification requirements of the Code of Practice for 'general' qualifications (including GCE).

The AS qualification will be reported on a five-grade scale of A, B, C, D, E. The A level qualification will be reported on a six-grade scale of A*, A, B, C, D, E. The award of A* at A level will provide recognition of the additional demands presented by the A2 units in term of 'stretch and challenge' and 'synoptic' requirements. Candidates who fail to reach the minimum standard for grade E are recorded as U (unclassified), and do not receive a certificate. The level of demand of the AS examination is that expected of candidates half way through a full A level course.

The AS assessment units will have equal weighting with the second half of the qualification (A2) when these are aggregated to produce the A level award. AS consists of three assessment units, referred to in this specification as BY 1, BY 2 and BY 3. A2 also consists of three units and these are referred to as BY 4, BY 5 and BY 6.

Assessment units may be retaken prior to certification for the AS or A level qualifications, in which case the better result will be used for the qualification award. Individual assessment unit results, prior to certification for a qualification, have a shelf-life limited only by the shelf-life of the specification.

The specification and assessment materials are available in English and Welsh.

1.2 Prior learning

The specification is equally accessible to all irrespective of age, gender and ethnic, religious or cultural background. The specification is not age-specific and provides opportunities for life-long learning.

The specification builds on the knowledge, understanding and skills set out in the national curriculum Key Stage 4 programme of study for Science and Additional Science and related courses.

Some prior knowledge of biological concepts is recommended. Prior learning from courses other than GCSE or from work based experience may provide a suitable foundation for this course of study.

Mathematical requirements are specified in the subject criteria and repeated in appendix 3 of this specification. It is recommended that, in addition, an understanding of some basic chemical concepts would be advantageous at the start of the course, although knowledge could be acquired during the teaching of the course.

It is recommended, therefore, that an understanding of the following terms is acquired before the end of the course: - ion, electron, atom, molecule, element, covalent bond, electrovalent bond, hydrogen bond, condensation reaction, hydrolysis, oxidation, reduction, pH, buffer, diffusion, solubility, partial pressure, along with an understanding of the electromagnetic spectrum and meaning of chemical formulae.

1.3 Progression

The six part structure of this specification (3 units for AS, and an additional 3 for the full A level) allows for both staged and end-of-course assessment and thus allows candidates to defer decisions about progression from AS to the full A level qualification.

This specification provides a suitable foundation for the study of Biology or a related area through a range of higher education courses; progression to the next level of vocational qualifications; or direct entry into employment. In addition, the specification provides a coherent, satisfying and worthwhile course of study for candidates who do not progress to further study in this subject.

1.4 Rationale

Biology provides a wide breadth of knowledge which touches on many varied aspects of a range of topics. These range from the internal workings of organisms in physiology and the interdependence of living things in ecology, to social issues including human influence on the environment and the ethical considerations of genetics.

The study of biology therefore encourages an appreciation of these issues and their implications as well as providing an insight into the living world.

An understanding of scientific method as the means by which the body of scientific knowledge is increased and an enquiring and critical approach is to be fostered, including an awareness that different perceptions, predictions and interpretations may be applied according to context.

The practical work serves to illustrate and to promote an investigatory approach. The use of computer technology such as CD-Roms, the Internet and computer simulations is encouraged.

It is intended that the use of a variety of approaches will stimulate interest, promote understanding and engender an overall appreciation and sense of wonder at the living world.

The broad objectives therefore are:

- to provide a broad factual base and skills
- to stimulate an interest in the subject
- to facilitate a critical appreciation of issues arising from the subject.

1.5 The Wider Curriculum

The specification provides a framework and includes specific content through which individual courses may address spiritual, moral, ethical, social and cultural issues. Specific relevant subject content includes:

Human genome project; gene therapy; genetic engineering; genetic fingerprinting.
Eutrophication; greenhouse effect; global warming.
Agricultural exploitation; pest control.
Incidence of disease; disease control.
Vaccination programmes; antibiotic overuse.
Evolution and natural selection; loss of biodiversity.
Cloning.
Effects of drugs.

Project work and individual study may serve to extend understanding of the issues in order that a balanced appreciation of the conflicts and dilemmas involved, may be encouraged.

The approach used in constructing the specification lends itself to the establishment of links with other areas of study particularly those involving economic and industrial understanding and environmental and health education. Many of the points listed above may also be used to illustrate the European dimension. For instance, the need for international co-operation with regard to issues such as pollution, exploitation of resources and health. In addition, the need for co-operation between different scientific communities to further knowledge and research, as with the human genome project. Further co-operation is also needed to enforce recommendations such as the limiting of human cloning, in order that knowledge is used for the good of and approval of society.

The specification framework also allows the use of the Welsh context for course designers in Wales to draw on local examples and priorities, thereby allowing development of the curriculum Cymreig. This allows for the consideration of local sensitivities, views and difficulties and also reflects the possible differences in approach to solutions which take place in Wales. For instance, local interest in diseases such as emphysema and conflicts between production and conservation in agriculture.

The specification encourages an awareness of health and safety considerations in undertaking both fieldwork and practical work in the laboratory.

1.6 Prohibited combinations and overlap

Every specification is assigned a national classification code indicating the subject area to which it belongs. Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code will only have one grade (the highest) counted for the purpose of the School and College Performance Tables. The classification code for this specification is 1010.

This specification does not overlap significantly with any other, although there will be elements of overlap, for example, with Applied Science, Health and Social Care and specifications in Sports Science. There are no prohibited combinations.

1.7 Equality and Fair Assessment

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

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

In *GCE Biology* practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Regulations and Guidance Relating to Candidates who are eligible for Adjustments in Examinations.* This document is available on the JCQ website (www.jcq.org.uk).

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

Sensitive Issues

It should also be noted that some aspects of the specification may raise contentious issues e.g. evolution which should be treated with understanding.

In addition the inclusion of human infections and diseases in the specification may raise difficulties for individuals, particularly those with personal involvement e.g. genetic disorders, therefore a sensitive approach is required.

2 AIMS

The AS and A specifications in Biology aim to encourage students 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.

How science Works

A further aim of the AS and A specifications in Biology/Human Biology is to encourage students to understand ***How Science Works***. The skills, knowledge and understanding of ***How Science Works*** include the requirement that candidates should:

- use theories, models and ideas to develop and modify scientific explanations;
- use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas;
- use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems;
- carry out experimental and investigative activities, including appropriate risk management, in a range of contexts;
- analyse and interpret data to provide evidence, recognising correlations and causal relationships;
- evaluate methodology, evidence and data, and resolve conflicting evidence;
- appreciate the tentative nature of scientific knowledge;
- communicate information and ideas in appropriate ways using appropriate terminology;
- consider applications and implications of science and appreciate their associated benefits and risks;
- consider ethical issues in the treatment of humans, other organisms and the environment;
- appreciate the role of the scientific community in validating new knowledge and ensuring integrity;
- appreciate the ways in which society uses science to inform decision-making.

3 ASSESSMENT OBJECTIVES

Candidates must meet the following assessment objectives in the context of the content detailed in Section 4 of the specification:

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.

Assessment objective weightings shown as % of full A level - (AS in brackets)

Unit	Unit Weighting %	AO1%	AO2%	AO3%
BY1	20	9.5 (19)	9.5 (19)	1 (2)
BY 2	20	9.5 (19)	9.5 (19)	1 (2)
BY 3	10	1 (2)	1 (2)	8 (16)
BY 4	20	7	12	1
BY 5	20	7	12	1
BY 6	10	1	1	8
Total	100	35	45	20

The grid indicates the emphasis on the skills in the different examination components, however the totals are approximate. Whilst every effort will be made to keep to these totals it is not intended that the grid should give an exact specification for each operational paper.

4 SPECIFICATION CONTENT

The following content specifies the knowledge, understanding and skills to be examined. It does not constitute a teaching programme.

The content includes the knowledge, understanding and skills cited in the AS and A level biology subject criteria as developed by the regulatory bodies, which is common to all AS and A level biology specifications.
AS modules will be assessed at AS level and A2 modules will be assessed at A level, irrespective of when they are taken.

Suggested practical work has been cited. However, as practical and investigative work is an integral part of science, practical work should be carried out wherever possible. Note that practical activities may be referred to on the theory papers

How science works permeates the specification, however some content in particular lends itself to such aspects. Therefore points of content where issues, ethical questions or scientific theories or opinion may be illustrated have been noted by the symbol *. However, as the list is not exhaustive, other areas may also be considered suitable particularly in the light of different teaching and learning strategies.

SUPPORT MATERIALS

Both the Biology and Human Biology specifications are fully supported by detailed teacher guidance notes which clarify the depth of treatment required and practical requirements.
In addition, Revision Guides for students are available which fully reflect these specifications.

AS

Assessment Unit BY1: Basic biochemistry and cell structure (Common Unit)

This unit incorporates the biochemistry and structure which is fundamental to the functioning of living organisms: structure and function of biological compounds and enzymes; basic cell structure and organisation; cell division; cell membranes; membrane transport.

1.1 Chemical elements are joined together to form Biological compounds.

(a) The main elements found in living organisms. Some elements are needed in trace amounts (details not required).
Key elements are present as inorganic ions: Mg^{2+}, Fe^{2+}, Ca^{2+}, PO_4^{3-}
The importance of water in terms of its polarity, ability to form hydrogen bonds, surface tension, as a solvent, thermal properties, as a metabolite.

(b) Structure, properties and functions of carbohydrates: monosaccharides (triose, pentose, hexose sugars); disaccharides (sucrose, lactose, maltose); polysaccharides (starch, glycogen, cellulose, chitin). Alpha and beta structural isomerism in glucose resulting in storage and structural carbohydrates as illustrated by starch, cellulose and chitin. Chemical properties enabling the use of starch and glycogen as storage and cellulose and chitin as structural compounds.

(c) Structure, properties and functions of lipids as illustrated by triglycerides and phospholipids.
Implications of saturated and unsaturated fat on human health. *

(d) Structure and role of amino acids and proteins. The peptide link.
Relation of molecular structure to function.
Primary, secondary, tertiary and quaternary structure of proteins.
Globular and fibrous proteins

Candidates should be able to use given structural formulae (proteins, triglycerides and carbohydrates) to show how bonds are formed and broken by condensation and hydrolysis, including peptide, glycosidic and ester bonds.
(Candidates should be able to recognise and understand but not **reproduce** the structural formulae of the above molecules).

Suggested Practical Activities: Iodine-Potassium iodide test for starch; Benedict's test for reducing and non-reducing sugars; Biuret test for protein.

1.2 Cell structure and organisation.

(a) The internal membranes of eukaryotic cells and their importance.
The structure of the following organelles: mitochondria; endoplasmic reticulum (rough and smooth); ribosomes; golgi body; lysosomes; centrioles; chloroplasts; vacuoles; nucleus; chromatin; nuclear envelope; nucleolus; plasmodesmata.
The function of these organelles.
Structure of prokaryotic cells and viruses.
Comparison of cell structure of eukaryote, animal and plant, prokaryote and virus.

(b) Levels of organisation: aggregation of cells into tissues. Brief histology of: epithelium, cuboidal and ciliated; muscle, smooth and striated; connective tissue, collagen. Aggregation of tissues into organs.

Suggested Practical Activities: The use of the light microscope. Examination of a range of living cells e.g. *Spirogyra*, onion epidermis, *Elodea* cells, potato tuber cells. Temporary preparations using simple materials e.g. iodine in potassium iodide, methylene blue, dilute glycerine.
Examination of slides showing: epithelia, muscle, collagen.
A study of a range of electron micrographs of prokaryote and eukaryote cells to show structure.

1.3 Cell membranes and transport

(a) The principal components of the plasma membrane and the fluid mosaic model. Factors affecting permeability of the membrane. *

(b) Transport mechanisms: diffusion and factors affecting the rate of diffusion, osmosis and water potential, pinocytosis, facilitated diffusion, phagocytosis, secretion (exocytosis), active transport and influence of cyanide.

Suggested Practical activities: Determination of water potential by measuring changes in mass, and solute potential by measuring the degree of incipient plasmolysis.
Permeability of cell membranes using beetroot.

1.4 Biological reactions are regulated by enzymes.

(a) Metabolism is a series of enzyme controlled reactions.
The protein nature of enzymes. Enzymes may act intracellularly or extracellularly.
Active sites interpreted in terms of three dimensional structure, theory of induced fit as illustrated by lysozyme. *

(b) The meaning of catalysis; the lowering of the activation energy. Influence of temperature, pH, substrate and enzyme concentration on rate of activity. Inactivation and denaturation. The need for scientific method in carrying out experiments and investigations.

(c) The principles of competitive and non competitive inhibition (references to reversible and irreversible action not required). *

Suggested Practical Activities: Investigations into the effect of enzyme and substrate concentrations on enzyme activity. The importance of buffers for maintaining a constant pH. Investigations into the effects of biological washing powders. (These experiments could be used to exemplify experimental design.)

1.5 Medical and industrial applications of enzymes.

(a) The importance of immobilised enzymes. Industrial processes utilise immobilised enzymes enmeshed in an inert solid support so allowing enzyme reuse and improving stability.

(b) Biosensors and their use giving rapid, accurate and sensitive diagnosis in medicine as illustrated by glucose oxidase testing of blood for diabetes.

Suggested Practical activities: Investigation into the immobilisation of enzymes e.g. pectinase/lactase.

1.6 Nucleic acids

(a) Structure of nucleotides (pentose sugar, phosphate, organic base) as subunits of nucleic acids.

(b) Structure of nucleic acids: DNA bases: purines-adenine and guanine, pyrimidines-cytosine and thymine, complementary base pair rule, hydrogen bonding and the double helix (triple and double bonding not required), antiparallel strands.
Comparison between the structure of RNA and DNA.

1.7 Genetic information is copied and passed on to daughter cells.

(a) Interphase (no subdivisions required) and the main stages of mitosis. Significance of mitosis as a process in which daughter cells are provided with identical copies of genes. Cytokinesis in animal cells.

(b) Significance in terms of damage and disease: repeated cell renewal, damage repair and healing and unrestricted division leading to cancerous growth.

(c) Significance of difference between mitosis and meiosis (no stages of meiosis required).

Suggested Practical activities: Prepare and/or observe slides of root tip for mitosis.

Assessment Unit BY2: Biodiversity and Physiology of Body Systems (Biology)

This unit is intended as an overview of a variety of organisms with the emphasis on the comparative adaptations. It is not intended that there should be a detailed coverage of the anatomy and physiology of such a wide range of organisms nor are students expected to memorise the detailed classification of any groups.

2.1 All organisms are related through their evolutionary history.

(a) Biodiversity is the number of different organisms on the planet. Biodiversity varies spatially and over time.

(b) Biodiversity has been generated through natural selection and adaptation over millions of years. Adaptive radiation e.g. Darwin's finches on the Galapagos. *

(c) Organisms are classified into groups based on their evolutionary relationships. Classification places organisms into discrete and hierarchical groups with other closely related species. The need for classification and its tentative nature. Characteristic features of Kingdoms: Prokaryotae, Protoctista, Plantae, Fungi, Animalia. *

(d) Animal biodiversity is classified into over 20 major phyla and several minor ones with each phylum containing organisms based on a basic blueprint. Basic features of: Annelids, Arthropods, Chordates. Arthropods are subdivided into four groups (details not required). Some phyla contain many more species than others. *

(e) Physical features and biochemical methods can be used to assess the relatedness of organisms. DNA 'genetic fingerprinting' and enzyme studies show relatedness without the problem of morphological convergence. *

(f) All organisms are named according to the Binomial system. The species concept.

Suggested Practical activities: Observation of examples from different groups.

2.2 Adaptations for Gas exchange

(a) Adaptations for gas exchange allow an increase in body size. Small animals exchange gases across their general body surface. Comparison of amoeba, flatworm and earthworm.

(b) Larger animals have specialised respiratory surfaces with common features. Respiratory surfaces are adapted to environmental conditions – gills for aquatic environments, lungs for terrestrial environments.

(c) Large, active animals have ventilating mechanisms to maintain gradients across respiratory surfaces. Ventilation in bony fish. Counter current flow compared with parallel flow.
Structure and function of the human breathing system. Ventilation in humans and exchange of gases.

(d) The insect tracheal system as an example of adaptation to life on dry land.

(e) The structure of the angiosperm leaf. The role of leaf structures in allowing the plant to function and photosynthesise effectively. The leaf as an organ of gaseous exchange. Stomatal opening and closing.

Suggested Practical activities: Examination of: fish gill, lung, TS lung, TS trachea, insect trachea, TS leaf dicotyledon e.g. *Ligustrum* (Privet).

2.3 Adaptations for Transport

(a) A comparison of the vascular systems of animal groups:
Insects - open circulatory system, dorsal tube shaped heart, lack of respiratory gases in blood. Vascularisation of earthworm, closed circulatory system and pumps, carriage of respiratory gases in blood.

(b) Mammalian circulatory system- double circulatory system compared with single circulation in the fish. The names of the main blood vessels associated with the human heart. Structure and function of heart and blood vessels. The cardiac cycle and the maintenance of circulation to include graphical analysis of pressure changes. Role of sinoatrial node and Purkinje fibres.

(c) The function of red blood cells and plasma in relation to transport of respiratory gases, dissociation curves of haemoglobin of mammal (adult and fetus). Dissociation curves of animals adapted to low oxygen level habitats e.g. Llama, lugworm. Bohr effect and chloride shift.
Transport of nutrients, hormones, excretory products and heat.
The formation of tissue fluid and its importance in exchange.

(d) Structure of the dicotyledon root. Absorption of water. Movement of water through the root: apoplast, symplast and vacuolar pathways. Structure and role of endodermis. The structure of xylem. Movement of water from root to leaf. Transpiration stream, cohesion-tension theory. Environmental factors affecting transpiration. Angiosperm adaptations: hydrophytes, xerophytes

(e) The structure of phloem as seen by the light and electron microscope. Translocation of organic materials from source to sink. Phloem transport: diffusion; cytoplasmic strands; mass flow models. Experimental evidence that solutes e.g. sucrose, are carried in the phloem. Use of aphids and autoradiographs. *

Suggested Practical Activities: Examination of TS primary stem dicotyledon and root.TS and LS primary xylem and phloem. The use of a simple potometer. Computer modelling may be used to extend this investigation. TS leaf marram grass and water lily. Examination of epidermal strips and/or replicas to compare stomatal numbers in leaves adapted to different environments. Examination of TS artery and vein. Observation of erythrocytes and leucocytes in prepared blood smears.

2.4 Reproductive strategies

(Alternation of generations not required)

(a) Types of reproduction: Asexual and sexual reproduction in plants and animals.
The relative advantages and disadvantages. Males and females produce different sized gametes.

(b) The concept of colonisation of land with reference to the reproductive strategies of vertebrates. Internal and external fertilisation. The different type of zygote development. Degree of parental care.

(c) Insects as an example of a successful land colonising animal group: incomplete and complete metamorphosis.

(d) Comparison of reproductive strategies in plants and animals. The reasons for the successful colonisation of land by angiosperms. The link between angiosperms and insects. The concept of the seed.

2.5 Adaptations for nutrition

(a) The differences between autotrophic and heterotrophic methods of nutrition. The principles of saprotrophic nutrition in Fungi. Secretion of enzymes, external digestion, absorption by diffusion.

(b) Processing food in a tube gut. Ingestion, digestion, absorption and egestion.

(c) The layered structure of the wall of mammalian gut.
Regional specialisations of the mammalian gut. Functions of stomach, small intestine and colon.

(d) Adaptations to different diets. Comparison of dentition in a carnivore and a grazing herbivore. Adaptations of herbivore gut to a high cellulose diet. Comparison of the gut regions of herbivore and a ruminant.

2.6 Adaptations for parasitism

(a) The principles of parasitism as shown by a gut parasite e.g *Taenia solium* or *Echinococcus granulosis*.

Suggested Practical activities: TS ileum. Growth of *Mucor* on bread. Starch agar diffusion. Slides of parasite such as tapeworm. Examination of skull and dentition in carnivore and herbivore.

Assessment Unit BY3: Practical work (Common Unit)

Details given under scheme of assessment. Content based on BY1 and BY2.

A Level

Assessment Unit BY4: Metabolism, Microbiology and Homeostasis (Biology)

Unit BY4 involves the study of energy supply in living organisms along with microbiology and populations; homeostasis and nervous system plus a brief overview of some adaptations and non mammalian systems.

4.1 Importance of ATP

(a) The importance of chemical energy in biological processes.
The central role of ATP as an energy carrier and its use in the liberation of energy for cellular activity. Structure of ATP

(b) The synthesis of ATP by means of a flow of protons through the enzyme ATP synthetase. Chemiosmosis and electrochemical gradient.
The similarity between mitochondrial and chloroplast membrane function in providing a proton gradient for ATP synthesis.

(c) The maintenance of the proton gradient by proton pumps driven by electron energy. The alternate arrangement of pumps and electron carriers to form the electron transport chain. (Names of proton pumps and electron carriers in the electron transport system are **not** required).

4.2 Respiration releases chemical energy from organic molecules

(a) All living organisms carry out respiration in order to provide energy in the cell.

(b) Glycolysis as a source of triose phosphate, pyruvate, ATP and reduced NAD. The formation of acetyl CoA.
(The names of intermediates are **not** required.)

(c) The Krebs cycle as a means of liberating energy from carbon bonds to provide ATP and reduced NAD with release of carbon dioxide. The role of reduced NAD as a source of electrons and protons for the electron transport system.

The energy budget of the breakdown of glucose under aerobic and anaerobic conditions. Fat and amino acid utilisation.

Suggested Practical Activities: Demonstration of dehydrogenase activity using artificial hydrogen acceptors, as illustrated by methylene blue or DCPIP or tetrazolium compounds.

4.3 Photosynthesis uses light energy to synthesize organic molecules.

(a) The distribution of chloroplasts in relation to light trapping.
Chloroplasts as transducers converting the energy of light photons into the chemical energy of ATP.
Light harvesting. Absorption of various wavelengths of light by chlorophyll and associated pigments and energy transfer to reaction centres.

(b) Basic features of Photosystems I and II.
Cyclic and non-cyclic photophosphorylation sources of electrons for the electron transport chain. Photolysis as a source of electrons for Photosystem II. Reduction of NADP by addition of electrons and hydrogen ions; occurs in the stroma maintaining the proton gradient.

(c) Reduced NADP as a source of reducing power and ATP as a source of energy for the following reactions.
The light independent stage and the formation of glucose; uptake of carbon dioxide by ribulose bisphosphate to form glycerate 3-phosphate catalysed by Rubisco.
Reduction of glycerate 3-phosphate to triose phosphate (carbohydrate), with the regeneration of ribulose bisphosphate.
Other carbohydrates, lipids and amino acids can be made from the triose phosphate. (No details of chemistry of these processes needed).

(d) The role of inorganic nutrients in plant metabolism as illustrated by the utilisation of nitrogen and magnesium.

Suggested Practical Activities: Separation of chloroplast pigments by chromatography.
A quantitative investigation of the effects of different coloured/wavelength light on the rate of photosynthesis. Computer modelling may be used to extend this investigation**.**

4.4 Microbiology

(a) Bacteria may be classified according to their shape and by their reaction to the Gram stain. *

(b) Culture of microorganisms in the laboratory. Conditions necessary for growth. Principles of aseptic technique.

(c) Counting microorganisms to monitor population growth, viable count, using serial dilutions, plating and counting colonies.

(d) Principles underlying a simple batch culture fermenter. Industrial application of a batch culture fermenter as exemplified by penicillin production.

Suggested Practical Activities: Examination of bacteria in order to recognise bacilli and cocci. Safe handling using aseptic technique. Use of simple stains e.g. methylene blue for staining bacteria (from milk) and examination using the light microscope. Gram staining and microscopic investigation of yoghurt. Investigation into the numbers of bacteria in fresh and stale milk, using techniques of serial dilution, plating and counting colonies.

4.5 Factors controlling population size.

(a) Populations and the way in which they grow - a simple quantitative treatment. Immigration, emigration, birth and death rates.
Graphs showing population growth.
Factors affecting population growth; competition; carrying capacity.
Regulation by density dependent and density independent factors.

(b) The principles of chemical and biological control of pests and their relative advantages and disadvantages,

(c) The importance of organic breakdown in recycling nutrients.
Role of bacteria in the nitrogen cycle (Generic names other than *Nitrosomonas*, *Nitrobacter*, *Azotobacter* and *Rhizobium* not required). Significance of nitrates in proteins and nucleic acids. The importance of human activities such as ploughing and drainage in producing the aerobic conditions needed for nitrification.
The carbon cycle.

Suggested Practical Activities: Observation of root nodules. Culture of nitrogen fixing bacteria.

4.6 Control systems co-ordinate and regulate processes.

(a) The concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium.
The role of negative feedback in restoring conditions to their original levels.

(b) Structure of the mammalian kidney including nephron.
Functions of the mammalian kidney including nitrogenous excretion and water regulation. Adaptations of the cells of the proximal tubule for reabsorption.

(c) Endocrine glands contribute to homeostatic balance as illustrated by the role of the posterior pituitary gland in the secretion of antidiuretic hormone.
The role of antidiuretic hormone.

(d) The need for different excretory products and adaptations of the loop of Henlé in different environments.

Suggested Practical Activities: Observation of kidney. Low and high power examination of prepared sections of kidney.

4.7 The nervous system

(a) Responding to a stimulus requires information from a receptor to be relayed to an effector. Effectors are either muscles or glands.

(b) The main areas of the spinal cord. The basic pattern of spinal nerves in relation to the spinal cord. Dorsal root and ventral root.
The simple reflex arc as the basis for protective, involuntary actions.
Comparison with nerve nets.

(c) The structure of the motor neurone, to include drawing and labelling of diagram.
The nature and transmission of the nerve impulse. Analysis of oscilloscope traces. Factors affecting speed of conduction in other organisms.

(d) The structure and role of the synapse and synaptic transmission. The effect of chemicals such as organophosphates and psychoactive drugs (in brief) on transmission.

(e) Plants are responsive to their environment and show photoperiodism via phytochromes however the complete mechanism is not fully understood

Suggested Practical Activities: Examination of TS spinal cord.

Assessment Unit BY5: Environment, Genetics and Evolution (Common Unit)

Unit BY5 involves the study of variation and evolution plus genetics and applications; ecosystems and energy flow along with human effects on the environment.

5.1 The genetic code and cell function

(a) The two major functions of DNA: replication and protein synthesis.
The semi-conservative replication of DNA catalysed by DNA polymerase.
Evidence from Meselson and Stahl experiment. *
The genetic code. The triplet code for amino acids.

(b) The transcription of DNA to produce messenger RNA.
Translation by ribosomes and transfer RNA, which has an anticodon and a specific amino acid binding site, to synthesize proteins (other details of the structure of tRNA not required).

'One gene - one polypeptide' hypothesis.
Polypeptides may be further modified and combined.

(c) Main stages of meiosis (names of subdivisions of prophase 1 not required). Cytokinesis in animal cells.

Suggested Practical Activities: Observation of prepared slides of developing anthers for meiosis.

5.2 Sexual reproduction in human.

(a) The structure and function of the reproductive systems in human.
Spermatogenesis and oogenesis to produce spermatozoa and secondary oocyte.

(a) Sexual intercourse, fertilisation and implantation. Any blockage of the fallopian tubes eg as a result of infection, will prevent fertilisation. Pregnancy testing kits rely on the reaction between antibodies bound to coloured beads and a hormone in urine.

Suggested Practical Activities: Histology of the ovary and testis.

5.3 Sexual reproduction in plants

(a) The generalised structure of flowers to compare wind and insect pollinated.
Cross and self pollination. Fertilisation.

(b) Formation and structure of seed and fruit as shown by broad bean and maize. Germination of *Vicia faba* (broad bean).

Suggested Practical Activities: Dissection/examination of wind and insect-pollinated flowers. Examination of prepared slides of anthers; ovaries.

5.4 Inheritance

(a) The importance of meiosis and fertilisation in sexual reproduction giving rise to variation. Random assortment, crossing over and fertilisation as sources of variation.

(b) Alleles as different forms of the same gene.
An understanding of the principles of monohybrid and dihybrid Mendelian inheritance. Chi squared. Codominance. Linkage.
Sex linkage as illustrated by haemophilia.

(c) Gene mutation as illustrated by sickle cell anaemia and chromosome mutation as illustrated by Down's syndrome. Mutagens and carcinogens. Oncogenes

Suggested Practical Activities: Experiment to illustrate gene segregation (*Drosophila*, maize cobs and tomato plants are suitable, but other material may be used). Fast cycling brassicas (SAPS).

5.5 Variation and evolution

(a) Genetic and environmental factors produce variation between individuals.
Variation may be continuous and discontinuous; heritable and non-heritable.

Inter and intra-specific competition for breeding success and survival.
Selective agencies (e.g. supply of food, breeding sites, climate).

The gene pool and genetic drift.
Selection can change the frequency of alleles in a population.

(b) Isolation and speciation.
Separation of populations by geographical, behavioural, morphological seasonal and other isolation mechanisms. Hybrid sterility.
Darwin's theory of evolution that existing species have arisen through modification of ancestral species by natural selection. *

5.6 Applications of reproduction and genetics.

(a) The principles involved in cloning as illustrated by: separating cells of developing animal embryos, nuclear transplants from somatic cells into egg cells, tissue cultures of animals, micropropagation of plants.
The advantages and disadvantages. *

(b) The Human Genome Project has been used to locate and sequence alleles on human chromosomes.
The potential uses and abuses of this knowledge. Possibility of automated routine screening for particular predisposing genes. Ethical issues surrounding this knowledge and gene ownership. *

(c) Advantages and disadvantages of using gene therapy for the treatment of disease as illustrated by cystic fibrosis.
Formation of recombinant DNA by insertion of foreign DNA into bacterial plasmids and cloning of the bacteria to produce useful molecules as illustrated by insulin.
The use of restriction endonuclease, DNA ligase, reverse transcriptase, marker gene. Advantages and disadvantages of genetic engineering.
Issues associated with genetically modified food crops such as tomatoes and soya. *

(d) Genetic fingerprinting of an individual produces a unique pattern of bands of DNA. Gene amplification, PCR.
Uses of this technique and associated issues. *

(e) Issues surrounding the use of: stem cells for replacing damaged tissues and organs; IVF for aiding poor fertility.

5.7 Energy and Ecosystems

(a) The concept of ecosystems. The sun is the source of energy for the ecosystem.
The concept of habitat and community. Transfer of energy from plants to animals. Trophic levels and the efficiency of energy transfer. Gross and net production. Pyramids of energy

(b) Principles of succession as illustrated by the change from bare rock to woodland.
Use of terms primary and secondary succession, pioneers, sere and climax community.

5.8 Effects of Human activities and sustainability

(a) Human influence on the environment has created new selection pressures as illustrated by warfarin resistance in rats, and antibiotic resistant forms of bacteria. Artificial selection. *

(b) Reasons for species becoming endangered and causes of extinction. The conservation of gene pools in the wild and in captivity. *

(c) Agricultural exploitation. Conflicts between production and conservation and possible means to resolve such conflicts as illustrated by: *

- forests: reasons for and scale of forest destruction, consequences, managed forests, ecotourism. Native woodlands and biodiversity.
- oceans: the problems of over-fishing and attempts at regulation as illustrated by the principle of quotas, exclusion zones and restricted net mesh size, human choices. Fish farming and associated issues.

(d) The effects of human activities on the carbon cycle. The economic importance of the nitrogen cycle in relation to food production and fertiliser application.
Eutrophication and algal blooms. Drainage has adverse effects on habitats. *

(e) Global warming and climate change affect distribution of species and are a possible cause of extinction. Possible need for changes in farming practices such as growing drought resistant crops. *

(f) Energy may be released from biomass and used as biofuels such as gas and diesel. Issues surrounding this land use. *

(g) Increased human pressures on the environment. The need to achieve sustainability by changes in human attitudes and informed choices. The need for political decision making to be informed by knowledge based on sound scientific principles. Environmental monitoring and the need to provide data which is reliable and valid. Issues surrounding the collection of data; possibility of conflicting evidence and interpretation. Recognition of the possible tentative nature of conclusions. *

Suggested Practical Activities: Investigation of endangered species using secondary sources (ICT is suitable). Case studies on individual conservation projects.

Assessment Unit BY6: Practical work (Common Unit)

Details given under scheme of assessment. Content based on BY4 and BY5 but microscope work could be taken from any unit.

Calibration of microscope using a stage micrometer and eye piece graticule. Use of the units mm and μm. Measurement using microscope. Calculation of the magnification of drawings.

Further exemplification of *How science works* related to content

The requirements for *How science works* are given below with further exemplification provided in italics with the relevant bullet points.

The skills, knowledge and understanding of ***How Science Works*** include the requirement that candidates should:

- use theories, models and ideas to develop and modify scientific explanations;

  Lock and key model for enzymes; Theories for movement of water and organic materials through plants; use of statistical modelling for gene frequencies/ population growth.

- use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas;
- use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems;
- carry out experimental and investigative activities, including appropriate risk management, in a range of contexts;
- analyse and interpret data to provide evidence, recognising correlations and causal relationships;

  A thinking and questioning approach is fundamental to the scientific investigation of ideas and phenomena either in terms of practical investigation or logical reasoning. Practical investigations provide opportunities for these four HSW aspects. In addition correlations and causal relationships could also be considered in relation to genetic conditions.

- evaluate methodology, evidence and data, and resolve conflicting evidence;

  Practical work could also be used here but in addition any other data collection could be used such as information on populations/ conservation.

- appreciate the tentative nature of scientific knowledge;

  Scientific ' certainty' exists often as a balance of probability within the context of current knowledge and understanding at any particular time. Examples include classification; our understanding of genetic conditions; sustainability of resources.

- communicate information and ideas in appropriate ways using appropriate terminology;

  A variety of forms could be used including extended prose, annotated diagrams, graphical representations in different forms; statistical analyses.

- consider applications and implications of science and appreciate their associated benefits and risks;

  Suitable examples include: species diversity; environmental issues; recombinant DNA technology; medical issues; stem cells; cloning.

- consider ethical issues in the treatment of humans, other organisms and the environment;

  Suitable examples include: environmental issues; DNA technology; gene therapy; cloning; stem cells.

- appreciate the role of the scientific community in validating new knowledge and ensuring integrity;

  Peer review is used to validate new research. Part of this review involves the validity of the scientific method used including the reliability and validity of the results and their interpretation in the light of current thinking. Statistical data is subject to the same process. Suitability of sample size. Reliability of evidence from genetic fingerprints; cloning; GM crops; publication of any research data.

- appreciate the ways in which society uses science to inform decision-making.

  Suitable examples include: health issues; conservation; environmental issues; stem cells; GM crops. Media presentation and bias. Influence of pressure groups. Political considerations such as cost versus benefit e.g. health screening programmes

5 SCHEME OF ASSESSMENT

AS and A level qualifications are available to candidates following this specification.

AS

The AS is the first half of an A level course. It will contribute 50% of the total A level marks. Candidates must complete the following **three units** in order to gain an AS qualification.

		Weighting Within AS	Weighting Within A Level
BY1	Basic Biochemistry and organisation	40%	20%
BY2	Biodiversity and physiology of Body Systems	40%	20%
BY3	AS Practical assessment	20%	10%

For Unit BY2 there is either a Biology or Human Biology option. Entry to this unit will determine any AS qualification title awarded. However the AS Human Biology option could be included in an A level qualification in Biology.

BY 1 and 2: Written Paper (1 hour 30 minutes)

An approximate guide to the structure of the examination papers, BY1 and BY2 follows:-

Type of question	Marks per question	Number of questions per paper	
		BY1	BY2
Short structured Longer structured Essay (1 out of 2)	2 - 5 7 - 15 10 - 12	2-3 2-4 1	2-3 2-4 1
Total marks Time		70 1 hr 30 min	70 1 hr 30 min

Questions comprise a mix of recall and application of knowledge set in appropriate contexts. These contexts may be drawn from a variety of examples including contemporary biological applications for example in medicine or agriculture.

BY 3: Practical Work

The practical assessment is based on the content of assessment units BY1 and BY2 and addresses mainly AO3 (39 marks) with some AO1 and AO2 (5 marks).

The practical assessment comprises a written report of a centre set investigation carried out by candidates.

The investigations are to be conducted under supervised conditions and the completed work submitted to an external assessor for marking during the summer term, by a date provided annually.

Assessment of microscope work involves candidates producing any labelled, specimen drawing at low power. The drawing should be submitted for marking at the same time as the investigative work.

See section 8 'Internal Assessment Guidelines' for further details.

A Level

The A level specification consists of two parts: Part 1 (AS) and Part 2 (A2).

Part 1 (AS) may be taken separately and added to A2 at a further examination sitting to achieve an A level qualification, or alternatively, both the AS and A2 may be taken at the same sitting.

Candidates must complete the AS units outlined above plus a further three units to complete A level Biology. The A2 units will contribute 50% of the total A level marks.

		Weighting within A2	Weighting within A Level
BY4*	Metabolism, Microbiology and Homeostasis	40%	20%
BY5*	Environment, Genetics and Evolution	40%	20%
BY6*	A2 Practical assessment	20%	10%

*Includes synoptic assessment

For Unit BY4 there is either a Biology or Human Biology option. Entry to this unit will determine the qualification title awarded.

BY 4 and 5: Written Paper (1 hour 45 minutes)

An approximate guide to the structure of the examination papers, BY4 and BY5 follows:-

Type of question	Marks per question	Number of questions per paper	
		BY4	BY5
Short structured Longer structured Essay (1 out of 2)	2 - 5 7 - 15 10 - 12	2-4 2-5 1	2-4 2-5 1
Total marks Time		80 1 hr 45 min	80 1 hr 45 min

Questions comprise a mix of recall and application of knowledge set in appropriate contexts. These contexts may be drawn from a variety of examples including contemporary biological applications for example in medicine or agriculture.

Examination papers for BY4 and BY5 assess the subject content of the units and include some marks which specifically address the requirement for synoptic assessment as defined below.

BY 6: Practical work

The practical assessment is based on the content of assessment units BY4 and BY5 and addresses mainly AO3 (44 marks) with some AO1 and AO2 (6 marks).

The practical assessment comprises a written report of a centre set investigation carried out by candidates. The work should relate to the A2 subject content and show progression from AS.

The investigations are to be conducted under supervised conditions and the completed work submitted to an external assessor for marking during the summer term by a date provided annually.

Assessment of microscope work involves candidates producing any labelled, specimen drawing at either low or high power plus calibration and size calculation. The drawing and calibration should be submitted for marking at the same time as the investigative work.

See section 8 'Internal Assessment Guidelines' for further details.

Synoptic Assessment

Synoptic assessment, testing candidates' understanding of the connections between the different elements of the subject and their holistic understanding of the subject, is a requirement of all A level specifications. In the context of Biology this means:

Requiring 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; and
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data
- bring together scientific knowledge and understanding from different areas of the subject and apply them

Examination papers for BY4 and BY5 include some marks which specifically address the requirement for synoptic assessment. These are largely skills based questions such as comprehension and data response which require the bringing together of different parts of the course. Essays may also incorporate credit for synoptic aspects in the answers given. Answers including some fundamental concepts and content from AS units may be credited in synoptic questions.

Practical work is considered to be inherently synoptic due to the bringing together of knowledge to be applied to an activity and the use of a variety of acquired skills.

Synoptic questions in particular may incorporate concepts and ideas which are designed to be more challenging for candidates. Such questions may provide credit for extra insight and appreciation of the inter relatedness of different aspects of the subject and creativity of thought. Such answers are likely to be in relation to data response and extended answer or essay questions.

Quality of Written Communication

Candidates will be required to demonstrate their competence in written communication in all assessment units, both AS and A2, where they are required to produce extended written material, particularly in theory examinations. Mark schemes for these units include the following specific criteria for the assessment of written communication.

- legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning;
- selection of a form and style of writing appropriate to purpose and to complexity of subject matter;
- organisation of information clearly and coherently; use of specialist vocabulary where appropriate.

Markschemes therefore will, where appropriate, be constructed to allow for the presentation of coherent accounts, cogent argument, appropriate format, use of scientific terminology and clarity. Generally this involves the allocation of marks for these specific points but will not include marks solely for the quality of written communication.

All assessment objectives subsume the use of written communication. Use of appropriate language, punctuation and grammar is expected as the means by which ideas can be expressed and logical argument shown in answers to questions. Marks will not be awarded unless the meaning is clearly conveyed.

Availability of Units

Availability of Assessment Units				
Unit	**January 2009**	**June 2009**	**January 2010 & each subsequent year**	**June 2010 & each subsequent year**
BY 1	✓	✓	✓	✓
BY 2		✓	✓	✓
BY 3		✓		✓
BY 4			✓	✓
BY 5				✓
BY 6				✓

There is no requirement to study the theory units in a particular order although progression in the order BY1, BY2, BY4, BY5, would provide a logical sequence. There is no terminal unit requirement.

Assessment Units BY1, BY2 and BY4 are available in January whilst BY1, BY2, BY4 and BY5 are available in June. BY3 and BY6 are both available annually.

Note: BY3 and BY6 are to be submitted in May.

Awarding, Reporting and Re-sitting

The overall grades for the GCE AS qualification will be recorded as a grade on a scale from A to E. The overall grades for the GCE A level qualification will be recorded on a grade scale from A* to E. Results not attaining the minimum standard for the award of a grade will be reported as U (Unclassified). Individual unit results and the overall subject award will be expressed as a uniform mark on a scale common to all GCE qualifications (see table below). The grade equivalence will be reported as a lower case letter ((a) to (e)) on results slips, but not on certificates:

	Max. UM	A	B	C	D	E
Units 1, 2, 4 and 5 (weighting 20%)	120	96	84	72	60	48
Units 3 and 6 (weighting 10 %)	60	48	42	36	30	24
AS Qualification	300	240	210	180	150	120
A Qualification	600	480	420	360	300	240

At A level, Grade A* will be awarded to candidates who have achieved a Grade A in the overall A level qualification and 90% of the total uniform marks for the A2 units.

Candidates may re-sit units prior to certification for the qualification, with the best of the results achieved contributing to the qualification. Individual unit results, prior to certification of the qualification have a shelf-life limited only by the shelf-life of the specification.

6 KEY SKILLS

Key Skills are integral to the study of AS/A level Biology and may be assessed through the course content and the related scheme of assessment as defined in the specification. The following key skills can be developed through this specification at level 3:

- Communication
- Application of Number
- Problem Solving
- Information and Communication Technology
- Working with Others
- Improving Own Learning and Performance

Mapping of opportunities for the development of these skills against Key Skills evidence requirement is provided in 'Exemplification of Key Skills for [Biology], available on the WJEC website.

7 PERFORMANCE DESCRIPTIONS

Introduction

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

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

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

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

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

AS performance descriptions for biology

	Assessment objective 1	**Assessment objective 2**	**Assessment objective 3**
Assessment objectives	**Knowledge and understanding of science and of How science works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How science works** • Candidates should be able to: • analyse and evaluate scientific knowledge and processes • apply scientific knowledge and processes to unfamiliar situations including those related to issues • assess the validity, reliability and credibility of scientific information.	**How science works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of most principles, concepts and facts from the AS specification b) select relevant information from the AS specification c) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument b) describe significant trends and patterns shown by data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly c) comment critically on statements, conclusions or data d) carry out accurately most of the calculations specified for AS e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues c) make observations and measurements with appropriate precision and record them methodically d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.
E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles and facts from the AS specification b) select some relevant information from the AS specification c) present information using basic terminology from the AS specification.	Candidates characteristically: a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument b) describe some trends or patterns shown by data presented in tabular or graphical form c) identify, when directed, inconsistencies in conclusions or data d) carry out some steps within calculations e) translate data successfully from one form to another, in some contexts.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques and comment on ethical issues c) make observations and measurements and record them d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

A2 performance descriptions for biology

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Assessment objectives	**Knowledge and understanding of science and of How science works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How science works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes • apply scientific knowledge and processes to unfamiliar situations including those related to issues • assess the validity, reliability and credibility of scientific information.	**How science works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate detailed knowledge and understanding of most principles, concepts and facts from the A2 specification b) select relevant information from the A2 specification c) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving several steps in the argument b) describe significant trends and patterns shown by complex data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly c) evaluate critically any statements, conclusions or data d) carry out accurately most of the calculations specified for A2; and apply the principles of statistical analysis when directed e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another f) select a wide range of facts, principles and concepts from both AS and A2 specifications g) link together appropriate facts principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues c) make observations and measurements with appropriate precision and record these methodically d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts e) use an appropriate statistical technique to assess the validity of a hypothesis.
E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles, concepts and facts from the A2 specification b) select some relevant information from the A2 specification c) present information using basic terminology from the A2 specification.	Candidates characteristically: a) apply given principles or concepts in familiar and new contexts involving a few steps in the argument b) describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form c) identify, when directed, inconsistencies in conclusions or data d) carry out some steps within calculations e) translate data successfully from one form to another, in some contexts f) select some facts, principles and concepts from both AS and A2 specifications g) put together some facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques and comment on ethical issues c) make observations and measurements and record them d) interpret, explain and communicate some of the results of their own and others' experimental and investigative activities, in appropriate contexts e) use a given statistical technique.

8 INTERNAL ASSESSMENT GUIDELINES

General Information

The assessment objectives for AS and A2 practical work are the same. The expectations and opportunities for practical work are rooted within the subject content in the relevant AS and A2 units. Therefore for A2 ecology, fieldwork and appropriate statistical analysis could be included.
The demands are commensurate with the level expected part way through the A level course for AS and having completed further studies for A2. Hence, the work should inherently involve slightly more complex and demanding activities for candidates at A2 compared with AS.

The use of ICT is encouraged where it may be employed as an appropriate tool for the task in hand. For instance, laboratory equipment may include sensors such as pH or oxygen probes linked to computerised data systems or computerised information sources and retrieval.

Scheme of Assessment

The practical assessment comprises a written report of a centre set investigation carried out by candidates (Exemplar available in Guidance Notes for Teachers). Centres must submit the outline plan of a candidate devised investigation for approval by the WJEC before its use as an assessed investigation. A proforma is provided for this purpose (appendix 6). WJEC reserves the right not to accept any submitted candidate devised work that has not been submitted for and granted prior approval.

The investigations are to be conducted under supervised conditions. The report should be written under the marking section headings (1-5) below. A risk assessment must be included. The completed report is to be submitted to an external assessor for marking during the summer term by a date provided annually. Full details of the method used must be included along with the completed authentication cover sheet (see appendix 4). The report should be concise, relevant to the investigation in hand and address the marking criteria below. The marking criteria are clarified further in the guidance notes for teachers.

Microscope work is an exercise in observation with an understanding of scale and a realisation that specimens are three dimensional. Making a simple record of what is observed ensures that due attention is paid to proportions and spatial relations in a specimen. It is expected that these skills will be developed during the course.

Assessment at AS level involves candidates producing any labelled, specimen drawing at low power. The specimen should be selected from those suggested in the specification. However, at A2 level, assessment of microscope work involves candidates producing any labelled, specimen drawing at either low or high power plus the calibration of the microscope and measurement of an indicated tissue or structure with a size calculation. The specimen should be relevant to or selected from those suggested in the specification (note that drawings of bacteria are not suitable for assessment).

The drawing(s) and calibration, as appropriate, should be submitted for marking at the same time as the investigative work. In addition teachers should submit the signed cover sheet for practical assessment including confirmation that the candidate worked safely in the laboratory and an indication of the teacher's result for the investigation method used.

Marking scheme

Each practical will be marked against generic marking criteria as follows. The biological knowledge is what would be reasonably expected of an AS or A level candidate in relation to past performances of candidates at this level. Some marks are considered to be synoptic in nature since they require the application and bringing together of knowledge and/or skills acquired from different parts of the course. The areas for mark allocation are as follows:

Generic marking criteria for AS investigative work

In the context of the investigation undertaken:

1. Aim/prediction
Statement of suitable qualitative or quantitative aim/prediction [2]

2. Experimental design
e.g. Identification of any risks specific to the practical and procedure for minimising risk; variables identified: independent; dependent; controlled; appropriate range; control. [9]

3. Results
Recording e.g. arrangement in table; appropriate units; headings; repeat readings; means. [4]
Processing data in a suitable format e.g. choice of graphs as appropriate: axes; scale; plotting; line [7]

4. Analysis
e.g. comment on the trend / reliability of results / use or suitability of simple error bars / accuracy and suitable suggestions for improvement [5]

Conclusion from the data plus concise explanation of conclusion using relevant biological knowledge. [6]

Accuracy of data collected with reference to data collected by teacher/ theoretical expectation [1]

5. Further work
Plan to extend the investigation with apparatus needed and identification of variables. [4]

Total 38 marks

Observation – Microscopy
Candidates are required to submit **1 drawing**, labelled and with suitable heading, from any slide relevant to/suggested in the AS specification. The drawing is assessed under the following criteria:

1. Clean, single, sharp and complete lines with no shading [2]

2. Drawing the correct proportions of all tissues [2]

3. The correct identification of all main tissues/structures by unambiguous labelling [2]

Total 6 marks

A2 assessment

Topics rooted in the A2 content therefore ecological investigations/ fieldwork and/or statistical analysis could be included. Synoptic aspects with AS units are permissible but not repeating an investigation based solely on AS content.

Generic marking criteria for A2 investigative work

In the context of the investigation undertaken:

1. **Aim/prediction**
   Statement of suitable quantitative aim/prediction [2]

2. **Experimental design**
   e.g. Identification of any risks specific to the practical and procedure for minimising risk; variables identified: independent; dependent; controlled; appropriate range; control; sampling method; sample size. [9]

3. **Results**
   Recording e.g. arrangement in table; appropriate units; headings; repeat readings; calculation. [5]
   Processing data in a suitable format e.g. appropriate graphs, appropriate statistical test: axes; scale; plotting; line; null hypothesis; formula; standard deviation. [8]

4. **Analysis**
   e.g. Detailed comments on the trend / reliability of results / use or suitability of error bars / accuracy and suitable suggestions for improvement. [7]

   Conclusion from the data, related to aim plus concise explanation of conclusion using relevant biological knowledge. [7]

   Accuracy of data collected with reference to data collected by teacher/ theoretical expectation
   [1]

5. **Further work**
   Plan to extend the investigation with apparatus needed and identification of all variables. [5]

Total 44 marks

Observation – Microscopy

Candidates are required to submit **1 drawing**, labelled and with suitable heading, from a slide relevant to/suggested in the specification (AS or A2 but not the same slide as above). The drawing of the specimen may be produced using either a low or high power objective lens. The magnification chosen **must be noted on the candidate's work**. Drawings of specimens examined at low power, as in ecological investigations, are also acceptable.

The drawing will be assessed under the following criteria:

1. The correct identification of all main tissues/structures by unambiguous labelling. [1]

2. Calibration of the microscope for the appropriate objective lens. [3]

3. Identification of point of measurement on drawing and calculation of actual measurement (mm /µm) of measured region. [2]

Total 6 marks

Assessment conditions

The practical assessment overall should be viewed in the same way as a theory examination with regard to security and malpractice and candidates warned to this effect. The experimental work and written report should be solely that of the candidate. The teacher may intervene to aid progress but must annotate the work to this effect and recognise that any associated marks can not be awarded as a result.

The practical work, at both AS level and A2 level, may be carried out in a series of practical sessions or on 1 day or blocks at the centre's discretion. In between sessions the written work should be retained by the teacher. Subsequent amendments to the work are not permissible.

Safe, skilful working

It is anticipated that the skills of candidates will be encouraged and developed throughout the course by frequently carrying out a variety of practical/microscope work and receiving tuition in practical techniques. By the time the assessment takes place, therefore, the level of skills and safety awareness should be sufficiently developed in order to ensure that candidates work in a safe, ordered manner, showing good laboratory/field practice and using common biological equipment in a competent, precise and skilful manner. Safety awareness is also assessed by the inclusion in their report of each candidate's risk assessment for their investigation. The level of skill used will also be reflected in the results shown and associated comments made by the candidate about the accuracy shown by the investigation. A comparison of results obtained by the teacher is also required in order to indicate the level of skill shown by the candidate.

Submission of work

The cover sheet for practical assessment (refer to Guidance Notes for Teachers) should be signed and dated by both the teacher and candidate to verify it is the candidate's own work.

In addition, the teacher must verify that whilst in the laboratory/field the candidate worked in a safe and skilful manner.

The teacher must also record his/her results of the same experiment and, if need be, comment on the comparison between his/her results and that of the candidate or in some cases the theoretical expectation of results.

Any unauthenticated work or work which has not been verified for safety cannot be marked and will be returned to the centre.

The name of a person to whom the work should be sent for marking will be sent out by WJEC annually, normally in late April.

The report of the investigation plus microscope work and associated information, as stipulated above, should be sent to the nominated person to arrive by the due date as published annually, normally in early May.

Any loose pages, such as the microscope work, must be clearly labelled with the candidate's name and centre and attached to their investigation report (preferably using treasury tags). Any unattributed work cannot be marked and candidates will therefore penalise themselves as a result.

Work must not be submitted in large or bulky folders/files. The authenticity of any word processed work as being solely that of the candidate must be assured.

Appendix 1: Lines of Best fit

If there is a continuous relationship between the two variables plotted on a graph, a line of best fit should be drawn joining, or approximating to, the points. Mathematical relationships may be deduced from this line.

In a great deal of biological data there is no such continuous relationship. In this case a series of straight lines should be used to join successive points. The values between the points cannot be shown on the graph and cannot be deduced from the readings. A smooth curve should therefore only be used if there is good reason to think that the intermediate values would fall on that curve. Joining points by straight lines indicates that the points in between recorded points are unknown and that, in addition, how they vary between recorded points is also unknown.

In other disciplines a 'line of best fit' is regarded as the norm and the possibility of straight line joining of points is not considered. Therefore, an awareness of the particular requirements for presenting biological data is required and the need for appropriate explanation to enable an understanding of why this difference occurs.

Appendix 2: Terms used in Examination Questions

Examination questions are worded extremely carefully so that they are concise and unambiguous. Despite this, candidates tend to penalise themselves unnecessarily when they mis-read questions, either because they read them too quickly or too superficially. It is essential that candidates appreciate the precise meaning of each word in the question if they are to be successful in generating concise, relevant and unambiguous responses. The mark value which follows each part of each question provides a useful guide as to the amount of information required in the answer. A list of words frequently used in examination questions, together with their approximate meanings follows:

Annotate	Give notes of explanation, For example, each label of a large labelled annotated diagram would include a short description of its function and/or structure, as appropriate.
Brief	A short statement of only the main points.
Calculate	Work out, showing all stages in the derivation of the answer.
Compare	Write about the similarities **and differences** between two or more, for example, structures or processes.
Criticise	State the faults/shortcomings of, for example, an experiment.
Define	State the meaning of, for example, a term without actually using the term itself.
Describe	A request for factual detail about, for example, a structure or process expressed logically and concisely.

Diagrams	These should always be large, drawn in the correct proportion, **fully labelled**, have a title and, when appropriate, be referred to in the text of a response. Label lines should be drawn with a ruler so that they do not cross other label lines. They should touch the appropriate structure. Colour and shading should normally be avoided.
Discuss	A critical account of the various viewpoints and arguments in the topic set, drawing attention to their relative importance and significance.
Distinguish between	State the differences between, for example, two or more terms often for the purpose of identification.
Explain	Describe and give reasons for.
Graphs	These should: (a) be plotted in **pencil** so that they can be corrected neatly. (b) make maximum use of the paper. (c) have fully labelled axes, curves and, where appropriate, a title. (d) have all points marked clearly on each curve using, for example, an x but never just a dot. (e) have points of a particular curve joined by a series of straight lines drawn with a ruler or with a smooth curve, but never with a sketchy line. (f) take note of any particular instructions given in the question. When a graph is being interpreted it is essential to relate any changes/trends to its biological context, using data as support where possible.
Illustrate	Include diagrams/drawings/figures as much as possible.
List	A sequence of numbered points one below the other.
Name	Write the full name.
Outline	Give the main points.
State	A concise answer giving no reasons.
Suggest	Give hypotheses/ideas/thoughts on a subject not necessarily 'known' to the candidate.
What is meant by	A definition is usually required. The amount of information to be included is dictated by the mark value.
Using the data	Numerical answer required.

Appendix 3: Mathematical content for science subjects

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

Arithmetic and numerical computation

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

Handling data

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

Algebra

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

Graphs

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

APPENDIX 4

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Level 200..

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Safon Uwch 200..

AS BIOLOGY/HUMAN BIOLOGY
ASSESSMENT UNIT 3

B/H3

COVER SHEET
PRACTICAL ASSESSMENT 200..

Centre Name: _____ **Centre Number:** _____

Candidate's Name (in full): _____ **Candidate Number:** _____

Title of Investigation: _____

_____

This sheet should be attached to the practical work report, along with the microscope work (with candidate's name) at the back, *using toggle/treasury tag.*

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.
If you copy any work from someone else, allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

Declaration by Candidate:

I have read and understood the **Notice to Candidate** (above). I have produced the attached work under supervision in class and without assistance other than that which my teacher has explained is acceptable within the specification.

Candidate Signature: …….. **Date:** ……

Declaration by Teacher:

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate. I confirm that the candidate's practical work was carried out with due regard to safety and with skill and care.

Teacher's Signature: …… **Date:** ……

Results of experiment carried out by teacher plus comment (if appropriate).

_____

_____

_____

APPENDIX 5

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Level 200..

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Safon Uwch 200..

A2 BIOLOGY/HUMAN BIOLOGY
ASSESSMENT UNIT 6

B/H6

COVER SHEET
PRACTICAL ASSESSMENT 200..

Centre Name: _____ **Centre Number:** _____

Candidate's Name (in full): _____ **Candidate Number:** _____

Title of Investigation: _____

_____

This sheet should be attached to the practical work report, along with the microscope work (with candidate's name) at the back, *using toggle/treasury tag.*

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.
If you copy any work from someone else, allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

Declaration by Candidate:

I have read and understood the **Notice to Candidate** (above). I have produced the attached work under supervision in class and without assistance other than that which my teacher has explained is acceptable within the specification.

Candidate Signature: …….. **Date:** ……

Declaration by Teacher:

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate. I confirm that the candidate's practical work was carried out with due regard to safety and with skill and care.

Teacher's Signature: …… **Date:** ……

Results of experiment carried out by teacher plus comment (if appropriate).

_____

_____

_____

APPENDIX 6

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Level 200..

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Safon Uwch 200..

BIOLOGY/HUMAN BIOLOGY
Approval of Candidates Practical Work for use as Assessment

Candidate's Name (in full): ________________________________**Candidate Number:** ______

Centre Name: ____**Centre Number:** _________

Teacher's Name: ____**Unit:** _________________

Aim of proposed investigation:

……

……

Outline Plan of Investigation:

……

……

……

……

……

……

Before submission of this form, the planned investigation should be checked against the generic marking scheme in the specification, in order to ensure that the marking points may be accessed by this investigation.

This form should be sent to WJEC at the latest by 30 January of the year in which the investigation is to be submitted. The investigation should not be continued until approval is received by the centre.

- -

For Office Use:

Approved for submission / Not approved

Signed: ………………………………………………….. **Date:** …………………