GCE

in

Biology

S P E C I F I C A T I O N

For first teaching from Autumn 2002

CCEA Advanced Subsidiary GCE in Biology
for first examination in Summer 2003

CCEA Advanced GCE in Biology
for first examination in Summer 2004

Subject Code 1010

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FOREWORD

This booklet contains CCEA's Advanced Subsidiary (AS) and Advanced GCE Biology specification for first teaching from September 2002.

The AS is the first part of the full Advanced GCE course and will be assessed at a standard appropriate for candidates who have completed half of the full Advanced GCE course.

The full Advanced GCE comprises the AS and the second half of the Advanced GCE course referred to as A2. However, the AS can be taken as a "stand-alone" qualification without progression to A2.

The A2 will be assessed at a standard appropriate for candidates who have completed a full Advanced GCE course and will include an element of synoptic assessment.

The Advanced GCE award will be based on the aggregation of the marks from the AS (50%) and the A2 (50%).

Students with a CCEA qualification in this or other subjects will be well equipped for the challenges and opportunities of further and higher education and employment wherever they may study or work.

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Additional Copies of the Specification

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CONTENTS

KEY FEATURES

- free-standing AS course including a study of contemporary Biology;
- experimental and investigative skills assessed through externally-examined units and coursework;
- many opportunities for IT demonstrations and simulations;
- extensive opportunities for developing evidence for assessment of Key Skills.

SUMMARY OF EXAMINATION INFORMATION

Teaching and Learning Module	Assessment Unit (AU)	Nature of Assessment	Test Time	Percentage Weighting	Examination Availability
AS 1	1	External/ written test	1 hr	16.6	Winter, Summer
AS 2	2	External/ written test	1 hr	16.7	Winter, Summer
AS 3	3A	External/ written test	45 min	9.3	Winter, Summer
AS 3	3B	Internal practical assessment		7.4	Summer
A2 1	4	External/ written test	1 hr 30 min	16.7	Winter, Summer
A2 2	5	External/ written test	1 hr 30 min	16.7	Summer
A2 3	6A	External/ written test	1 hr	9.3	Summer
A2 3	6B	Internal/ practical coursework		7.4	Summer

1 INTRODUCTION

1.1 RATIONALE

This specification is designed to promote continuity, coherence and progression within the study of Biology. The AS builds on (but does not depend upon) the knowledge, understanding and skills developed within GCSE Science: Biology and Science: Double Award. The Advanced GCE specification incorporates the AS. The A2 section of the Advanced GCE builds upon the foundations of knowledge, understanding and skills developed within the AS and provides the basis for further study of Biology and related subjects.

This specification adheres to the 1999 Subject Criteria for AS and Advanced GCE Biology and has been designed to conform with the GCE Advanced Subsidiary and Advanced Level Examinations Qualification-Specific Criteria and Common Criteria established jointly by the regulatory authorities in England, Wales and Northern Ireland and published by the Qualifications and Curriculum Authority (QCA).

Biology is the study of living organisms which includes their structure, functioning, origin and evolution, classification, interrelationships and distribution.

The spiritual, moral, ethical, social and cultural issues which arise from this study can be met in certain parts of the specification:

1.6 Recombinant DNA Technology
2.3 Populations
4.2 Immunity
4.6 Communities
5.2 Reproductive Strategies

Awareness of environmental issues and health and safety considerations can be met in:

2.2 Ecological energetics
2.3 Populations
4.7 Nutrient cycling
4.8 Adverse affects of human activity in the environment

European developments in this regard can be met through questions using stimulus material to exemplify this context.

This specification has been designed to be as free as possible from ethnic, gender, religious, political or other forms of bias.

1.2 AIMS

Courses based on this specification should encourage students to:

(a) develop essential knowledge and understanding of concepts of biology, and the skills needed for the use of these in new and changing situations;

(b) develop an understanding of scientific methods;

(c) be aware of advances in technology, including information technology, relevant to biology;

(d) recognise both the value and responsible use of biology in society;

(e) sustain and develop their enjoyment of, and interest in, biology.

In addition, Advanced GCE specifications in biology should encourage students to:

(f) show knowledge and understanding of facts, principles and concepts from different areas of biology and to make and use connections between them.

1.3 ASSESSMENT OBJECTIVES

The assessment objectives provide an indication of the skills and abilities which the assessment units are designed to assess, together with the knowledge and understanding specified in the subject content. It is not always possible to make a clear distinction between these different elements in constructing examination questions and therefore a particular question may test more than one assessment objective.

Certain of the assessment objectives are common to the AS and the Advanced GCE. These are listed below:

AO1 Knowledge with understanding

Candidates should be able to:

(a) recognise, recall and show understanding of specific biological facts, terminology, principles, concepts and practical techniques;

(b) draw on existing knowledge to show understanding of the ethical, social, economic, environmental and technological implications and applications of biology;

(c) select, organise and present relevant information clearly and logically, using appropriate vocabulary where appropriate.

AO2 Application of knowledge and understanding, analysis, synthesis and evaluation

Candidates should be able to:

(a) describe, explain and interpret phenomena and effects in terms of biological principles and concepts, presenting arguments and ideas clearly and logically, using specialist vocabulary where appropriate;

(b) interpret and translate from one form into another, data presented as continuous prose, or in tables, diagrams, drawings and graphs;

(c) apply biological principles and concepts in solving problems in unfamiliar situations including those which relate to the ethical, social, economic and technological implications and applications of biology;

(d) assess the validity of biological information, experiments, inferences and statements.

AO3 Experiment and investigation

Candidates should be able to:

(a) devise and plan experimental and investigative activities, selecting appropriate techniques;

(b) demonstrate safe and skilful practical techniques;

(c) make observations and measurements with appropriate precision and record these methodically;

(d) interpret, explain, evaluate and communicate the results of their experimental and investigative activities clearly and logically using biological knowledge and understanding and using appropriate specialist vocabulary.

In addition, assessment objective AO4, applies only to the A2 part of the course.

AO4 Synthesis of knowledge, understanding and skills

Candidates should be able to:

(a) bring together principles and concepts from different areas of biology and apply them in a particular context, expressing ideas clearly and logically and using appropriate specialist vocabulary;

(b) use biological skills in contexts which bring together different areas of the subject.

The assessment objectives are to be weighted in AS; A2 and Advanced GCE as indicated.

	Assessment Objectives	AS Level	Weighting A2	Advanced GCE
AO1	Knowledge with understanding.	45–55%	15–25%	30–40%
AO2	Application of knowledge and understanding, analysis, synthesis and evaluation.	30–40%	15–25%	22.5–32.5%
AO3	Experiment and investigation.	15–29%	10–20%	12.5–20%
AO4	Aynthesis of knowledge, understanding and skills.	0%	40%	20%

1.4 SPECIFICATION STRUCTURE

The specification adopts a modular structure and candidates are required to study three teaching and learning modules for the AS course and six modules for the full Advanced GCE course. The modules are listed below:

AS Level	
Module 1:	Cell Biology
Module 2:	Physiology and Ecology
Module 3A:	Practical Processes
Module 3B:	Teacher-assessed coursework
A2 Level	
Module 4:	Co-ordination, Biochemistry and Environment
Module 5:	Reproduction, Genetics and Taxonomic Diversity
Module 6A:	Synoptic paper
Module 6B:	Teacher-assessed practical investigation

1.5 KEY SKILLS

The key skill of Communication will contribute to the assessment of this specification through the assessment of candidates' quality of written communication as detailed on page 8.

This specification provides opportunities for developing and generating evidence for assessing the following nationally specified key skills at the levels indicated:

- Communication – Level 3;
- Application of Number – Level 3;
- Information Technology – Level 3;
- Working with Others – Level 3;
- Improving Your Own Learning and Performance – Level 3;
- Problem Solving – Level 3;

The opportunities provided are referenced to the relevant key skills specifications and exemplified in Appendix 1 on page 46.

1.6 OVERLAP WITH OTHER QUALIFICATIONS

There are small amounts of overlap between this specification and GCE specifications in Chemistry, Physics and Advanced GNVQs in Science (full and Single Award compulsory units).

The overlap is insufficient to restrict the combination of any of these subjects with GCE Biology.

1.7 PROHIBITED COMBINATIONS

In any one series of examinations a candidate may not take examinations on this specification together with examinations on another specification of the same title and/or Human Biology, Social Biology.

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

The classification code for this specification is 1010.

2 SCHEME OF ASSESSMENT

2.1 THE RELATIONSHIP BETWEEN ASSESSMENT UNITS AND ASSESSMENT OBJECTIVES

The relationship between the assessment units and the assessment objectives is set out in Tables 1 and 2.

Table 1: AS Assessment Weightings

		Assessment Objectives				
Assessment Unit (AU)	**Nature of Assessment**	**AO1 %**	**AO2 %**	**AO3 %**	**AO4 %**	**Assessment Unit Weighting %**
1	External	21.5	11.8	0	0	33.3
2	External	21.5	11.8	0	0	33.3
3A	External	7.4	7.4	3.7	0	18.5
3B	Internal	0.0	0.0	14.8	0	14.8
	Totals	**50.4**	**31.0**	**18.5**	**0**	**100%**

Table 2: Advanced GCE Assessment Weightings

		Assessment Objectives				
Assessment Unit (AU)	**Nature of Assessment**	**AO1 %**	**AO2 %**	**AO3 %**	**AO4 %**	**Assessment Unit Weighting %**
1	External	10.7	5.9	–	–	16.7
2	External	10.7	5.9	–	–	16.7
3A	External	3.7	3.7	1.9	–	9.3
3B	Internal	–	–	7.4	–	7.4
4	External	8.3	8.3	–	–	16.7
5	External	4.2	4.2	–	8.3	16.7
6A	External	–	–	–	9.3	9.3
6B	Internal	–	–	5.0	2.4	7.4
	Totals	**37.6**	**28.1**	**14.3**	**20.0**	**100%**

2.2 NATURE OF ASSESSMENT UNITS

The assessment units which make up the AS and full Advanced GCE awards are described below:

Modules 1 and 2: Written papers (55 marks) lasting 1 hour

Section A (33 marks), about seven structured questions with a mark range of about 5–9.

Section B (12 marks), one question requiring answers in continuous prose.

Module 3A: Written paper (40 marks) lasting 45 min

This paper assesses the experience and understanding of candidates' practical work in both Units 1 and 2. There will be approximately five structured questions, including:

- A question on a practical procedure.
- An activity question, eg a drawing exercise or a question involving recognition of features in a photograph.
- A question testing understanding of the use of a piece of apparatus.
- A question testing graphical construction, including choice of appropriate graphical technique, and evaluation of the trends shown.
- A question testing understanding of the elements of planning in investigative work.

Module 3B (40 marks)

Teacher-assessed coursework covering a range of practical skills and abilities.

Modules 4 and 5: Written papers (75 marks) lasting 1½ hours

Section A (60 marks), about seven structured questions with a mark range of about 5–15.

Section B (15 marks), one question requiring an answer in continuous prose.

Module 6A: A synoptic paper lasting 1 hour (50 marks)

This requires candidates to make and use connections between different areas of biology, for example, by applying knowledge of a number of areas to a particular situation or context or by using knowledge and understanding of principles and concepts in planning experimental work and in the analysis and evaluation of data.

The paper will include opportunities for candidates to use ideas and skills which permeate biology, for example, the analysis and evaluation of empirical data and other information in contexts which may be new to them.

Section A (35 marks), about four structured questions, including the following themes.

- Analysis and evaluation of information supplied graphically.
- Testing statistical skills.
- Comprehension of a passage.

Section B (15 marks), one question requiring an answer in continuous prose.

Module 6B (40 marks)

This will be a teacher-assessed investigation carried out by the candidate. Candidates will be assessed on Planning, Implementing and Recording, and Analysis and Interpretation.

2.3 THE SEQUENCE, TIMING AND RE-SITTING OF ASSESSMENT UNITS

Assessment units will normally be taken in the following sequence.

Module 1, 2, 3A and 3B, followed by Modules 4, 5, 6A and B.

Candidates may sit the following assessment units in the winter examination sessions: Modules 1, 2 and 4.

Candidates may sit the following assessment units only in the summer examination session: Modules 3B, 5, 6A, 6B.

Assessment units may be re-sat once only. The better result will count towards the final award.

The results of individual assessment units, prior to certification of the qualification will have a shelf-life limited only by the shelf-life of the specification. Candidates may, however, retake the whole qualification more than once.

2.4 QUALITY OF WRITTEN COMMUNICATION

Assessment will take into account candidates' quality of written communication where they are required to respond in continuous prose. Quality of written communication is incorporated within the assessment objectives of the specification and refers to candidates' ability to:

- select and use a form and style of writing appropriate to purpose and to complex subject matter;

- organise relevant material clearly and coherently using specialist vocabulary where appropriate;

- ensure writing is legible, with accurate use of spelling, grammar and punctuation in order to make meaning clear.

Quality of written communication may be assessed within all assessment objectives and assessment units: except the teacher assessed components, 3B and 6B.

2.5 SYNOPTIC ASSESSMENT

The definition of synoptic assessment in the context of biology is as follows:

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. The emphasis of synoptic assessment is on understanding and application of the principles included in the specification.

Synoptic assessment should:

- require candidates to make and use connections between different areas of biology, for example, by applying knowledge of a number of areas to a particular situation or context or by using knowledge and understanding of principles and concepts in planning experimental work and in the analysis and evaluation of data;

- include opportunities for candidates to use ideas and skills which permeate biology, for example, the analysis and evaluation of empirical data and other information in contexts which may be new to them.

2.6 RECOMMENDED PRIOR LEARNING

This specification has been written to build upon the knowledge and understanding of Biology represented in GCSE Science: Double Award or GCSE Science: Biology or GNVQ Intermediate Science. Candidates should normally have achieved a Grade C at GCSE or its equivalent in GNVQ Intermediate Science, but this is not a requirement.

2.7 BACKGROUND KNOWLEDGE IN MATHEMATICS, STATISTICS AND OTHER SCIENCES

The units, conventions, nomenclature, symbols and notation used in the examination papers will be in accord with those given in SI Units, Signs, Symbols and Abbreviations published by the Association for Science Education.

In order to be able to develop the knowledge, understanding and skills in this specification, students need to have been taught and to have acquired competence in the areas of mathematics set out below. Material given in bold type is for Advanced GCE only.

Questions in which the principal interest is in the mathematical, statistical, physical or chemical processes will not be set, but some of the questions in the examination may require the use of this knowledge in answering biological problems.

Mathematical and Statistical Knowledge

- Use calculations involving simple arithmetic and algebraic transformations.
- Use expressions in decimal and standard form.
- Use ratios, fractions and percentages.
- Make estimates of the results of calculations (without using a calculator).
- Use calculators to find and use x^n, $1/x$ and $\sqrt{x}$.
- Handle integral positive and negative indices.
- Use an appropriate number of significant figures.
- **Understand the principles of sampling as applied to biological data.**
- **Understand the importance of chance when interpreting data.**
- Determine arithmetic means.
- **Understand the terms mean, median and mode.**
- **Determine population variance, standard deviation and standard deviation (error) of the mean.**
- **Fit confidence limits to means at a stated level of probability.**
- Construct and interpret frequency tables and diagrams, bar charts and histograms.
- Calculate rate of change from a graph showing a linear relationship.
- **Understand probability in order to understand how genetic ratios arise.**
- Use scatter diagrams to identify a correlation between two variables.
- **Frame null hypotheses.**
- **Test the significance of difference between means of two samples from normal distributions using Student's t.**
- **Use Chi^2 test for goodness of fit between observed and expected frequencies in one way classifications.**

Physical Knowledge

(a) Solids, liquids and gases.

(b) Density.

(c) Change of state: evaporation, cooling by evaporation; saturated vapour pressure and relative humidity.

(d) Relation between pressure, volume and temperature of a gas.

(e) Partial pressures of gases.

(f) Solubility of gases; effects of temperature and pressure on solubility.

(g) Diffusion of gases and solutes. Osmosis.

The following terms and symbols will be used in connection with osmosis and water relationships.

Solute (osmotic) potential, ψ_s: this term (always a negative quantity) will be used to describe that component of the water potential of a system which is due to solute particles.

Pressure potential, ψ_p: this term will be used to describe the contribution of mechanical pressure (a positive quantity) or tension (a negative quantity) to the water potential of a system.

Water potential of the ψ_{cell}, cell: this term will be used to describe the algebraic sum of the solute and pressure potentials associated with the cell.

$\psi_{cell} = \psi_s + \psi_p$

(h) Surface area to volume ratio.

(i) Temperature.

(j) Heat as a form of energy, transference of heat energy by conduction, convection and radiation.

(k) The electromagnetic spectrum. Colour in terms of wavelengths; filters, pigments.

(l) Basic principles of the compound optical microscope and electron microscope. Understanding of resolving power.

Chemical Knowledge

(a) In general, elements and compounds will be named according to current rules of the IUPAC, but familiar trivial names will be also given, where appropriate.

(b) Recognition of the chemical symbols for atoms and ions featured in the syllabus content. (Chemical formulae will **not** be required **except** where indicated.)

(c) pH scale as a measure of hydrogen ion concentration.

(d) Acids and bases.

(e) Exergonic and endergonic reactions.

(f) Isotopes as tracers.

(g) **Oxidation and reduction: significance of addition or removal of oxygen or hydrogen or electrons.**

2.8 PRACTICAL WORK

Candidates will be expected to have a personal experience of the practical procedures listed below. All practical work should be conducted in accordance with current recommendations relating to safety in the laboratory and in the field. The obtaining of specimens from field should only be done with due regard to safety and in accordance with legislation protecting wildlife and the specialist advice published by the various conservation agencies. No animal should be subjected to wounding or mutilation or to the deliberate infliction of disease of any kind or conditions likely to cause pain or distress.

(a) Accurate and critical observation of appropriate living and preserved specimens.

(b) The setting up and use of a light microscope to view slides of suitable tissues and cells up to ×400 magnification. Preparation and staining of temporary mounts of tissues. The use of eye piece and stage micrometer, haemocytometer.

(c) Qualitative biochemical tests including use of iodine solution, Benedict's reagent, clinistix, biuret reagent and bicarbonate indicator and paper chromatography.

(d) The use of a colorimeter, and probes/sensors for temperature, pH, light and oxygen.

(e) The setting up and use of a simple respirometer, J-tube apparatus and pulse meter.

(f) The setting up of simple Mendelian crosses using Drosophila.

(g) The use of sampling procedures and devices in ecological investigations.

Suitable practical tasks are listed at the end of the sub-sections within Section 3 of the specification.

The investigation A2 Module 6B should allow candidates to demonstrate that they can bring together principles and concepts from different areas and apply them in the unfamiliar context of a specific problem to develop a hypothesis. The use of biological skills to plan procedures and statistical analysis, will be used to test the hypothesis. A similar synthesis of knowledge, understanding and skills will be required to fully analyse, interpret and evaluate the outcomes of the implemented procedures.

2.9 CANDIDATES WITH PARTICULAR REQUIREMENTS

Details of arrangements for candidates with particular assessment requirements are provided in the *Joint Council for General Qualifications GCSE and GCE Regulations* and *Guidance for Candidates with Special Assessment Needs.*

2.10 AWARDS AND CERTIFICATION

Both the AS and the full Advanced GCE will be awarded on a five-grade scale: A, B, C, D and E. Candidates who fail to reach the minimum standard for a Grade E will be recorded as U (unclassified) and will not receive an AS or Advanced GCE certificate. The results of individual assessment units will be reported. This qualification will comply with the grading, awarding and certification requirements of the revised GCE Code of Practice for courses starting September 2000.

3 SUBJECT CONTENT

The subject content is organised into six teaching and learning modules. The content of these modules is set out below and for each module the major topics to be covered are listed in bold typeface, together with related guidance notes. The notes provide further detail of the content required.

The modules are set out in the normal sequence in which their associated assessment units would be taken. The AS modules are described first followed by the A2 modules which comprise the second half of the full Advanced GCE course. The content of each module should be read in conjunction with the relevant aims and assessment objectives set out in Section 1 of this specification.

Links between different parts of the specification have been identified where appropriate, and have been printed in italics.

MODULE 1: CELL BIOLOGY

1.1 Molecules

(a) Water and inorganic ions.

The importance of water as a solvent.

The roles of inorganic ions (potassium, calcium, magnesium, iron, hydrogen carbonate, nitrate, phosphate):

(i) as components of biologically important compounds (calcium pectate, chlorophyll, haemoglobin, ATP, nucleic acids, phospholipids);

(ii) in osmotic and buffering systems (details of the physical chemistry of buffering systems **not** required).

(b) The following organic compounds in relation to their occurrence and function.

Carbohydrates: disaccharides (maltose and sucrose) and polysaccharides as condensation products of monosaccharides (glucose and fructose, $C_6H_{12}O_6$); cellulose as a structural polymer of glucose; starch and glycogen as storage polymers of glucose; pentoses as components of nucleic acids and ATP.

Lipids as condensation products of glycerol and fatty acids; saturated and unsaturated fatty acids; phospholipids as components of membranes.

Proteins as condensation products of amino acids. Amino acids as small nitrogen containing molecules. Levels of protein organisation: the amino acid sequence as the primary structure of proteins; secondary structure of polypeptides (α – helix and β – pleated sheet); the folding of the polypeptide as the tertiary structure; the quaternary structure where the protein consists of more than one polypeptide.

The importance of overall shape in relation to function; fibrous (collagen) and globular (enzymes) proteins; conjugated proteins (glycoprotein and haemoglobin).

Nucleic acids as condensation products of nucleotides. The nucleotide as a condensation product of a pentose sugar, a nitrogenous base and inorganic phosphate. The helical structure of DNA in terms of two anti-parallel nucleic acid chains with specific base pairings. Comparison of DNA and RNA. The organic base sequence as the genetic code.

Practical work to include qualitative biochemical tests for starch, reducing and non-reducing sugars and proteins using iodine solution, Benedict's reagent, clinistix and Biuret reagent, as appropriate.

The chromatography of amino acids.

1.2 Enzymes

Enzymes: the protein nature of enzymes. The role of cofactors and coenzymes. The action of enzymes in terms of the formation of an enzyme-substrate complex (Lock and Key Theory, Induced fit hypothesis), and provision of an alternative reaction pathway resulting in lower activation energy; substrate specificity. The effects of temperature, pH and substrate concentration on enzyme activity.

Enzyme immobilisation (physically or chemically securing enzymes on or inside an insoluble support material such as fibres, gels or plastic beads) as a technique enabling cost-effective enzyme applications, as exemplified by diagnostic reagent strips as biosensors (eg albustix, clinistix).

Practical work to include experiments to investigate enzyme specificity, the effects of temperature, pH and enzyme concentration on enzyme activity using suitable enzymes; illustration of enzyme immobilisation; the use of a colorimeter to follow the course of a starch/amylase catalysed reaction; the use of a pH sensor with a catalysed reaction, such as urea/urease.

1.3 Cells

Ultrastructure of eukaryotic and prokaryotic cells: prokaryotic cells (eg bacteria) as those without nuclei, mitochondria or endoplasmic reticulum and possessing naked, circular DNA; eukaryotic cells as those with a membrane-bound nucleus, mitochondria, chromosomes (helical DNA with a protein coat) and capable of developing a mitotic spindle.

Eukaryotic ultrastructure to include: mitochondria (cristae and matrix); chloroplasts (thylakoids, grana, stroma, lipid droplets and starch grains); rough endoplasmic reticulum (a membrane system with attached ribosomes); ribosomes as sites of protein synthesis; Golgi apparatus; lysosomes; microtubules (centrioles and cell spindle); plasmodesmata as plant cell to cell junctions.

Nuclear components restricted to chromosomes (DNA and histones as constituents, but without detail of their configuration), enchromatin, heterochromatin, nucleolus (the location of the DNA which codes for ribosomal RNA), and the nuclear envelope as a perforated double membrane.

Membranes (the fluid mosaic model) as structures surrounding cells, and contributing to their internal structures. Passage of substances across membranes: diffusion, osmosis and the role of membrane carriers in facilitated diffusion and active transport; endocytosis and exocytosis; membrane permeability; the water potential of a cell as the algebraic sum of the solute and pressure potentials; measurement of the average water potential of cells in a plant tissue and the average solute potential of cells at incipient plasmolysis.

Comparison of plant and animal cell structure: plant cells bounded by an extracellular cellulose cell wall, possessing chloroplasts; animal cells as lacking chloroplasts and possessing centrioles.

The recognition of these cellular structures from photomicrographs (light microscope – LM – and/or electron microscope – TEM/SEM – as appropriate).

Specialisation of cells and their aggregation in tissues; amalgamation of tissues in organs.

Practical work to include the setting up and use of a light microscope to view slides of suitable tissues and cells. Candidates should be able to make accurate drawings of cells and block diagrams of tissues and should be able to use a suitable graticule to make measurements and understand the concept of scale in relation to their drawings.

The estimation of the average water potential of cells in a plant tissue using a weighing method; estimation of the average solute potential of cells at incipient plasmolysis.

1.4 DNA as the fundamental unit of continuity, promoting stability and change

Replication of DNA as a semi-conservative process involving the opening of the helix followed by the synthesis of complementary nucleic acid chains alongside the existing chains to form two identical helices.

Transcription as a process involving the unpairing of the bases in one region of the DNA helix followed by the synthesis of a strand of mRNA carrying a triplet code sequence complementary to the sense strand of DNA.

Translation as the “reading” of a triplet mRNA code at a ribosome during which tRNA molecules, carrying complementary anticodons, pair with mRNA codons bringing specific amino acids into position on ribosomal sites for condensation to form a polypeptide or protein. One gene/one polypeptide theory.

1.5 Continuity of cells

The cell cycle: division of a nucleus following replication of DNA at interphase; cytokinesis in animal and plant cells.

The process of mitosis and its significance in maintaining genetic constancy; the appearance and behaviour of chromosomes.

Practical work to include preparation and staining of root tip squashes to recognise and study stages in mitosis using a light microscope.

1.6 Recombinant DNA technology (genetic engineering)

Gene transfer: methods used to obtain donor DNA, eg use of restriction endonucleases and reverse transcriptase; incorporation of donor genes into a "vector", eg bacteriophages, and bacterial plasmids; transformation of recipient cells, eg Escherichia coli, Saccharomyces cerevisiae; selection of transformed cells for cloning.

An appreciation of the range of substances produced by engineered micro-organisms: insulin, human growth hormone (HGH), enzymes, adhesives, lung surfactant protein, interferon. (Details of production **not** required.)

Transgenic animals and plants (organisms into which one or more genes from another individual have been artificially inserted): the potential for transgenics in cost-effective production of useful substances and desirable traits (details of transgenic procedures **not** required); genes introduced in animals to improve growth rate, milk yield/quality, meat production/quality and for production of substances of medical value, eg interferon, blood clotting factors, alpha-1-antitrypsin, human serum albumin, haemoglobin, drugs; genes introduced in plants to improve crop yields, increase variety, prolong "shelf-life" by controlled ripening, increase protein content, improve texture, improve flavour and give cultivated plants increased resistance to pests, diseases, and unfavourable environmental conditions.

Gene therapy (replacing an absent or faulty gene with a correct gene, thereby restoring normal metabolism and eliminating a disease): the advantages and problems of somatic cell gene replacement therapy; gene therapy as a possible cure for single gene disorders, eg sickle-cell anaemia, cystic fibrosis, muscular dystrophy.

Safety precautions with genetically engineered organisms: an appreciation of why such precautions are necessary; precautions currently employed, eg use of bacterial strains ill-adapted to the human physiology, "suicide genes", containment mechanisms; the need for legislation.

MODULE 2: PHYSIOLOGY AND POPULATIONS

2.1 Transport and exchange mechanisms

(a) The principles of exchange and transport

The relationship between size and surface area to volume. Features of exchange surfaces which aid passive and active transport; methods of increasing surface area; thin separating surface; concentration gradients; as exemplified in root hairs, leaf, capillaries, erythrocytes, alveoli and villi. The principle of mass transport as exemplified by movement in xylem, translocation in phloem, circulation and ventilation in the mammal.

(b) Plants

The structure of the stem and root of a dicotyledonous plant, and the structure and function of component tissues: parenchyma, collenchyma, sclerenchyma, cambium, xylem, phloem, endodermis and root hairs; the paths of transport (apoplast and symplast). The uptake of water and mineral salts; their movement through xylem (cohesion-tension theory and root pressure hypothesis); the influence of external conditions and stomatal aperture on transpiration rates. (The mechanism of stomatal opening and closure **not** required.) Translocation of organic materials as an energy-requiring mass flow process in phloem tissue. Structural adaptations of xerophytes and hydrophytes.

Practical work to include preparation and staining of appropriate sections of stems. Candidates should be able to make accurate drawings of cells and block diagrams of tissues from their own or prepared slides of dicotyledonous stem and root sections.

Demonstrations and measurements of transpiration using a potometer; stomatal counts.

The leaf as the organ of photosynthesis: the structure of a mesophytic leaf; gas exchange; the distribution of chloroplasts. External factors limiting the rate of photosynthesis; compensation point. Absorption of light by chlorophyll and its associated pigments; absorption and action spectra.

Practical work to include observation of the cells and tissues of a mesophytic leaf. Candidates should be able to make accurate drawings of cells and block diagrams of tissues from a prepared slide.

The investigation of the effects of light intensity and carbon dioxide concentration on the rate of photosynthesis using an aldus apparatus or oxygen sensor; use of bicarbonate indicator to demonstrate a compensation point.
The chromatography of chloroplast pigments.

(c) Animals

(i) Circulatory systems:

The layout of the mammalian circulatory system; structure and functioning of the mammalian heart and its nervous control; the histological structure and function of arteries, veins and capillaries: squamous endothelium, smooth muscle, elastic and fibrous tissue.

Practical work to include the dissection of the thoracic cavity of a small mammal or the study of prepared specimens and photographs. The study of prepared slides of arteries, veins and capillaries. The microscopic examination of stained blood films and identification of cells.

Investigation of the effects of physical activity on pulse rates.

Composition and functions of mammalian body fluids; the microscopical identification of blood cells as erythrocytes, monocytes, lymphocytes and polymorphs (further classification of the latter **not** required); the role and major constituents of plasma; the mechanism of tissue fluid formation and reabsorption; the clotting of blood.

Haemoglobin, myoglobin and the carriage of oxygen; the effect of CO_2, temperature and altitude on dissociation curves.

(ii) Respiratory systems

Characteristics of gas exchange surfaces and the factors which affect the rate of exchange, the structure and functioning of the respiratory system of a mammal. Interpretation of spirometer traces.

Simple respirometry. Respiratory quotient (RQ): the measurement of RQ and its use in identifying respiratory substrates and in detecting anaerobic respiration.

Relationship between energy output and oxygen uptake in Man; oxygen debt as the additional oxygen required to further metabolise accumulated lactic acid and/or resynthesise depleted ATP.

Practical work to include the use of simple respirometers.

The use of simple apparatus to demonstrate variation of breathing rates with physical activity and quantitative comparisons of inspired and expired air using a J-tube apparatus.

The estimation of tidal volume, inspiratory reserve volume, expiratory reserve volume, vital capacity and oxygen debt from spirometer traces.

(iii) Digestive system

Gross structure of the human alimentary canal; histology of the ileum; absorption in the ileum (details of digestive enzymes **not** required).

Practical work to include the dissection of the digestive system of a small mammal or the study of prepared specimens and photographs.

The microscopic examination of stained sections of ileum.

2.2 Ecological energetics

Understand that energy flows through ecosystems and materials are recycled. Food chains and food webs, trophic levels; pyramids of numbers, biomass and energy (productivity) and their relative usefulness. The loss of matter and energy as they move through the trophic levels and the implications for agriculture: the extra energy cost of producing animal products.

2.3 Populations

Population dynamics: birth, death, immigration and emigration rates as contributors to change in population size; the S-shaped (sigmoidal) and J-shaped ("boom and bust") growth curves; opportunist (r-selected) and equilibrium (K-selected) species. (Population growth equations **not** required).

Interaction between organisms: mutualism; competition (intra and inter-specific); parasitism, predation and grazing. Treatment of these interactions limited to their general nature as they relate to energy sources, nutrition and available space as appropriate. The general principles underlying the biological control of competitors, predators (of both consumers and producers) and parasites which have harmful effects on agricultural productivity or health.

Population distribution influenced by ecological factors: climatic factors (temperature ranges, availability of water, light intensity, light quality and day length), edaphic factors (pH values, availability of macro and micro-nutrient elements, aeration of soils) and biotic factors (limits on populations imposed by competitors, predators and the accumulation of wastes). The ecological niche.

Practical work to include ecological methods: sampling procedures, random and belt transect; sampling devices, quadrats, pitfall traps, standard sweep techniques to estimate species abundance, density, percentage cover, and population size using simple mark/recapture techniques and haemocytometer for yeast populations. The application and limitations of the methods should be emphasised.

The study of the distribution of plants and animals in at least one habitat and the investigation of the influences of abiotic and biotic factors on them.

MODULE 4: CO-ORDINATION, BIOCHEMISTRY AND ECOSYSTEMS

4.1 Homeostasis

The concept of homeostasis and the components of homeostatic mechanisms; temperature regulation in homoiotherms (endotherms) and poikilotherms (ectotherms). The role of the hypothalamus in the control of body core temperature. The detection of external temperature change by skin receptors; involuntary activity (eg shivering) and voluntary activity (eg taking exercise, moving into shade). Adaptations of mammals to hot and cold climates.

Links: 2.1 (a)

The structure and function of the mammalian kidney to include an understanding of the principles of ultrafiltration and reabsorption.

Links: 1.3

The principles of endocrine control. The importance of endocrine balance and the concept of negative feedback as exemplified by the role of ADH in osmoregulation in mammals.

4.2 Immunity

The functioning of the human immune system: natural barriers to infection (eg skin, tears, acid and mucus); antigens as chemicals capable of provoking the production of specific, complementary antibodies; the antigen-antibody reaction in terms of the formation of a specific complex, leading to the destruction of the antigen by phagocytosis; antibody-mediated immunity (the role of B-lymphocytes, plasma cells, memory b-cells only; details of antibody structure and classification of antibody types **not** required) and cell-mediated immunity (the role of killer T-lymphocytes, helper T-lymphocytes and memory T-lymphocytes only); an outline comparison of active and passive immunity.

The importance of the antigenic characteristics of cells and tissues in transfusions and transplants. Immunosuppression and its consequences. Human blood antigens (limited to those of the ABO and rhesus systems) and the basis of blood group polymorphisms (ABO and rhesus only).

The structure, composition and replication of viruses as exemplified by a bacteriophage. Human Immuno-deficiency Virus (HIV) as the causative agent of AIDS; the destruction of T-helper cells by HIV, mutation of HIV as a problem for vaccine production; methods of avoiding contact with HIV.

Links: 1.3, 1.4, 1.5, 2.1 (b)

4.3 Co-ordination and control

(a) Plants

The role of phytochromes in the control of flowering in long-day and short-day plants.

The role of auxins, cytokinins and gibberellins in stem elongation; the role of auxins in phototropism.

(b) Animals

The gross structure of the mammalian eye and its functioning in normal vision: binocular vision; accommodation; rods and cones; convergence and summation in rods; dark adaptation; visual acuity provided by cones.

The generation and transmission of nerve impulses; "all or nothing" law, refractory period. (The ionic bases for neurone resting and action potentials **not** required). Synaptic transmission; the role of acetylcholine. The gross structure and function of the spinal cord and peripheral nerves; the reflex arc as a functional unit.

Mammalian voluntary muscle as an effector; the sliding filament theory of contraction only in terms of the interaction between actin and myosin filaments (the role of the other proteins **not** required).

Recognition and understanding of the structure and function of the mammalian nerve (myelinated axon and synapse, by LM and TEM), skeletal muscle and cardiac muscle (LM and TEM), smooth muscle (LM).

Practical work to include the study of prepared slides/photographs of mammalian eye, spinal cord, skeletal muscle, cardiac muscle and smooth muscle.

Links: 1.3

4.4 Respiration

The nature and function of ATP: adenine, ribose and phosphate as components of ATP; the ATP/ADP cycle coupling respiration with energy utilisation; the use of ATP in synthesis, mechanical work and active transport.

Glycolysis as a process common to aerobic and anaerobic respiration which occurs in the cytoplasm and involves the phosphorylation of glucose, its conversion to fructose bisphosphate which splits into two triose phosphate molecules for oxidation by NAD^+ to glycerate bisphosphate which provides the energy for the synthesis of ATP during its conversion to pyruvate (C_3); the relatively small net yield of ATP from glycolysis.

Anaerobic respiration in terms of glycolysis and further reactions which produce no more ATP but which regenerate the co-enzyme NAD^+ (ethanol and carbon dioxide production in plants and microorganisms; lactate production in animals).

Aerobic respiration in terms of glycolysis followed by further oxidation of pyruvate via the Krebs cycle in the mitochondrial matrix and by electron transport at the mitochondrial cristae.

Krebs cycle: the oxidative decarboxylation of pyruvate to produce NADH ($+H^+$) and an acetyl group (C_2) combined with co-enzyme A in which form it enters the Krebs cycle by reacting with a C_4 acid to produce a C_6 acid which undergoes oxidative decarboxylation in a series of reactions to produce the original C_4 acid plus NADH ($+H^+$), $FADH_2$ and ATP; the net yield of NADH ($+H^+$), $FADH_2$ and ATP from one molecule of pyruvate; the Krebs cycle as a focal point, linking carbohydrate, fat and protein metabolism.

The electron transport chain: NAD^+, flavoprotein, co-enzyme Q and the cytochromes as links in the chain at progressively lower energy levels; oxygen as the ultimate hydrogen acceptor; the points at which ATP is synthesised; the net yield of ATP for each pair of hydrogen atoms starting at NADH ($+H^+$) or reduced flavoprotein. The larger yield of ATP from aerobic than anaerobic respiration; the significance of anaerobic respiration in providing ATP without the use of oxygen.

Practical work to include experiments to illustrate this role of hydrogen acceptors using redox indicator (such as methylene blue or tetrazolium chloride).

Links: 1.1, 1.2, 1.3, 2.1 (b)

4.5 Photosynthesis

The chloroplast as the site of photosynthesis: light-dependent stage on the thylakoids; light-independent stage in the stroma.

The light-dependent stage of photosynthesis: photoactivation of photosystem I (PSI) and photosystem II (PSII) resulting in the passage of electrons from PSII to PSI (the Z-scheme) coupled with the production of ATP (photophosphorylation); the final acceptor of PSI electrons as $NADP^+$ (with H^+ from the dissociation of water) producing reduced NADP (NADPH); the replacement of PSII electrons from hydroxyl ions (OH^-) from the dissociation of water with the concomitant release of oxygen. (Cyclic photophosphorylation **not** required).

The light-independent stage of photosynthesis: CO_2 fixation and reduction in a C_3 plant in terms of reaction with ribulose bisphosphate (C_5) producing two molecules of glycerate phosphate (C_3) which is reduced by NADPH to a triose phosphate with the consumption of ATP. The recycling of 5/6 of the triose phosphate to regenerate ribulose bisphosphate; the utilisation of the remaining 1/6 in the synthesis of C_6 sugars and other compounds. (CAM and C_4 metabolism **not** required).

Practical work to include experiments to illustrate the role of hydrogen acceptors using redox indicator (such as DCPIP).

Links: 2.1 (a)

4.6 Communities

Communities based on localised interactions among autotrophic and heterotrophic populations; the concept of an ecosystem. Community development: the general features involved in colonisation (eg the role of pioneer species) and succession (primary and secondary). Biotic and climatic climaxes. Stability of complex communities compared with simple communities.

Links: 2.2, 2.3

4.7 Nutrient cycling

Carbon cycle: respiration, combustion and decomposition adding CO_2 to the atmospheric pool, and photosynthesis removing CO_2 from the atmospheric pool. Nitrogen cycle: the role of decomposers, nitrifying and N_2-fixation bacteria in provision of nitrogen in a utilisable form for plants; denitrification returning N_2 to the atmospheric pool.

Links: 2.2, 2.3

4.8 Adverse effects of human activity on the environment

Aspects of pollution to be considered: global warming, ozone depletion, acid rain, eutrophication, pesticides; typical effects of these on food chains/ environment and human health; possible remedies for these problems.

The causal factors and consequences of deforestation; management regimes to ensure sustainable production for conservation.

Links: 2.2, 2.3

MODULE 5: REPRODUCTION, GENETICS AND TAXONOMIC DIVERSITY

5.1 Meiosis

Chromosome number: haploidy and diploidy.

The process of meiosis (but excluding the names for the prophase stages) and its significance in producing haploid cells and genetic variation; independent assortment of chromosomes; recombination resulting from chiasma formation (crossing-over); the appearance and behaviour of chromosomes.

Practical work to include the study of prepared slides/photographs of the process of meiosis.

Links: 1.3, 1.4, 1.5

5.2 Reproductive strategies

The contribution of asexual and sexual reproduction to the continuity of life.

(a) The principles of asexual reproduction and its adaptive value.

Plant tissue culture/micropropagation as an extremely cost-effective method of producing large numbers of genetically identical offspring (clones) from parent plants. An outline of the method involved: selection of the explant and its sterilisation; transfer to a nutrient medium, transfer to a multiplication medium, and finally transfer to a rooting (storage) medium. An appreciation of the problems associated with micropropagation.

(b) The principles of sexual reproduction and its adaptive value in generating variation; fertilisation as an essential feature.

The use of artificial insemination, and an outline of embryo manipulation/ cloning and the use of embryo transplants in agriculture; the biological principles underlying in vitro fertilisation and the implantation of embryos as remedies for human infertility.

Links: 1.4, 1.5, 1.6

5.3 Genes and patterns

Autosomes, sex chromosomes and sex determination in mammals. The inheritance of traits showing discontinuous variation. Mendel's laws of inheritance: the law of segregation of factors; the law of independent assortment of factors. Alleles as alternative forms of the same gene; homozygotes and heterozygotes. Monohybrid and dihybrid inheritance. Genotype and phenotype; dominance and codominance; lethal allelic combinations. Multiple alleles. Sex linkage. Test crosses.

Effects of the environment in contributing to the phenotype.

Gene interaction including epistasis. The additive effects of genes (polygenes) in the inheritance of traits showing continuous variation.

Practical work should include one breeding experiment using Drosophila to demonstrate principles of inheritance and the analysis of experimental results for goodness of fit to expected ratios.

The study of a karyotype prepared from a print of human metaphase chromosomes.

Links: 1.4

5.4 Mechanism of change

Heterozygotes as important reservoirs of genetic variation. Mutation as a source of genetic variation. Gene mutation (limited to base deletions and substitutions) and chromosome mutation (aneuploidy and polyploidy); mutagenic agents. The significance of polyploidy in plant breeding.

The concept of the gene pool and population genetics: the application of the Hardy-Weinberg equation ($p^2 + 2pq + q^2 = 1$) to calculate allele and genotype frequencies in an outbreeding population. The Hardy-Weinberg principle and the influence of mutation, non-random fertilisation, migration and selection on allele and/or genotype frequencies.

Selection (stabilising and directional) and its contribution to the maintenance of polymorphic populations and evolutionary change in populations.

Geographic isolation leading to allopatric speciation; other secondary isolating mechanisms.

Links: 1.4, 2.3

5.5 Taxonomy

The concept of the species based on breeding compatibility and the production of fertile offspring. A hierarchical classification based on presumed phylogeny: organisms are named in a binary fashion consisting of genus and species; genera are organised into a hierarchy of higher taxa (family, order, class in ascending order); classes are arranged into phyla; phyla are classified into kingdoms. The five kingdom system of classification.

5.6 Kingdom Prokaryotae

Structure of prokaryotic cells. Reproduction by division. Example: a rod-shaped bacterium.

Links: 1.3, 1.6

5.7 Kingdom Protoctista

Eukaryotic, unicellular or showing limited differentiation; some are heterotrophs (eg Phylum Protozoa) while some are autotrophs (eg Phylum Chlorophyta).

Links: 1.3

5.8 Kingdom Fungi

The fungi as lysotrophs (decomposers) consisting of hyphae with chitinous cell walls and feeding by extracellular digestion. Example: a mould.

Links: 1.2, 1.3

5.9 Kingdom Plantae

The plants as autotrophs (producers) possessing chlorophyll in chloroplasts and a cellulose cell wall.

The divisions listed below should be studied to illustrate their differing levels of organisation and progression of life cycles.

Division Bryophyta

Multicellular plants showing distinct differentiation. Life cycle with an alternation of generations in which the haploid gametophyte is dominant. Example: a moss.

Form:

These are multicellular plants showing adaptations to terrestrial life (presence of rhizoids in the gametophyte, and cuticle and stomata in sporophyte capsules) and possessing leaf-like structures for photosynthesis. The rhizoids do not deeply penetrate the soils, and moss distribution is therefore, limited to areas with water and ions close to the surface of the soil. Support is by turgor within the cells. There is no vascular tissue to strengthen the structures.

Life cycle:

The leafy moss structure is the haploid gametophyte. The stalk and capsule represent the diploid sporophyte. The leafy haploid gametophyte bears eggs enclosed in an archegonium and sperm are produced in an antheridium. The sperm swim in a film of water to an archegonium to fertilise the egg. The fertilised egg develops into the sporophyte which stays attached to the gametophyte and which bears a capsule within which spores are formed by meiosis. Germination of the spores by mitosis produces new independent gametophytes which then produce gametes by mitosis.

Division Tracheophyta

Multicellular plants which are well differentiated and possessing a vascular system. Life cycle with an alternation of generations in which the diploid sporophyte is dominant, and in which the gametophyte is represented by a prothallus (pteridophytes) or by the contents of developing spores (spermatophytes). Examples: a fern (pteridophytes) and an angiosperm (spermatophytes).

Form:

These are multicellular plants showing differentiation into true roots, stem and leaves. They are well adapted to terrestrial life with a waterproof cuticle, fine control over stomata and efficient water and nutrient distribution systems. There are well developed systems for water and ion distribution (xylem) and for the distribution of organic nutrients (phloem). Support is by turgor within cells and by the woody xylem vessels and other strengthening elements of the vascular bundles.

Life cycle:

The plant is a diploid sporophyte. The gametophyte is very much reduced. The mature sporophyte develops sporangia which produce spores by meiosis. These spores produce a miniature gametophyte which produces gametes by mitosis. These fuse to form a diploid zygote. The zygote grows into a new sporophyte. In ferns the gametophyte is a prothallus which produces antheridia and archegonia. The sporophyte is dependent on the prothallus for a short time after fertilisation. In angiosperms (flowering plants) the male gametophyte is the germinating pollen grain which produces the male gamete nuclei by mitosis. The male gamete is delivered to the female gamete via a pollen tube. The female gametophyte is the embryo sac which produces the egg nucleus by mitosis. Both the male and female gametes are protected from desiccation.

Links: 1.3, 1.5, 2.2

5.10 Kingdom Animalia

The animals as heterotrophs capable of locomotion.

Phylum Cnidaria

Diploblastic animals showing little differentiation. Example: Hydra.
These are multicellular animals with two body layers (ectoderm and endoderm) separated by a non-cellular, jelly layer (mesogloea). All forms are radially symmetrical. The body is supported by the aqueous medium and there is also a hydrostatic skeleton formed by the fluid-filled enteron.

Feeding:

Prey is captured by the use of stinging cells (cnidocysts) and conveyed to the mouth by tentacles. There is a single opening to the sac-like gut. Initial digestion is by extracellular secretions but the final phases of digestion are intracellular (endocytosis).

Phylum Platyhelminthes

Triploblastic animals showing tissue differentiation but no body cavity. Example: a planarian.

There are three body layers (ectoderm, mesoderm, endoderm) but no body cavity (acoelomate). All forms are bilaterally symmetrical, possessing well differentiated organ systems (eg for digestion). There is no specialised skeletal system but the mesoderm (mesenchyme) helps to support the body.

Feeding:

Planarians are normally detritivores but there are a few active predators. There is a single opening to the gut (mouth). Nutrients are distributed by extensions of the gut throughout the body. There is an initial extracellular phase of digestion but it is completed intracellularly.

Phylum Annelida

Triploblastic animals with a body cavity (coelomate) and well developed tissue differentiation. Example: an earthworm.

There are three body layers (ectoderm, mesoderm and endoderm) with the mesoderm containing a body cavity (coelom) within which lies the well differentiated digestive and other systems. The body is bilaterally symmetrical, metamerically segmented and typically long and thin. A hydrostatic skeleton is formed from the segmental body cavities.

Feeding:

Earthworms are detritivores. The gut has both a mouth and an anus and shows regional specialisation. Digestion is extracellular and nutrients are distributed by a well developed circulatory system.

Phylum Chordata

Triploblastic, coelomate animals with an internal skeleton. Example: a small mammal.

There are three body layers (ectoderm, mesoderm and endoderm) with the mesoderm containing a body cavity within which lies the well differentiated digestive, reproductive, circulatory and excretory systems. Chordates are bilaterally symmetrical, segmented and have a post-anal tail. There is a stiff dorsal rod (notochord) or spinal column and segmental muscle blocks. The skeleton consists of an internal jointed system of calcified bones.

Feeding:

Mammals may be active predators, omnivores or herbivores. The gut has both a mouth and an anus and well developed specialised regions. Digestion is extracellular.

Practical work to include the study of appropriate living and preserved specimens, prepared slides and photographs of the organisms in 5.7 to 5.10 wherever possible.

Links: 1.3, 2.1 (b)

4 GRADE DESCRIPTIONS

The following grade descriptions indicate the level of attainment characteristic of the given grade at Advanced Level. They give a general indication of the required learning outcomes at each specific grade. The descriptions should be interpreted in relation to the specified subject content; 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 overall. Shortcomings in some aspects of the examination may be balanced by better performance in others.

Grade A

Candidates recall and consistently use biological knowledge, facts, principles and concepts from the whole specification with few significant omissions and show good understanding of the principles and concepts they use. They select biological knowledge relevant to most situations and present their ideas clearly and logically, making use of appropriate biological terminology, particularly when referring to specific technical terms and in expressing more general concepts and ideas.

Candidates carry out accurately a range of calculations in a logical manner with little guidance and, where appropriate, support their solutions by logical explanation. They demonstrate good understanding of principles and apply them in familiar and new contexts. They show insight into problems and suggest a number of possible solutions using techniques, arguments or knowledge and understanding from more than one area of the specification and other areas of their experience. Most responses are correct, relevant and logical. In particular, longer questions are answered to an appropriate depth, communicating ideas effectively with coherent and detailed explanations.

In experimental activities, candidates independently formulate a clear and accurate plan. They use a range of manipulative techniques safely and skilfully, making and recording observations with appropriate precision. They interpret and describe the trends and patterns shown by data presented in tabular or graphical form, indicating, where appropriate, anomalies and inconsistencies. They provide coherent, logical and comprehensive explanations using appropriate biological knowledge and terminology. They comment critically on data, evaluate it and use it to support or reject various hypotheses. They present clearly and concisely both sides of an argument by weighing up the evidence.

Grade C

Candidates recall and show a sound use of biological knowledge, facts, principles and concepts from many parts of the specification and show understanding of some fundamental principles and concepts. They frequently select biological knowledge relevant to a particular situation or context and present their ideas clearly and logically, making use of appropriate biological terminology.

Candidates carry out a range of calculations, making progress with minimal guidance. They show knowledge of fundamental principles and are often able to apply these in new contexts. They bring together information from more than one area of the specification. Many responses are correct, relevant and logical.

In experimental activities, candidates formulate a plan which may need some modification. They use a range of techniques safely, making and recording observations and measurements which are adequate for the task. They interpret and explain experimental results relating these to biological knowledge an understanding and, with help, evaluate their results. They comment on data and use selected data to support a particular hypothesis. They make choices in statistical sampling.

Grade E

Candidates recall and use biological knowledge, facts, principles and concepts from some parts of the specification and demonstrate some understanding of fundamental principles and concepts beyond that expected of sound GCSE candidates.

Candidates select discrete items of knowledge in response to structured questions and use basic biological terminology. This may be displayed consistently across the questions set or may vary between quite good and poor on different questions.

Candidates select appropriate facts and principles to solve problems concerning familiar material. Where problems are concerned with unfamiliar material, answers relate to the appropriate subject area even if difficulties are experienced in applying the facts and principles involved.

With some guidance, candidates carry out accurately straightforward calculations involving the rules of number, such as calculations of percentages, making clear the steps in the calculation. They apply knowledge and biological principles contained within the specification to material presented in a familiar or closely related context.

They make connections between some ideas encountered in different parts of the specification. Their answers show some logic and coherence although they may include irrelevant material. They use correctly a limited range of biological terminology.

In experimental activities, candidates formulate some elements of a practical approach when provided with guidance. They carry out frequently encountered practical procedures in a reasonably skilful manner, recognising the risks in familiar procedures and obtaining some appropriate results. They interpret broad trends shown by data presented in tabular or graphical form. They select appropriate facts and principles to produce limited but relevant explanations and make superficial conclusions from data. They may need assistance to relate these to biological knowledge and understanding.

5 GUIDANCE FOR TEACHERS ON INTERNAL ASSESSMENT AND EXTERNAL MODERATION

5.1 INTRODUCTION

The specification in Biology requires that the practical skills of all candidates are assessed by:

(i) the internal assessment of coursework; and

(ii) by supplementary questions on examination papers.

These notes for guidance relate to the internal assessment component which is to be conducted by the teacher using practical work arising from the teaching programme developed to cover the specification.

All practical work should be conducted in accordance with current regulations and recommendations relating to safety in the laboratory.

5.2 AS LEVEL ASSESSMENT

Each candidate must be able to apply a wide range of practical, intellectual and communication skills in the context of a practical exercise. It is assumed that a wide range of basic skills has been acquired at GCSE level. The coursework to be assessed at AS Level should therefore be technically and intellectually more demanding, requiring a higher level of technical expertise and intellectual ability.

Candidates will be expected to have experience of a range of practical work. Support material supplied by the Council will provide guidance for a list of practical skills and the depth of treatment required.

Two practical tasks must be assessed and made available for external moderation.

Teachers are free to devise their own practical work, within the limitations set out in the previous paragraphs. Centres must confirm with the Council that any assessments they propose, with related mark schemes, satisfy the requirements of this syllabus. It is realised that practical work set by an individual teacher will differ from that set by other teachers depending on the facilities and resources available. However, centres should be aware of the requirement for internal moderation and standardisation so that a consistent approach by teachers within individual centres is essential.

Candidates' work must be annotated in detail showing where mark descriptors for assessment criteria within each skill were satisfied.

Each candidate will be required to demonstrate ability in the following skill areas:

A Implementing

B Recording and Communicating

C Interpretation

D Evaluation of experimental design

At AS Level the ability to plan an investigation will be assessed only within the written practical paper.

Analysis will not require any statistical analysis beyond the calculation of means or other appropriate measure of central tendency.

Practical tasks should include the following actions, which must be accessible for assessment:

- **implementing** a sequence of instructions;
- **recording and communicating** in an appropriate form;
- **interpretation** of the results;
- **evaluation of the design** of the practical task.

Each of these actions should be marked following the criteria listed below.

A Implementing

The following points are needed to satisfy the mark scheme for the implementing of a practical task.

• Skilful handling of apparatus and materials.	1 mark
• Appropriate safety procedures and care of living organisms observed.	1 mark
• Organised and methodical carrying out of the practical procedure.	1 mark
• Adhering to the sequence of instructions.	1 mark
• Measurements at the level of accuracy required	1 mark
Total	**5 marks**

B Recording and Communicating

The following points are needed to satisfy the mark scheme for the **recording and communicating** in the form of a table.

- Organisation of the raw data, or where appropriate, accurate calculation of derived data. 1 mark
- Caption fully explains the contents of the table. 1 mark
- Logical construction of the table (organised for analysis). 1 mark
- Column headings explanatory 1 mark
- Units included 1 mark

Total **5 marks**

or

The following points are needed to satisfy the mark scheme for the **recording and communicating** in the form of a drawing.

- Scale included. 1 mark
- All structures clearly drawn (proportionality). 1 mark
- Clear lines. 1 mark
- Necessary labels included. 1 mark
- Difficult structures distinguished clearly. 1 mark

Total **5 marks**

or

The following points are needed to satisfy the mark scheme for the **recording and communicating** in the form of a graph.

- Organisation of the raw data, or where appropriate, accurate calculation of derived data. 1 mark
- Caption fully explains the data plotted. 1 mark
- Appropriate scale and labels for axes. 1 mark
- Values accurately plotted. 1 mark
- Appropriate bars/lines drawn. 1 mark

Total **5 marks**

C Interpretation

The following points are needed to satisfy the mark scheme for the interpretation of the results.

- Written communication of the data. 1 mark
- Trend(s) clearly identified. 1 mark
- Explanation of the trend(s). 1 mark
- Using appropriate biological knowledge and understanding. 1 mark
- Biological significance of the observed trend(s). 1 mark

Total **5 marks**

D Evaluation Of Experimental Design

The following points are needed to satisfy the mark scheme for evaluation of the design of the practical task.

- Comment on the appropriateness of the observations/measurements. 1 mark
- The procedures used to prevent variation of factors not under investigation. 1 mark
- Assess the variation shown within the replicates. 1 mark
- Comment on the reliability of the observations/measurements. 1 mark
- Suggest a further line(s) of investigation using biological knowledge and understanding. 1 mark

Total **5 marks**

5.3 ADVANCED GCE ASSESSMENT

The problem solving/investigational skills of each candidate will be demonstrated by means of a practical investigation, planned, implemented, analysed and interpreted by the candidate working independently with minimal guidance. This investigation should be centred around the testing of a simple scientific hypothesis derived from the candidate's own biological knowledge or research.

Each candidate is to be assessed on one occasion in each of the following skill areas:

A Planning

B Implementing and Recording

C Analysis and Interpretation

The assessment of all three skill areas must be made in the context of a complete investigation.

The major features of each of the skill areas are as follows:

Planning

Planning is an activity which is to be carried out in response to a problem set by the teacher or one suggested by the candidate. This should take place in preparation for a practical. Each candidate should work individually, under supervision, to present a written plan in continuous prose (though with the experimental design perhaps shown as a flow diagram) to the teacher.

Inappropriate plans should not be implemented but, with resulting mark loss for skill area A, could be improved with teacher assistance and subsequently implemented.

Implementing and Recording

Candidates should not be expected to carry out practical tasks unless they have previously had adequate opportunity to learn the specific skills required. They should not, however, have a practice run at a particular exercise to be assessed. Each candidate should have details of what is to be done, either in the form of instructions originating from the teacher or in the form of plans drawn up by the candidate and previously assessed. Assessment of the skill of implementing necessarily entails observation of each candidate individually at work. Teachers must therefore he prepared to subdivide their classes for assessment purposes if necessary, and to annotate each candidate's work as appropriate.

Analysis and Interpretation

These activities are a conclusion to an individual practical enquiry carried out by the candidate. This skill area must involve statistical work, either in the calculation and plotting of means and confidence limits (graphical analysis), or in a t-test or Chi^2 test, used appropriately. It may be necessary to pool class results for the purposes of statistical analysis. It is important, however, to ensure that each candidate works individually, under supervision, to carry out the analysis and interpretation.

Practical investigations should include the following actions, which must be accessible for assessment:

Skill Area	Skill Area	Marks
A1	Developing a hypothesis using biological knowledge.	5
A2	Planning a procedure to test the hypothesis.	5
A3	Planning for analysis.	5
B1	Implementing a procedure.	5
B2	Recording and communicating in the form of a table.	5
C1	Statistical analysis.	5
C2	Interpretation of the results.	5
C3	Evaluation of the practical procedures.	5
		Maximum 40

A1 Develop a hypothesis

The following points are needed to satisfy the mark scheme for developing a hypothesis.

- What you understand to be the nature of the problem. 1 mark
- Outline the biological basis of the problem. 1 mark
- Link your ideas together to suggest an explanation. 1 mark
- State precisely in a hypothesis the most appropriate explanation. 1 mark
- Predict the result of a test of the hypothesis to indicate clearly the direction of the link. 1 mark

Total **5 marks**

A2 Plan a procedure

The following points are needed to satisfy the mark scheme for a plan of the procedure.

- Using suitable equipment and materials. 1 mark
- Select a suitable range for the independent variable or suggest conditions for the experimental treatment. 1 mark
- Communicating an ordered sequence to follow procedure. 1 mark
- Which provides a fair test. 1 mark
- Clearly stating what must be recorded. 1 mark

Total **5 marks**

A3 Planning for analysis

The following points are needed to satisfy the mark scheme for a plan for analysis.

- State the level of accuracy required or appropriate units of measurement. 1 mark
- The format to be used to present the results. 1 mark
- Decide which method of analysis will be most appropriate. 1 mark
- Decide how much replication is required for successful analysis. 1 mark
- Consider the feasibility of replication considering the time and materials available. 1 mark

Total **5 marks**

B1 Implementing

The following points are needed to satisfy the mark scheme for the implementing of a practical task.

• Skilfull handling of apparatus and materials.	1 mark
• Appropriate safety procedures and care of living organisms observed.	1 mark
• Organised and methodical carrying out of the practical procedure.	1 mark
• Adhering to the sequence of planned actions and making modifications as appropriate.	1 mark
• Measurements at the level of accuracy required.	1 mark
Total	**5 marks**

B2 Recording and communicating

The following points are needed to satisfy the mark scheme for the recording and communicating in the form of a table.

• Organisation of the raw data, or where appropriate, accurate calculation of derived data.	1 mark
• Caption fully explains the contents of the table.	1 mark
• Logical construction of the table (organised for analysis).	1 mark
• Column headings explanatory.	1 mark
• Units included.	1 mark
Total	**5 marks**

C1 Analysis

The following points are needed to satisfy the mark scheme for the **statistical analysis** of the results.

- Table of statistical parameters. 1 mark
- State an appropriate null hypothesis. 1 mark
- Accurate calculation of statistic. 1 mark
- Correct determination of probability value. 1 mark
- Correct decision regarding the null hypothesis. 1 mark

Total **5 marks**

or

The following points are needed to satisfy the mark scheme for the **graphical analysis** of the results.

- Table of statistical parameters. 1 mark
- Including accurate calculation of confidence limits. 1 mark
- Caption fully explains the data plotted. 1 mark
- Appropriate scale and labels for axes. 1 mark
- Correct plotting of means and confidence limits. 1 mark

Total **5 marks**

C2 Interpretation

The following points are needed to satisfy the mark scheme for the **interpretation** of the results.

- Assessment of the reliability of the data. 1 mark
- Comment about the reliability of the data. 1 mark
- Trend(s) clearly identified using statistical evidence. 1 mark
- Explanation of the trend(s). 1 mark
- Using appropriate biological knowledge and understanding 1 mark

Total **5 marks**

C3 Evaluation of the practical procedures

The following points are needed to satisfy the mark scheme for **evaluation of the practical procedures** of the practical task.

- Comment on the appropriateness of the range of the independent variable or the conditions for the experimental treatment. 1 mark
- The procedures used to prevent variation of factors not under investigation. 1 mark
- Comment on the appropriateness of the observations/measurement. 1 mark
- Assess the validity of the implementation of the procedure. 1 mark
- Suggest another independent variable which could be investigated. 1 mark

Total **5 marks**

5.4 CONDUCT OF THE ASSESSMENTS

The assessments should take place within the context of topics being taught. The stage at which a particular category of practical work is assessed will depend on various factors such as the order of teaching of topics and the availability of resources. The teacher is therefore expected to apply professional judgement in this matter.

Candidates should be made aware at the beginning of the course that their class practical work will be assessed for examination purposes. They should also be informed when a particular skill area is being assessed and should understand the criteria being used.

The teacher must exercise control and supervision of all assessed coursework to ensure that the work assessed is that of the individual candidate concerned. Work done at home should **not** be used for assessment purposes.

Candidates' records of the complete practical investigation involving teacher assessment must be available for moderation.

Each piece of assessed coursework must be annotated to show how marks have been awarded in relation to the relevant criteria.

5.5 RECORDING ASSESSMENTS

Teachers will be required to complete an individual record sheet for each candidate and a final mark sheet for all candidates in the centre. These forms will be supplied by the Council.

5.6 MODERATION OF ASSESSMENTS

Centres will be required to submit selected samples of candidates' coursework to the Council for moderation. Samples from each centre, selected according to criteria supplied annually by Council, will be required initially. The Council may, if necessary, require all candidates' work from a centre to be submitted during the moderation process. It is assumed that, prior to moderation, centres will ensure that a process of internal standardisation has been carried out.

6 RESOURCE LIST

The following list is an indication of books and other resources which teachers and students may find useful in teaching and studying a course based on this specification. It is not intended to be a list of prescribed texts, nor is it intended to be an exhaustive list of all available resources.

Author	Title	Publisher
Burnet, L	*Essential Genetics – a course book*	Cambridge University Press 1986
Burnet, L	*Exercises in Applied Genetics*	Cambridge University Press 1986
Campbell, N A	*Biology*	The Benjamin/Cumming Publishing Company 1996
Carter, D C, Gosden, M S, Orton, A, Wain, G T and Wood-Robinson C	*Mathematics in Biology*	Thomas Nelson and Sons Limited 1981
Clegg, C J and Mackean, D G	*Advanced Biology: Principles and Applications*	John Murray 1994
Cornwell, A and Miller, R	*A-Level Biology. Exam Practice Kit*	Longman 1997
Cremona, J	*A Field Atlas of the Seashore*	Cambridge University Press 1988
Freeland, P W	*Problems in Practical Advanced Level Biology*	Hodder and Stoughton 1985
Freeland, P	*Microorganisms in Action*	Hodder and Stoughton 1991
Green, N, Stout, W and Taylor, D	*Biological Science 1 and 2*	Cambridge University Press 1994
Hayward, G	*Applied Genetics. University of Bath Macmillan Science*	Macmillan Education 1990
Hayward, G	*Applied Ecology. University of Bath Science 16–19.*	Nelson 1992
Jones, M Reed, R and Weyers, J	*Practical Skills in Biology*	Longman 1999
Jones, M	*Transport, Regulation and Control. Cambridge Modular Sciences*	Cambridge University Press 1995
Jones, M and Gregory, J	*Central Concepts in Biology. Cambridge Modular Sciences.*	Cambridge University Press 1996

Author	Title	Publisher
King, T J	*Ecology*	Nelson 1980
Pickering, W R	*Advanced Biology. Revision Handbook.*	Oxford University Press 1996
Reiss, M J and Chapman, J L	*Ecology and Conservation. Cambridge Modular Sciences.*	Cambridge University Press 1994
Roberts, M B V	*Biology. A Functional Approach.*	Nelson
Roberts, M B V	*Biology. A Functional Approach. Student's Manual.*	Nelson
Rowland, M	*Biology. University of Bath Science. 16–19*	Nelson 1992
Taylor, D	*Growth, Development and Reproduction. Cambridge Modular Sciences.*	Cambridge University Press 1996
Taylor, D and Jones, M	*Foundation Biology. Cambridge Modular Sciences*	Cambridge University Press 1994
Taylor, J	*Microorganisms and Biotechnology. University of Bath Science 16–19 Project.*	Macmillan 1990

Internet Resources

Addison Wesley Longman on-line catalogue	http://www.awl-he.com/
Biologist's Guide to Internet Resources	http://www.csc.fi/molbio/unapost.index.html
Databases covering genetic and chemical information	http://www.ebi.ac.uk/flybase
Natural History Museum (UK)	http://www.nhm.ac.uk
New Scientist	http://www.newscientist.com
Scientific American	http://www.sciam.com
The Smithsonian (USA)	http://www.si.edu
The World Wide Web Virtual Library (Biosciences)	http://www.golgiharvard.edu/biopages.html

APPENDIX 1: OPPORTUNITIES FOR DEVELOPING AND GENERATING EVIDENCE FOR ASSESSING KEY SKILLS

The following table signposts and exemplifies the types of opportunity for developing and generating evidence for assessing key skills that may arise during an AS/Advanced GCE course in Biology. The opportunities are referenced to Section B of the relevant key skills specifications at Level 3. The subject exemplifications illustrate typical opportunities which may arise during the normal teaching and learning process. These are only a small selection of such opportunities and are not part of the key skills specifications themselves. It is for teachers and students to decide which pieces of work, if any, to use to develop and assess key skills.

KEY SKILLS

Communication

In this the student must demonstrate that they can:

- take part in discussions;
- make a presentation;
- select and synthesise information;
- write about complex subjects.

Application of number

In this the student must demonstrate that they can:

- plan an activity and interpret information from different sources;
- carry out multi-stage calculations;
- present findings, explore results and justify choice of method.

Information Technology

In this the student must demonstrate that they can:

- compare and use different sources to find information and make selections;
- explore, develop and exchange information, and derive new information;
- present information, including text, numbers and images.

Working with others

In this the student must demonstrate that they can:

- plan work, agreeing objectives, responsibilities and working arrangements;
- seek to establish and maintain cooperative working relationships;
- review work and agree ways of improving future collaborative work.

Improving own learning and performance

In this the student must demonstrate that they can:

- agree targets and plan how these will be met;
- use your plan, seeking feedback and support from others, to help meet targets;
- review your progress and establish evidence of your achievements.

Problem solving

In this the student must demonstrate that they can:

- explore problems, compare different ways of solving them and select options;
- plan and implement options;
- apply agreed methods for checking problems have been solved and review approaches to tackling problems.

Key Skill: Communication

Key Skills Specification Part B Reference		Subject Exemplification
Activity	**Evidence**	
C3.1a Contribute to group discussion about a complex subject.	• make clear and relevant contributions in a way that suits your purpose and situation; • listen and respond sensitively to others and develop points and ideas; and • create opportunities for others to contribute when appropriate.	Discussion of topics such as pollution, both global and local, (4.8), deforestation (4.8). Remedies for human infertility (5.2).
C3.1b Make a presentation about a complex subject using at least **one** image to illustrate complex points.	• speak clearly and adapt your style of presentation to suit your purpose, subject, audience and situation; • structure what you say so that the sequence of information and ideas may be easily followed; and • use a range of techniques to engage the audience, including effective use of images.	The ethical considerations of recombinant DNA technology in areas of transgenic animals and plants (1.6), cell ultrastructure (1.3), IVF treatment (5.2).
C3.2 Read and synthesise information from **two** extended documents about a complex subject. One of these documents should include at least **one** image.	• select and read the material that contains the information you need; • identify accurately, and compare the lines of reasoning and main points from texts and images; and • synthesise the key information in a form that is relevant to your purpose.	Prepared notes on any topic will have more than one source. Textbooks, journals such as the Biological Review, CD-ROMs could all contribute to the gathering of information.

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
C3.3 Write **two** different types of documents about a complex subject. One of these documents should include at least **one** image.	• select and use a form and style of writing that is appropriate to your purpose and complex subject matter; • organise relevant information clearly and coherently using specialist vocabulary when appropriate; and • ensure your text is legible and your spelling and punctuation are accurate, so your meeting is clear.	Preparation for extended prose answers in content examination papers. The interpretation of the analysis of an investigation.

Key Skill: Application of Number

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
N3.1 Plan and interpret information from **two** different types of sources, including a large data set.	• plan how to obtain and use the information required to meet the purpose of your activity; • obtain the relevant information; and • choose appropriate methods for obtaining the results you need and justify your choice.	Planning for analysis in coursework as well as strategies for collating data from practical tasks. The use of secondary data in areas such as genetics and ecology.
N3.2 Carry out multi-stage calculations to do with: (a) amounts and sizes; (b) scales and proportions; (c) handling statistics; (d) rearranging and using formulae. You should work with a large data set on at least one occasion.	• carry out calculations to appropriate levels of accuracy, clearly showing your methods; • check methods and results to help ensure errors are found and corrected.	All investigations must include statistical analysis. Coursework will always involve calculations which summarise or transform raw data. Further examples include Rf values, use of graticules, measurements from spirometer tracks, use of calibration curves for colorimeters.
N3.3 Interpret results of your calculations, present your findings and justify your methods. You must use at least **one** graph, **one** chart and **one** diagram.	• select appropriate methods of presentation and justify your choice; • present your findings effectively; and • explain how the results of your calculations relate to the purpose of your activity.	The various tasks suggested for practical exercises involve a range of ways of presenting information for analysis and interpretation.

Key Skill: Application of Number

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
IT3.1 Plan, and use different sources to search for, and select, information required for two different purposes.	• plan how to obtain and use the information required to meet the purpose of your activity; • choose appropriate sources and techniques for finding information and carry out effective searches; and • make selections based on judgements of relevance and quality.	Many topics, such as pollution, biotechnology and reproduction are comprehensively covered in CD-ROMs such as Encarta. Some web-sites provide statistics for these topics.
IT3.2 Explore, develop and exchange information and derive new information to meet two different purposes.	• enter and bring together information in a consistent form, using automated routines where appropriate; • create and use appropriate structures and procedures to explore and develop information and derive new information; and • use effective methods of exchanging information to support your purpose.	Simulations of various biological processes provide data, which can be integrated in notes or used to provide secondary information for analysis and interpretation. Examples: photosynthesis, predator/prey cycles, genetic crosses.
IT3.3 Present information from different sources for **two** different purposes and audiences. Your work must include at least **one** example of text, **one** example of images **one** example of numbers.	• develop the structure and content of your presentation using the views of others, where appropriate, to guide refinements; • present information effectively, using a format and style that suit your purpose and audience; and • ensure your work is accurate and makes sense.	Coursework data can be collated in a spreadsheet for graphical and statistical analysis. Secondary data from databases or simulations can be used in a spreadsheet format. Notes on topics, such as plant tissues or the life cycles can incorporate images from databases within text.

Key Skill: Application of Number

Key Skills Specification Part B Reference		Subject Exemplification
Activity	**Evidence**	
WO3.1 Plan complex work with others, agreeing objectives, responsibilities and working arrangements.	• agree realistic objectives for working together and what needs to be done to achieve them; • exchange information, based on appropriate evidence, to help agree responsibilities; and • agree suitable working arrangements with those involved.	Students could be asked to work on an information research and presentation task working as a group of three or four. For example, collaborative collection of data along a transect. The subsequent selection and presentation of the distribution of individual species and abiotic factors. with a view to making a presentation to the class in order to educate other students about that part of the specification. They may also be asked to produce and present to each member of class a set of notes to support the teacher in the provision of materials. 1.3 cell ultrastructure 1.6 various aspects of recombinant DNA technology 2.1 (b)(i) structure and functioning of the mammalian heart 2.2 biological control 4.2 antigenic characteristics of cells and tissues in transfusions and transplants 4.8 adverse effects of human activity on the environment 5.2 (b) remedies for human infertility 5.4 selection and evolutionary change in populations. To do this students would need a detailed task specification from the teacher and would then meet, discuss and record the objectives of the task, the responsibilities of each member of the group and the actions and resources needed to achieve those objectives. They would also have to agree and record where the work would be done and produce a schedule of working arrangements for the group.

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
WO3.2 Seek to establish and maintain cooperative working relationships over an extended period of time, agreeing changes to achieve agreed objectives.	• organise and carry out tasks so you can be effective and efficient in meeting your responsibilities and produce the quality of work required; • seek to establish and maintain cooperative working relationships, agreeing ways to overcome any difficulties; and • exchange accurate information on progress of work, agreeing changes where necessary to achieve objectives.	Having agreed and shared out the responsibilities associated with the task, individual students should carry out their part of the work in a thorough manner, gathering and recording information in a way which will make it easily understandable but sufficiently detailed to be of value as part of the learning and examination process. Students should meet during the information gathering period to review progress and agree ways to overcome difficulties. Records of such meetings should be kept as evidence that the students have been working together. These records may be on pro forma which should relate progress to previously agreed action plans and objectives.
WO3.3 Review work with others and agree ways of improving collaborative work in the future.	• agree the extent to which work with others had been successful and the objectives have been met; • identify factors that have influenced the outcome; and • agree ways of improving work with others in the future.	Students may meet with the teacher to review the activity against the objectives and to suggest alternative approaches which may be more successful. After the presentation to the class group students may receive and record feedback from the class group about how things could have been done differently to enhance the collaborative dimension of the work.

Key Skill: Improving own Learning and Performance

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
LP3.1 Agree targets and plan how these will be met over an extended period of time, using support from appropriate people.	• seek information on ways to achieve what you want to do, and identify factors that might affect your plans; • use this information to agree realistic targets with appropriate people; and • plan how you will effectively manage your time and use of support to meet targets, including alternative action for overcoming possible difficulties.	Set targets to improve note-taking skills and analysis of question demands (all modules). Summarise the subject content of the specification in flow chart form and check level of detail with your teacher, eg 1.4 transcription and translation of the genetic code 2.1 (c)(i) composition and function of mammalian body fluids 4.4 glycolysis 4.5 Z-scheme
LP3.2 Take responsibility for your learning by using your plan, and seeking feedback and support from relevant sources, to help meet targets. Improve your performance by: • studying a complex subject; • learning through a complex practical activity; • further study or practical activity that involves independent learning.	• prioritise action and manage your time effectively to complete tasks, revising your plan as necessary; • seek and actively use feedback and support from relevant sources to help you meet targets; and • select and use different ways of learning to improve your performance, adapting approaches to meet new demands.	Examine questions from past papers and discuss with your teacher your interpretation of what is being demanded. Check these against published mark schemes.

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
LP3.3 Review progress on two occasions and establish evidence of achievements, including how you have used learning from other tasks to meet new demands.	• provide information on the quality of your learning and performance, including factors that have affected the outcome; • identify targets you have met, seeking information from relevant sources to establish evidence of your achievements; and • exchange views with appropriate people to agree ways to further improve your performance.	Review progress by means of feedback from the teacher and your ability to produce flow charts, unaided, relating to subject content, eg analysis, interpretation and evaluation of practical tasks.

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
PS3.1 Explore a complex problem, come up with three options for solving it and justify the option selected for taking forward.	• explore the problem, accurately analysing its features, and agree with others on how to show success in solving it; • select and use a variety of methods to come up with different ways of tackling the problem; and • compare the main features of each possible option, including risk factors, and justify the option you select to take forward.	Devise a plan to find out the influence of an abiotic/edaphic factor on the distribution of a plant/animal species. Record the presence/absence of the species in sample quadrats where the factor has high/low incidence; • estimate the population abundance and a value for the factor within random sample quadrats; • record the factor and population abundance along a belt transect. Difficulties discussed may include the following: • the estimation of high/low incidence of the factor; • a scatter diagram of population size against estimates of the abiotic/edaphic factor may not show a correlation unless a large number of samples are used; • transect data provides rapidly gathered preliminary data easily displayed as line graphs.
PS3.2 Plan and implement at least one option for solving the problem, review progress and revise your approach as necessary.	• plan how to carry out your chosen option and obtain agreement to go ahead from an appropriate person; • implement your plan, effectively using support and feedback from others; and • review progress towards solving the problem and revise your approach as necessary.	For example, a belt transect of a grassland slope recording soil moisture and the incidence of moss/rushes.

Key Skills Specification Part B Reference		**Subject Exemplification**
Activity	**Evidence**	
PS3.3 Apply agreed methods to check if the problem has been solved, describe the results and review your approach to problem solving.	• agree, with an appropriate person, methods to check if the problem has been solved; • apply these methods accurately, draw conclusions and fully describe the results; and • review your approach to problem solving, including whether alternative methods and options might have proved more effective.	Interpret the graphical presentation of the transect data and observations during the practical procedure. Review the trends to find out the following: • if further information needs to be collected; • if other factors including biotic may be important. (A similar approach could be taken to estimating the size of a laboratory population such as yeast. Procedures investigated might include using the following: • a haemocytometer; • a colorimeter; • dilution plating).

APPENDIX 2: GLOSSARY OF TERMS USED IN WRITTEN EXAMINATIONS

This glossary has been produced by the GCE Biology (A/AS) examining and revising teams to help candidates understand what is required of them when a particular instructional or descriptive term is used in an examination question. The glossary includes commonly used terms and phrases, but is not intended to be exhaustive.

Candidates are reminded of the necessity to study carefully each question as a whole to ascertain exactly the requirements of that question. It is also important to note that mark allocations often give an additional indication of the amount of detail expected in an answer.

The terms below are presented in alphabetical order. Many of the examples given are extracts from questions which have been set in past CCEA Biology examinations at Advanced Level.

Account

Continuous prose is required in an account.

Example: Give an account of the ways in which point mutations contribute to variation.

In an **illustrated account**, diagrams should be used to supplement the prose account.

Example: Give an illustrated account of meiosis.

Calculate

Show all the stages involved in solving a numerical problem and state the answer prominently, with correct units as appropriate.

Example: Calculate the actual length of the mitochondrion in micrometres (mm). Show your working.

Comment on

Point out noteworthy features of a structure, process or set of results giving brief explanation(s) as appropriate.

Example: Comment on the changes in distribution of the plant species present along the transect.

Compare

State the similarities and/or differences, as appropriate, between two or more items.

Example: Compare the gas exchange surfaces in a typical leaf with those of a mammal.

Contrast

State the difference(s) between two or more items.

Example: Contrast the actions of the nervous and endocrine systems in mammals.

Compare and contrast

State, point by point, the similarities and differences between two or more items.

Example: Compare and contrast the structure of plant and animal cells.

Define

State briefly the meaning of.

Example: Define the term "population" as used in ecology.

Describe briefly/concisely

State the main features of an item.

Example: Describe, concisely, one cause and one effect of acid rain.

Describe fully

Use continuous prose, with diagrams where appropriate, to give a full account.

Example: Describe fully the process of urine formation in a mammal.

Describe how you would

The word "how" indicates that a practical procedure should be described. What is required is an account of the essential features of experimental design as appropriate to the question.

Example: Describe how you would investigate the effect of temperature on the activity of a named enzyme.

Determine

Use information given to arrive at the correct answer by reasoning, but not necessarily a numerical calculation.

Example 1: Determine the genotypes and phenotypes of the offspring of a cross between two heterozygous Himalayan rabbits.

Example 2: From the graph, determine the optimum pH of the enzyme.

Diagrams and Drawings

A **diagram** is a pictorial representation of the essential features of a structure.

A **drawing** is a true record of the appearance of a structure as observed in a photograph, photomicrograph or electron micrograph.

Clear pencil lines should be used to show the essential features represented in the diagram or observed in the photograph. These features should be labelled, as appropriate, using straight label lines, which should not cross.

Example 1: In the space below, draw a labelled diagram of a transverse section through a triploblastic, acoelomate animal.

Example 2: In the space below, produce a labelled drawing to show your interpretation of Photograph C.

In an **annotated** diagram or drawing, brief explanatory notes are given next to the labels.

Example: Make an annotated diagram to show the relationship between blood capillaries, tissue cells and lymph vessels.

A **block diagram/block drawing** shows locations of tissues but not individual cells.

Example: Draw a labelled block diagram to show the location of tissues, as seen in transverse section, in the root of a flowering plant.

A **flow diagram** is an abbreviated account of a process, using arrows to indicate sequence.

Example: Using a suitable flow diagram, outline the life cycle of a flowering plant.

Discuss

Use continuous prose to give a critical account of all the relevant points, inter-relating them where appropriate.

Example: Discuss the factors which may affect the growth rate of a green plant.

Distinguish between

State the essential difference between the meaning of two biological terms.

Example: Distinguish between a chromosome and a gene.

Explain

Apply understanding to give scientific reasons for a biological phenomenon or a set of results.

Example 1: Explain why the gametes produced by a flowering plant are genetically different, whereas those produced by a fern or a moss are genetically identical.

Example 2: Explain the results obtained for this enzyme between 0 and 30°C. (In this example, it is important not to simply describe the results in question.)

Identify

Recognise a feature from a photograph, diagram or verbal description and state the biological term used to describe it.

Example: Identify the structure labelled A in Photograph X.

List

The facts should be numbered and stated as briefly as possible. Single words may be sufficient.

Example: List three different commercially useful products of microbial respiration.

Outline

Essential points should be presented in the form of sentences.

Example: Outline three distinct differences between artificial insemination and in vitro fertilisation.

State

Give a brief answer to the question, in the form of a single word or concise sentence.

Example: State the appropriate null hypothesis.

Suggest

This instruction indicates that any reasonable explanation of the information will be acceptable. There is often not a single correct answer.

Example: Suggest a new hypothesis for the cause of beri-beri in the light of this discovery.

What is meant by?

This invites the candidate to present his or her understanding of a biological phenomenon. The extent of the account should be indicated by the mark value.

Example: What is meant by “alternation of generations”?