Rewarding Learning

CCEA GCE Specification in Biology

For first teaching from September 2008

For first award of AS Level in Summer 2009
For first award of A Level in Summer 2010

Subject Code: 1010

Foreword

This booklet contains CCEA's Advanced Subsidiary (AS) and Advanced GCE Biology for first teaching from September 2008.

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 the first 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 synoptic assessment and an element of stretch and challenge.

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

An A* will be awarded to the candidates who attain an overall grade A in the qualification and an aggregate of at least 90% of the uniform marks across the A2 units.

Subject Code 1010
QAN 500/2501/6
QAN 500/2503/X

Further copies of this publication may be downloaded from www.ccea.org.uk

Contents

1 Introduction

This specification sets out the content and assessment details for our Advanced Subsidiary (AS) and Advanced Level (A Level) courses in Biology. This specification is for first teaching from September 2008. You can view and download the latest version of this specification from our website: www.ccea.org.uk.

The AS course can be taken as a final qualification or as the first half of the A Level qualification. If students wish to obtain a full A Level qualification, they must also complete the second half of the course, which is referred to as A2. We will make the first AS award for this specification in 2009 and the first A Level award in 2010.

The specification builds on the broad objectives of the revised Northern Ireland Curriculum. It is also relevant to key curriculum concerns in England and Wales.

The specification is designed to promote continuity, coherence and progression within the study of Biology. The A Level award provides a basis for the further study, at tertiary level, of Biology and related courses. For those progressing directly into employment, an AS or A Level award is relevant not only in the fields of science, engineering and medicine, but also to areas of commerce and the public service in which problem-solving and practical skills are valued. The specification helps to provide an understanding of how biological developments affect the environment. The specification also contributes towards an understanding of ethical and cultural issues, thus adding to a full and rounded education.

1.1 Aims

Students should be encouraged to:

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

1.2 Key features

The key features of the specification are listed below:

- The total time spent in written examinations is only 7 hours (that is the same as in the 2000 specification).
- A2 students are stretched and challenged through the introduction of more testing and less structured questions.
- It provides a firm grounding for those wishing to enter higher education courses in Biology and related subjects. In most of these courses, an A Level award is a prerequisite for entry.
- The specification includes Northern Ireland perspectives, particularly with respect to biodiversity strategies and the human impact on ecosystems.
- Teachers and students are supported by the provision of *Notes for Guidance*, which you can download from our website: www.ccea.org.uk.

1.3 Prior attainment

The AS specification builds on the knowledge, understanding and skills developed within GCSE Science: Double Award, GCSE Science: Biology and other equivalent courses. Knowledge, understanding and skills developed within GCSE Mathematics are also relevant. The A2 specification builds on the knowledge, understanding and skills developed within the AS course.

1.4 Prohibited combinations

Students should not enter for examinations in this specification if they are also entered for examinations in any other GCE Biology specification.

Although there are small amounts of overlap between this specification and GCE specifications in Chemistry and GNVQ Advanced Science, we do not prohibit students from studying any of these subjects with GCE Biology.

The classification code for this subject is 1010.

2 Specification at a Glance

The structures of the AS and A Level courses are summarised in the table below:

Unit	Assessment	Weightings	Availability
AS 1: Molecules and Cells	1 hour 30 minutes written examination, externally assessed	40% of AS 20% of A Level	January and Summer
AS 2: Organisms and Biodiversity	1 hour 30 minutes written examination, externally assessed	40% of AS 20% of A Level	January and Summer
AS 3: Assessment of Practical Skills in AS Biology	Internal practical assessment	20% of AS 10% of A Level	Summer only
A2 1: Physiology and Ecosystems	2 hour written examination, externally assessed	40% of A2 20% of A Level	January and Summer
A2 2: Biochemistry, Genetics and Evolutionary Trends	2 hour written examination, externally assessed	40% of A2 20% of A Level	Summer only
A2 3: Assessment of Investigational and Practical Skills in Biology	Internal practical assessment	20% of A2 10% of A Level	Summer only

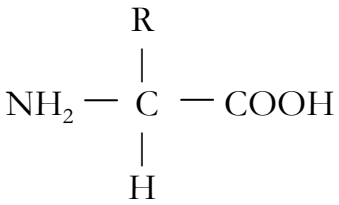
3 Subject Content

The AS course is divided into three units: AS 1, AS 2 and AS 3. Students following the A Level course must study three further units: A2 1, A2 2 and A2 3. The content of each of these units is set out below.

3.1 Unit AS 1: Molecules and Cells

This unit deals with Molecules, Enzymes, DNA Technology, Viruses, Cells, Cell Physiology, Continuity of Cells, and Tissues and Organs.

Content	Learning Outcomes
1.1 Molecules	Students should be able to: 1.1.1 Understand the importance of water: • as a solvent. 1.1.2 Outline the role of inorganic ions – potassium, calcium, magnesium, iron, hydrogen carbonate, nitrate and phosphate: • as components of biologically important compounds (calcium pectate, chlorophyll, haemoglobin, ATP, nucleic acids, phospholipids); • in osmotic and buffering systems (details of the physical chemistry of buffering systems NOT required). 1.1.3 Recognise the occurrence, structure and function of carbohydrates: • monosaccharides (α- and β- glucose, fructose, $C_6H_{12}O_6$); • condensation reactions in the synthesis of and hydrolysis reactions in the breakdown of disaccharides and polysaccharides; the glycosidic bond; • maltose and sucrose as disaccharides; • cellulose – a structural polymer of β-glucose; • starch and glycogen as storage polymers of α-glucose; • pentoses as components of nucleic acids (ribose and deoxyribose) and ATP (ribose).

Content	Learning Outcomes
1.1 Molecules (cont.)	Students should be able to: 1.1.4 Recognise the occurrence, structure and function of lipids: • lipids as fats and oils; • triglycerides as condensation products of glycerol and fatty acids and the release of these on hydrolysis; • saturated and unsaturated fatty acids; • the structure and properties of phospholipids as components of membranes. 1.1.5 Recognise the occurrence, structure and function of proteins: • the general structure of an amino acid molecule as  • proteins as condensation products of amino acids and the release of these on hydrolysis; • primary structure: the amino acid sequence of a polypeptide involving peptide bonds; • secondary structure: α- helix and β- pleated sheet involving H-bonds; • tertiary structure: the folding of a polypeptide involving; H-, ionic and disulphide bonds, hydrophobic interactions; • quaternary structure: more than one polypeptide making up a protein; • overall shape in relation to function in fibrous (collagen) and globular (enzyme) proteins; • conjugated proteins (glycoprotein and haemoglobin) containing prosthetic groups. 1.1.6 Recognise the occurrence, structure and function of nucleic acids: • nucleic acids as condensation products of nucleotides and the release of these on hydrolysis; • nucleotides as condensation products of a pentose sugar, a nitrogenous base and inorganic phosphate; • helical structure of DNA in terms of two antiparallel chains with specific base pairings;

Content	Learning Outcomes
1.1 Molecules (cont.)	Students should be able to: • comparison of DNA and RNA; • RNA differentiated as ribosomal RNA (rRNA), messenger RNA (mRNA) and transfer RNA (tRNA). (Details of RNA function specified at A2); • the organic base sequence as the genetic code determining the sequence of amino acids in a polypeptide chain (Details of polypeptide synthesis specified at A2). 1.1.7 Understand the replication of DNA: • replication as a semi-conservative process involving the opening of the helix (by DNA helicase) followed by the synthesis of complementary nucleic acid chains alongside each of the existing chains to form two identical helices; • the role of DNA polymerase; • the Meselsöhn – Stahl experiment. 1.1.8 Practical Work: *Use biochemical tests to detect the presence of carbohydrates and proteins:* • *iodine test;* • *Benedict's test;* • *Clinistix;* • *Biuret test*; *Carry out paper chromatography of amino acids:* • *preparation, running and development of the chromatogram*; • *calculation of R_f values.*
1.2 Enzymes	1.2.1 Understand the structure of enzymes: • enzymes as globular proteins and the concept of the active site and specificity; • the role of cofactors and coenzymes. 1.2.2 Understand the relationship between enzyme structure and function: • catalysts which lower the activation energy through the formation of enzyme – substrate complexes; • the Lock and Key hypothesis and Induced fit hypothesis; • effect of temperature, pH, substrate and enzyme concentrations on activity; • enzyme inhibitors (competitive and non-competitive).

Content	Learning Outcomes
1.2 Enzymes (cont.)	Students should be able to: 1.2.3 Understand the application of immobilised enzymes in biotechnology: • methods of immobilisation (physically or chemically securing enzymes on or inside an insoluble support material such as fibres, gels or plastic beads); • immobilisation as a technique enabling cost-effective enzyme applications (increased enzyme stability, facilitation of continuous flow processes, enzyme-free product though with reduced activity due to inaccessibility of some active sites); • diagnostic reagent strips as biosensors (eg clinistix). 1.2.4 Practical Work: *Carry out experimental investigation of factors affecting enzyme activity:* • *effect of temperature, pH, substrate and enzyme concentrations on enzyme activity;* • *illustration of enzyme immobilisation;* • *use of a colorimeter to follow the course of a starch – amylase catalysed reaction (or other appropriate reaction).*
1.3 DNA Technology	1.3.1 Explain the polymerase chain reaction (PCR): • the polymerase chain reaction (PCR) as a technique for amplifying a sample of DNA; • the process involves repetition of a three-step cycle; - heating to separate the DNA strands - cooling to allow annealing of DNA primers (complementary to base sequences on opposite strands at each end of the base DNA) - use of heat-stable DNA polymerase to extend the primers • appreciate the range of uses of PCR. 1.3.2 Understand the use of DNA probes to locate a specific section of DNA: • a DNA probe is a short length of DNA; - with known nucleotide, and so base, sequence - fluorescent (or radioactively labelled) and so useful as a marker • the probe will base pair with any complementary nucleic acid strands; • the use of gene probes in locating specific pieces of DNA.

Content	Learning Outcomes
1.3 DNA Technology (cont.)	Students should be able to: 1.3.3 Understand that differences in nucleotide sequences can be identified: • assessing differences in nucleotide sequences as a measure of genetic variation; • identifying different nucleotide sequences – genetic "marker" sites; • appreciate different genetic markers: restriction fragment length polymorphisms (RFLPs); microsatellite repeat sequences (MRSs); single nucleotide polymorphisms (SNPs). 1.3.4 Explain genetic fingerprinting and show an appreciation of its potential uses: • use of restriction endonucleases to cut chromosomal DNA and the subsequent separation of the fragments according to size (using gel electrophoresis) to produce unique profiles (details of gel electrophoresis procedure NOT required); • use of DNA probes to locate specific DNA fragments.
1.4 Viruses	1.4.1 Understand the structure of bacteriophages (phages) and the human immunodeficiency virus (HIV): • phages containing DNA bounded by a protein coat; • HIV containing RNA bounded by a protein coat and a lipid bilayer containing glycoprotein; and, as a retrovirus, containing reverse transcriptase whereby RNA is used to synthesise viral DNA (Details of transcription NOT to be dealt with until A2). 1.4.2 Appreciate that viruses replicate in host cells (thereby destroying them): • phages invade bacteria in which they replicate, destroying the bacterial cells (Details of the phage life cycle NOT required); • HIV invades a type of lymphocyte (helper T-cell) thereby weakening the immune system (Details of the immune system NOT to be dealt with until A2).

Content	Learning Outcomes
1.5 Cells	Students should be able to: 1.5.1 Describe the ultrastructure of eukaryotic and prokaryotic cells: • prokaryotic cells (eg bacteria) as those without nuclei, mitochondria or endoplasmic reticulum and possessing naked, circular DNA, small ribosomes, possibly plasmids, and a cell wall; • eukaryotic cells as those with a membrane-bound nucleus, chromosomes (helical DNA with a histone protein coat), mitochondria, endoplasmic reticulum, ribosomes, Golgi apparatus, vesicles, lysosomes, microtubules. 1.5.2 Understand the structure and function of membranes: • membrane structure (fluid mosaic model): phospholipid bilayer, intrinsic and extrinsic protein, carbohydrate glycocalyx, glycoproteins and glycolipids, cholesterol (in animal cells); • functions of membrane components: proteins/glycoproteins as carriers, hydrophilic channels, enzymes, receptors, antigens, recognition features; cholesterol in membrane stability. 1.5.3 Understand the structure and function of eukaryotic cell components: • membranes (fluid mosaic model) as structures surrounding cells and contributing to their internal structures; • mitochondria (envelope, cristae and matrix); • chloroplasts (envelope, lamellae, thylakoids, grana, stroma, lipid droplets and starch grains); • rough endoplasmic reticulum (a membrane system with attached ribosomes); • ribosomes as sites of protein synthesis; • smooth endoplasmic reticulum; • golgi apparatus; • lysosomes; • microtubules (centrioles and cell spindle); • plasmodesmata as plant cell to cell junctions; • nuclear components: Chromosomes (DNA and histones as constituents, but without detail of their configuration); euchromatin and heterochromatin; nucleolus (the location of the DNA which codes for ribosomal RNA); the nuclear envelope as a perforated double membrane; the outer membrane of the envelope is encrusted with ribosomes and is the site of origin of RER.

Content	Learning Outcomes
1.5 Cells (cont.)	Students should be able to: 1.5.4 Compare eukaryotic cell structure: • plant cells as protoplasts bordered by an extracellular cellulose cell wall and possessing chloroplasts and vacuole(s); neighbouring cell walls adhered by a middle lamella (a sticky material composed of calcium pectate); • fungal cells as protoplasm (often multinucleate) bounded by an extracellular wall of chitin; • animal cells as lacking chloroplasts and a cell wall and possessing centrioles. 1.5.5 Understand the use of microscopy in examining cell structure: • light microscope; • electron microscope (TEM/SEM as appropriate). 1.5.6 Practical Work: *Examine photomicrographs and electron micrographs (TEM/SEM):* • *Recognise cell structures from photomicrographs and electron micrographs (TEM/SEM);* • *Calculation of true size (in μm) and magnification, including the use of scale bars.*
1.6 Cell Physiology	1.6.1 Understand the mechanisms by which substances move across membranes: • diffusion; • osmosis to include understanding of the terms; - solute potential (ψ_s), pressure potential (ψ_p) and water potential (ψ_{cell}); - lysis, crennation in animal cells; - turgid, incipient plasmolysis, plasmolysed in plant cells; and - flaccid in plant tissues; • facilitated diffusion involving membrane carriers; • active transport involving membrane carriers and energy expenditure; • endocytosis (phagocytosis, pinocytosis); • exocytosis. 1.6.2 Account for membrane permeability: • movement of fat-soluble substances (and water since it is sufficiently small) through the phospholipid bilayer; • movement of water-soluble substances through hydrophilic protein channels; • the role of membrane carriers.

Content	Learning Outcomes
1.6 Cell Physiology (cont.)	Students should be able to: 1.6.3 Calculate the water potential of a cell: • as the algebraic sum of the solute and pressure potentials of a cell. 1.6.4 Practical Work: *Measure the average water potential of cells in a plant tissue*: • *using a weighing method for a potato or other suitable tissue*; • *calculation of the percentage change in mass;* • *determination of the average water potential from a graph of percentage change in mass against solute potential of immersing solution.* *Measure the average solute potential of cells at incipient plasmolysis:* • *use of onion epidermis or other suitable tissue;* • *calculation of percentage plasmolysis;* • *determination of the average solute potential from a graph of percentage plasmolysis against solute potential of the immersing solution at 50% plasmolysis the average pressure potential is zero.*
1.7 Continuity of Cells	1.7.1 Describe the cell cycle: • the main events during G_1, S and G_2 of interphase; • nuclear division (mitosis) following the replication of DNA during the S phase; • cytokinesis in animal and plant cells. 1.7.2 Understand chromosome structure: • consists of DNA and histones in the nucleus of eukaryotic cells. 1.7.3 Describe the process of mitosis: • its significance in maintaining genetic constancy; • the events of prophase, metaphase, anaphase and telophase including the appearance and behaviour of chromosomes. 1.7.4 Understand the chromosome number of a cell and its significance in haploidy and diploidy: • the chromosome number of a cell as revealed in a photomicrograph; • chromosomes and homologous pairs as revealed in a human karyotype; • haploidy as the situation in which cells have one set of chromosomes (non-homologous); • diploidy as the situation in which cells have two sets of chromosomes (homologous).

Content	Learning Outcomes
1.7 Continuity of Cells (cont.)	Students should be able to: 1.7.5 Describe the process of meiosis and understand its significance in producing haploid cells and genetic variation: • the events of prophase I (but excluding the names of the prophase stages), metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II, and telophase II including the appearance and behaviour of chromosomes; • recombination of genes resulting from chiasma formation (crossing-over) during prophase i as a source of genetic variation; • the independent assortment of chromosomes resulting from the random alignment of homologous pairs on the spindle as a source of genetic variation. 1.7.6 Practical Work: *Prepare and stain root tip squashes:* • *recognise chromosomes at different stages of cell division*; • *identify the stages of mitosis;* *Examine prepared slides or photographs of the process of meiosis:* • *identify the stages of meiosis*.
1.8 Tissues and Organs	1.8.1 Appreciate the specialisation of cells in tissues and organs: • a tissue as an amalgamation of cells all of which perform the same function; • an organ as a body part composed of several tissues grouped together to perform an overall function. 1.8.2 Understand the structure and function of the ileum (a mammalian organ): • the tissue layers as the mucosa, muscularis mucosa, submucosa, muscularis externa and serosa; • the role of the mucosa: - columnar epithelium (with microvilli for absorption, and containing goblet cells for secretion of mucus) - villi increasing surface area for absorption - crypts of Lieberkühn with Paneth cells (cell division to produce new epithelial cells for villi) - blood capillaries and lacteals for transport of products of digestion.

Content	Learning Outcomes
1.8 Tissues and Organs (cont.)	Students should be able to: • the adaptations of the epithelium for absorption to include a brush border of microvilli and numerous mitochondria; - the role of diffusion, active transport and pinocytosis in absorption - absorption of amino acids and monosaccharides into blood capillaries and fats into lacteals (details of digestive enzymes NOT required) • the role of the muscularis mucosa in movement of the villi (improving contact with the products of digestion); • the role of the submucosa as a layer containing blood and lymphatic vessels, and containing connective tissue providing support (further details of connective tissue not required); • the role of the muscularis externa in pendular movements, and in local constrictions churning food, and in peristalsis in movement of food along the gut; • the role of the serosa as a protective and supportive layer. 1.8.3 Understand the structure and function of a mesophytic leaf (a plant organ): • the tissue layers as the upper epidermis, palisade mesophyll, spongy mesophyll, xylem, phloem, lower epidermis and stomata; • the role of the upper epidermis with its waxy cuticle for conserving water; • the large surface area of the leaf as an adaptation for photosynthesis; • the role of the palisade mesophyll with its packed arrangement of cells and the distribution of chloroplasts for maximum light absorption; • the role of the spongy mesophyll with its loose arrangement of cells creating air spaces which facilitate diffusion of gases; • the role of xylem vessels within leaf veins (vascular bundles) in supplying the leaf with water and inorganic ions; • the role of phloem sieve-tubes in translocating sugars produced in photosynthesis away from the leaf.

Content	Learning Outcomes
1.8 Tissues and Organs (cont.)	Students should be able to: • the role of the lower epidermis with its waxy cuticle in reducing water loss; • the role of stomata (mostly in the lower epidermis) in gas exchange, surrounded by guard cells and closing at night to reduce transpirational water loss; • the leaf as an organ with adaptations for maximising photosynthesis while minimising transpirational water loss. 1.8.4 Practical Work: *Examine stained sections of the ileum using the light microscope or photographs of the same:* • *recognise the villi (and associated blood capillaries and lacteals), crypts of Lieberkühn (and Paneth cells), mucosa, columnar epithelium, goblet cells, muscularis mucosa, submucosa, muscularis externa, and serosa;* *Examine sections of a mesophytic leaf using the light microscope or photographs of the same:* • *recognise the epidermal layers, waxy cuticles, palisade mesophyll, chloroplasts, spongy mesophyll, vascular vessels with xylem and phloem, and guard cells and stomata;* *Make accurate drawings of sections of the ileum and the leaf to show the tissue layers:* • *draw block diagrams of tissues within the ileum and the leaf.*

3.2 Unit AS 2: Organisms and Biodiversity

This unit deals with Transport and Exchange Mechanisms in plants and mammals, Adaptation of Organisms, and Biodiversity with an emphasis on local contexts.

Content	Learning Outcomes
	Students should be able to:
2.1 Transport and Exchange Mechanisms	
(a) The principles of exchange and transport	2.1.1 Understand the relationship between an organism's size and its surface area to volume ratio: • surface area as the total number of cells in direct contact with the surrounding environment; • surface area affects the rate of exchange of materials at exchange surfaces; • volume as the total three-dimensional space occupied by metabolically active tissues; • volume of metabolically active tissue influences the demand for metabolites; • surface area influences the rate of supply of metabolites to tissues; • as an organism's size increases, its surface area increases less than its volume (many cells are not in direct contact with the surrounding environment); • large animals have a small surface area to volume ratio; • small animals have a large surface area to volume ratio. 2.1.2 Understand the features of exchange surfaces which aid passive and active transport: • methods of increasing surface area; • thin separating surface; • concentration gradients; • examples to include leaf mesophyll, root hairs, capillaries, erythrocytes, alveoli. 2.1.3 Understand the principle of mass transport: • the need for mass transport systems in flowering plants and mammals; • examples to include movement in xylem, translocation in phloem, circulation and ventilation in a mammal.

Content	Learning Outcomes
2.1 Transport and Exchange Mechanisms **(b) Gaseous exchange**	Students should be able to: 2.1.4 Understand factors affecting the rate of gas exchange: • large surface area for exchange; • moist surface into which gases dissolve; • diffusion gradients for O_2 and CO_2; • diffusion path; • appreciate the relationship between the factors shown in Fick's Law; $$\text{Diffusion rate} = \frac{\text{Surface area of membrane} \times \text{Difference in concentration across the membrane}}{\text{thickness of membrane}}$$ 2.1.5 understand gas exchange in plants: • exchange of gases involving O_2 and CO_2, and both the processes of respiration and photosynthesis; • net exchange of gases (mostly photosynthetic mid-day, only respirational at night) and the compensation point; • mesophyll surface representing a large, moist surface area for exchange of gases; • diffusion path: thinness of leaves; air space system through the spongy mesophyll; open stomata during the day facilitating the uptake of CO_2 (low CO_2 concentration gradient). 2.1.6 Understand gas exchange in a mammal: • mass flow of air to respiratory surface (maintaining diffusion gradients); • large surface area provided by alveoli; • thin respiratory 'membrane' (simple squamous epithelium of alveoli and simple squamous endothelium of a blood capillary wall); • moist outer surface of alveoli; • surfactant in moisture layer of alveoli to reduce surface tension; • rich vascular supply (maintaining diffusion gradients).

Content	Learning Outcomes
	Students should be able to:
2.1 Transport and Exchange Mechanisms	
(b) Gaseous exchange (cont.)	2.1.7 Understand the structure and functioning of the breathing system of a mammal: • respiratory tree (trachea, bronchi, bronchioles, alveolar ducts, alveoli); • intercostal muscles and ribcage, diaphragm; • mechanism of inspiration and expiration (nervous regulation NOT required); • the effects of smoking to include cilia damage, bronchitis, emphysema and lung cancer (further details **not** required). 2.1.8 Practical Work: *Use a J-tube to analyse air samples:* • *determination of the % O_2 content and % CO_2 content of samples of inspired and expired air;* *Understand the use of a simple respirometer:* • *measuring O_2 consumption (with KOH present);* • *measuring the net difference between CO_2 production and O_2 consumption (with no KOH present) and so determining CO_2 production;* *Understand the use of the Audus apparatus:* • *the effect of light intensity on the photosynthetic production of oxygen;* *Demonstrate a compensation point:* • *use of bicarbonate indicator.*
(c) Transport in plants and transpiration	2.1.9 Recognise and understand plant tissues in relation to water (and ion) transport and translocation: • epidermis; • endodermis; • xylem (protoxylem and metaxylem) vessels and their distinctive lignification patterns; • phloem tissue (sieve tube elements and companion cells). 2.1.10 Understand the uptake of water and mineral ions by root hairs: • water uptake involving osmosis; • ion uptake involving active transport.

Content	Learning Outcomes
2.1 Transport and Exchange Mechanisms **(c) Transport in plants and transpiration (cont.)**	Students should be able to: 2.1.11 Understand the apoplast and symplast pathways through plant tissues: • the apoplast pathway along cellulose cell walls; • the symplast pathway through protoplasts connected by plasmodesmata; • the apoplast and symplast pathways in the root and leaf; • the role of the endodermis in ensuring the symplast pathway into the stele. 2.1.12 Understand transpiration and the factors influencing its rate: • stomata as the main route of transpiration; • the cuticle as a minor alternative route of transpiration; • internal factors to include leaf surface area, stomatal density, cuticle thickness; • external factors to include light intensity (influencing stomatal aperture), air currents, temperature, humidity and soil water availability. 2.1.13 Understand the movement of water (and dissolved ions) through xylem: • cohesion-tension theory; • transpiration creating a negative pressure within leaf xylem vessels resulting in the transpiration stream; • the cohesive and adhesive forces of water; • the root pressure hypothesis. 2.1.14 Understand the translocation of organic solutes through phloem: • involving energy expenditure and two-way flow; • evidence for the above properties (Theories of translocation NOT required).

Content	Learning Outcomes
	Students should be able to:
2.1 Transport and Exchange Mechanisms	
(c) Transport in plants and transpiration (cont.)	2.1.15 Understand the structural adaptations of xerophytes and hydrophytes: • xerophytic adaptations to include leaf curvature, reduced surface area, cuticular thickening, hairs, sunken stomata, succulent tissue, deep roots, spines; • hydrophytic adaptations to include stomata mainly on the upper surface of leaves and a prominent air space system (aerenchyma). 2.1.16 Practical Work: *Demonstration of a bubble 'potometer' and its use in measurement of the rate of water uptake:* • *use to measure rate of water uptake;* • *use to investigate external factors influencing the rate of transpiration.*
(d) Circulatory systems in mammals	2.1.17 Know the layout of the mammalian circulatory system • the double circulation; • the major blood vessels of the thorax and abdomen. 2.1.18 Understand the histological structure and function of arteries, veins and capillaries: • squamous endothelium, smooth muscle, elastic and fibrous tissue in arteries and veins; • capillaries consisting of squamous endothelium only; • arteries containing numerous elastic fibres (allowing distension of the artery and development of a pulse wave) and smooth muscle (allowing vasoconstriction/vasodilation to control blood supply to organs); • atherosclerosis, atheroma; • veins containing abundant fibrous tissue for protection, and valves and large lumen to facilitate the return of blood to the heart.

Content	Learning Outcomes
2.1 Transport and Exchange Mechanisms **(d) Circulatory systems in mammals (cont.)**	Students should be able to: 2.1.19 Understand the structure and functioning of the mammalian heart: • structure to include the atria, ventricles, septa, AV-valves (tricuspid, bicuspid), chordae tendinae and papillary muscles; • the phases of the cardiac cycle as diastole, atrial systole and ventricular systole; • the flow of blood through the heart along pressure gradients involving the operation of valves; • myogenic stimulation and the wave of excitation through heart muscle: SA-node, AV-node, bundle of His, Purkinje fibres; • appreciation of changes in the volume of the heart chambers during the cardiac cycle; • appreciation of changes in pressure within the heart chambers and major arteries (aorta, pulmonary artery) during the cardiac cycle; • appreciation of the heart sounds and the representation of the excitation wave in an ECG. 2.1.20 Practical Work: *Examine prepared slides and/or photographs of blood vessels (in section) and mammalian heart (dissected and in section):* • *distinguish between arteries, veins and capillaries;* • *identification of heart chambers, AV-valves, semilunar valves, chordae tendinae, papillary muscles, interventricular septum, major blood vessels (vena cavae, pulmonary artery and aorta).*

Content	Learning Outcomes
2.1 Transport and Exchange Mechanisms **(d) Circulatory systems in mammals (cont.)**	Students should be able to: 2.1.21 Describe the composition and functions of mammalian body fluids: • adaptations of erythrocytes for O_2-transport; • polymorphs as microphages; • monocytes as macrophages; • lymphocytes (B-cells involved in antibody production, T-cells involved in cell-mediated immunity) (Details of the process of immunity NOT required); • plasma as the liquid component of blood involved in transport of products of digestion, ions, carbon dioxide, urea, heat, prothrombin, fibrinogen and clotting factors; • tissue fluid as the liquid medium bathing all cells within tissues and involved in exchange of metabolites with tissues. 2.1.22 Practical Work: *Examine stained blood films using the light microscope and/or photographs:* • *identification of erythrocytes, polymorphs, monocytes, lymphocytes and platelets.* 2.1.23 Describe the mechanism of blood clotting: • role of platelets (thrombocytes), thromboplastins (thrombokinase), prothrombin, clotting factors (eg Factor VIII), calcium ions, vitamin K, fibrinogen and fibrin. 2.1.24 Understand the chemical composition of haemoglobin in relation to its role in O_2-transport: • conjugated protein, the prosthetic groups (haem) of which contain Fe^{2+}; • each haemoglobin molecule contains four haem groups, each of which can transport one molecule of oxygen.

Content	Learning Outcomes
2.1 Transport and Exchange Mechanisms **(d) Circulatory systems in mammals (cont.)**	Students should be able to: 2.1.25 Understand the concept of partial pressure of oxygen and its effect on O_2-transport by haemoglobin: • loading of haemoglobin with oxygen at higher pO_2; • unloading of oxygen from haemoglobin at lower pO_2; • the effect of initial binding of oxygen with haemoglobin on subsequent oxygen loading by haemoglobin; • the haemoglobin oxygen dissociation curve. 2.1.26 Understand the Bohr Effect on O_2-transport by haemoglobin and the physiological advantage of this for a tissue: • increased pCO_2/temperature shifts the oxygen dissociation curve to the right; • increased pCO_2/temperature increases the dissociation of oxygen from haemoglobin; • increased oxygen supply to tissues where the CO_2 and temperature have increased due to increased rate of respiration and meeting the increased demand for oxygen. 2.1.27 Understand that myoglobin has a higher affinity for oxygen than does haemoglobin: • myoglobin as a pigment present in red muscle; • oxygen dissociation curve for myoglobin is displaced to the left of that for haemoglobin; • oxygen only dissociates from myoglobin when the pO_2 in muscle tissue is low; • Enabling aerobic respiration to continue for longer and delaying the onset of anaerobic respiration. 2.1.28 Understand the effect of altitude on O_2-transport by haemoglobin: • lower pO_2 in air at higher altitude; • haemoglobin of high altitude dwellers saturates with oxygen at a lower pO_2 than does the haemoglobin of lower altitude dwellers; • increased erythrocyte production by athletes during high altitude training.

Content	Learning Outcomes
2.2 The Adaptation of Organisms	Students should be able to: 2.2.1 Understand that organisms are adapted to their environment: • adaptation as a combination of behavioural, physiological and morphological ways in which an organism meets a particular environmental challenge; • study of behavioural, physiological and morphological ways that organisms meet environmental challenges; • study of organisms in their habitat (eg rough and smooth periwinkles on a rocky shore); • refer to xerophytic and hydrophytic adaptations in 2.1 (c). 2.2.2 Understand that ecological factors have an influence on the distribution of organisms: • climatic factors (temperature ranges, availability of water, light intensity, light quality and day length); • edaphic factors (pH values, availability of macro- and micronutrients, aeration of soils); • biotic factors (limits on populations imposed by competitors, predators and the accumulation of waste); • define the term *ecological niche*. 2.2.3 Understand the role of selection in maintaining the adaptiveness of populations of organisms in their environment: • fitness as those features which allow an organism to be adapted in its environment; • the role of selection in maintaining the fitness of a population of organisms; • those individuals with features best suited to their environment leave proportionally greater numbers of offspring; • this differential reproductive success maintains the fitness of a population; • natural selection does not create useful adaptations but rather edits genetically inheritable features in a population, increasing the frequency of some while decreasing the frequency of others over time; • stabilising selection in maintaining the constancy of features in a non-changing environment; • directional selection in bringing about a change in frequency of a feature in a changing environment, and accounting for the diversity of organisms.

Content	Learning Outcomes
2.2 The Adaptation of Organisms (cont.)	Students should be able to: 2.2.4 Practical Work: *Describe and carry out qualitative and quantitative techniques used to investigate the distribution and relative abundance of plants and animals in a habitat:* • *sampling procedures to include;* - *random sampling* - *line transect* - *belt transect* • *sampling devices to include quadrats, pitfall traps, sweep nets and pooters;* • *estimation of species abundance, density and percentage cover;* • *appreciation and, where possible, measurement of the biotic and abiotic factors which may be influencing the distribution of organisms.*
2.3 Biodiversity **(a) The variety of life**	2.3.1 Understand that the biochemical basis of life is similar for all organisms: • all living organisms contain the biochemicals carbohydrates, lipids, nucleic acids and proteins. 2.3.2 Understand that biodiversity involves variation among living organisms at all levels of biological organisation: • genetic diversity as the diversity of genes within a species; • species diversity as the diversity among species in an ecosystem; • ecosystem diversity as the variety of ecosystems within the biosphere. 2.3.3 Measure species diversity and appreciate that genetic diversity can be measured: • species diversity measured using the Simpson index; • the formula for the Simpson index is $D=\frac{\Sigma n_i(n_i-1)}{N(N-1)}$ where N is the total percentage cover or total number of organisms of all species and n is the percentage cover of a species or number of organisms of a particular species;

Content	Learning Outcomes
2.3 Biodiversity **(a) The variety of life (cont.)**	Students should be able to: • for plant species the percentage cover in a quadrat is usually used (since it is usually very difficult to count all the individual plants), for animal species the number of organisms of a species is used; • appreciate that genetic diversity can be measured. 2.3.4 Understand the principle of taxonomy: • nomenclature ie scientific naming of organisms using the binomial system; • systematics ie placing organisms into groups based on their similarities and differences. 2.3.5 Understand the concept of the species: • a species as a group of individuals of common ancestry that closely resemble each other, and are normally capable of interbreeding to produce fertile offspring. 2.3.6 Understand the other taxa within which species can be grouped: • genus as a group of similar and closely related species; • family as a group of apparently related genera; • order as a group of apparently related genera; • class as a grouping of orders within a phylum; • phylum as a grouping of organisms constructed on a similar plan; • kingdom as the largest and most inclusive grouping. 2.3.7 Understand phylogenetic taxonomy as a means of classifying sets of species according to ancestral relationships: • establishing relationships among organisms according to a number of measurable features including; - morphology and anatomy (external and internal features) - cell structure (prokaryote/eukaryote) - biochemistry (comparisons of DNA, RNA and the amino acid sequences in proteins) • closely related organisms possess a high degree of agreement in the molecular structure of DNA (base sequence), RNA (base sequence) and protein (amino acid sequence), while the molecules of organisms distantly related usually show a pattern of dissimilarity.

Content	Learning Outcomes
2.3 Biodiversity **(a) The variety of life (cont.)**	Students should be able to: 2.3.8 Appreciate the five kingdom system of classification: • The five kingdoms as; - prokaryotae - protoctista - fungi - plantae - animalia. 2.3.9 Describe features of Prokaryotae: • structure of prokaryotae cells; • reproduction by division; • example: a rod-shaped bacterium. 2.3.10 Describe features of Protoctista: • eukaryotic; • unicellular or showing limited differentiation; • some are heterotrophs (eg Phylum Protozoa) while some are autotrophs (eg Phylum Chlorophyta) (Details of feeding methods NOT required). 2.3.11 Describe the features of Fungi: • the Fungi as lysotrophs (decomposers); • consist of hyphae with chitinous cell walls; • feeding by extracellular digestion; • example: a mould. 2.3.12 Describe the features of Plantae: • the plants as autotrophs (producers); • possessing chlorophyll in chloroplasts; • possessing a cellulose cell wall. 2.3.13 Describe the features of Animalia: • the animals as heterotrophs; • they are capable of locomotion.

Content	Learning Outcomes
2.3 Biodiversity **(b) Human impact on biodiversity**	Students should be able to: 2.3.14 Appreciate factors that have an adverse impact on biodiversity: • removal of trees and hedgerows for agricultural and development purposes results in; - increased soil erosion caused by wind and rain - decreased biodiversity due to removal of habitat/food. 2.3.15 Appreciate neglect/lack of management resulting in hedgerows changing into rows of trees with gaps: • too frequent/badly timed cutting of hedgerows resulting in poor habitat conditions, development of gaps and consequent reduction in species present; • loss of hedgerow trees through senescence and felling without re-planting; • increased use of monocultures; • increased use of pesticides and slurry removes soil organisms that help improve soil structure; • increased use of pesticides may remove natural predators of pest species; • increased use of herbicides reduces plant species diversity (eg removal of arable weeds in crops) and reduces the variety of food available to a variety of animal species, thereby reducing animal species diversity; • increased use of artificial fertilisers; - increases soil erosion due to loss of soil crumb structure - nitrogenous fertilisers promotes the growth of some plant species only, which reduces both plant and animal diversity (loss of species-rich grassland) • drainage schemes followed by ploughing and re-seeding of unimproved pasture reduces biodiversity; • increased stocking rates eg of sheep, results in over-grazing and damage to hedgerows; • species extinction impacts adversely on other species eg in a food chain.

Content	Learning Outcomes
2.3 Biodiversity **(b) Human impact on biodiversity (cont.)**	Students should be able to: 2.3.16 Appreciate the need for strategies to encourage biodiversity: • management of hedgerows as important habitats (providing shelter and food) which support biodiversity; - timing and frequency of cutting - height × width of hedgerow - leaving hedgerow trees • hedgerows may act as wildlife corridors for many species including small mammals, birds, reptiles, amphibians and insects, allowing dispersal and migration to other habitats; • promote the use of polyculture instead of monoculture; • maintenance of set-aside areas of farmland to support a wide variety of species; • conservation of existing woodland; • importance of planting native species of tree on land with low species diversity; • increased use of organic fertiliser; • increased use of crop rotation and N_2-fixing plants to improve soil fertility; • increased use of species-rich hay meadow (with low soil nitrate levels); • implementation of integrated pest management schemes to decrease the use of pesticides; • use of predator strips (small areas of rough grass left undisturbed at field perimeters) to encourage natural predators for pest control; • appreciate the existence of governmental initiatives to encourage biodiversity (Details NOT required); - NI Biodiversity Strategy - Biodiversity Action Plans (NI District Councils) - Habitat Action Plan for species-rich hedgerows - DARD agri-environment schemes.

Content	Learning Outcomes
2.3 Biodiversity **(b) Human impact on biodiversity (cont.)**	Students should be able to: 2.3.17 Appreciate initiatives for the protection of habitats: • areas of special scientific interest (assi); • special areas of conservation (sac); • local examples include: - Bann Estuary - Cranny Bogs - Lough Melvin - Murlough - North Antrim Coast - Peatlands Park - Rathlin Island - Strangford Lough - Upper Lough Erne.

3.3 Unit AS 3: Assessment of Practical Skills in AS Biology

Introduction

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

(i) the internal assessment of practical tasks; 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.

The assessment objectives are to be weighted in AS and A2 internal assessment as indicated.

	Assessment Objectives	Weighting	
		AS Level	A2 Level
AO1	Knowledge and understanding	10%	10%
AO2	Application of knowledge and understanding	15%	15%
AO3	How science works	75%	75%
	Total	100%	100%

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

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 practical tasks to be assessed at AS Level should, therefore, be technically and intellectually more demanding, requiring a higher level of technical expertise and intellectual ability.

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 specification. 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 achieved.

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

At AS Level, each practical task will involve an experimental test of a prediction provided by the teacher. The candidate will not be required to plan or devise a procedure for the practical task.

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

Skill Area	Description	Marks
A	Implementing a sequence of instructions	10
B	Recording and communicating in an appropriate graphical form	20
C	Interpretation of the results	10
D	Evaluation of the experimental design of the practical task	10
		Maximum 50

A Implementing

The following must be included to satisfy the mark scheme for the implementing of a practical task:

- Skilful handling of apparatus and materials 2 marks
- Adherence to appropriate safety procedures and care of living organisms observed as identified in a risk assessment (before practical work begins) 2 marks
- Organised and methodical carrying out of the practical procedure 2 marks
- Adhering to the instructed sequence of actions 2 marks
- Measurements at the level of precision required 2 marks

Total 10 marks

B Recording and communicating

B1 The tabulation of raw and derived data

The following must be included to satisfy the mark scheme for the recording and communicating:

- Organisation of the raw data with the dependent variable in the body of the table and treatments or range of the independent variable as columns or rows 2 marks
- A caption, which is a concise statement identifying the variables included in the table and states the biological material used as the source of the data 2 marks
- Logical construction of the table (organised for analysis) 2 marks
- Explanatory column headings 2 marks
- Units for all variables and calculated values 2 marks

Total 10 marks

B2 An appropriate graphical presentation of the data

The following must be included to satisfy the mark scheme for the recording and communicating:

- Selection of an appropriate form of graph 2 marks
- A caption, which is a concise statement identifying the variables included in the graph and states the biological material used as the source of the data 2 marks
- Variables plotted correctly with appropriate scales 2 marks
- Labels for axes including units 2 marks
- Values accurately plotted/key for multiple plots and appropriate bars/line of best fit/ lines drawn 2 marks

Total 10 marks

C Interpretation

The following must be included to satisfy the mark scheme for the interpretation of the results:

- Written communication of the data 2 marks
- Trend(s) clearly identified 2 marks
- Explanation of the trend(s) 2 marks
- Use of appropriate biological knowledge and understanding 2 marks
- Communication of information and ideas in appropriate ways using appropriate terminology 2 marks

Total 10 marks

D Evaluation of the experimental design

The following must be included to satisfy the mark scheme for the evaluation of the design of the practical task:

- Comments on the appropriateness of the observations/measurements 2 marks
- The procedures used to prevent variation of factors not under investigation 2 marks
- Comments on the validity of experimental design and procedures 2 marks
- An assessment of the variation shown within the replicates 2 marks
- Comments on the reliability of the observations/measurements 2 marks

Total 10 marks

SCHEME OF MARKING

In each Skill Area, each of its subdivisions is to be assessed on the following scale:

A **score of 2** should be awarded to a candidate who shows competence, independence and, if necessary, initiative in the subdivision of the Skill Area under consideration. The actual criteria used in assessing these qualities will depend on the specific skill and on the category of practical exercise being carried out by the candidate.

A **score of 1** should be awarded to a candidate who falls short in one of the above qualities in the performance of the task required but who, nonetheless, shows satisfactory practical skills. For example, if it is necessary for the teacher to provide guidance to the candidate, a score of 1 is appropriate.

A **zero score** should not be awarded unless a candidate fails to attempt a task which would enable the skill to be assessed.

The teacher should ensure that, as far as possible, a candidate does not lose marks more than once as a consequence of a single error in practice or in calculation.

3.4 Unit A2 1: Physiology and Ecosystems

This unit deals with Homeostasis, Immunity, Coordination and Control in plants and animals, and Ecosystems.

Content	Learning Outcomes
	Students should be able to:
4.1 Homeostasis	
(a) Homeostasis principles	4.1.1 Understand the concept of homeostasis and the components of homeostatic mechanisms: • homeostasis as the maintenance of a constant state; • the control system has a sensor (receptor) which monitors the factor being controlled; • a corrective mechanism brings about changes resulting in regulation of this factor; • a negative feedback system stops the corrective mechanism and prevents over-correction.
(b) The kidney and excretion	4.1.2 Understand the role of the mammalian kidney in excretion and osmoregulation: • removal of toxic waste products of metabolism (urea, creatine); • maintenance of optimal water potential of body fluids. 4.1.3 Understand the gross structure of the mammalian kidney/excretory system: • recognise the cortex, medulla, pyramids, pelvis, ureters, bladder, urethra in photographs/diagrams. 4.1.4 Describe the structure of the nephron: • Bowman's capsule with podocytes; • proximal convoluted tubule consisting of a cuboidal epithelium containing numerous mitochondria and with surface microvilli and basal invaginations; • Loop of Henlé; - ascending limb with a cuboidal epithelium containing numerous mitochondria and which is impermeable to water - descending limb is permeable to water • distal convoluted tubule and collecting duct consisting of a cuboidal epithelium. 4.1.5 Describe the structure of the filter: • squamous endothelium of the blood capillaries in the glomerulus; • basement membrane as the effective filter; • podocytes in the wall of the Bowman's capsule.

Content	Learning Outcomes
	Students should be able to:
4.1 Homeostasis	
(b) The kidney and excretion (cont.)	4.1.6 Describe the mechanism of ultrafiltration: • afferent arterioles are wider in diameter than efferent arterioles; • high blood pressure within glomerular capillaries as the main driving force for filtration; • osmotic gradient from the filtrate in the nephron into the glomerular capillaries opposes the blood pressure; • resistance to further filtration due to back pressure of the filtrate in the nephron; • appreciate which components of blood are commonly filtered and which are not and the reasons why. 4.1.7 Describe the mechanism of selective reabsorption: • in the proximal convoluted tubule there is active transport of salt, glucose and amino acids from the filtrate into the cuboidal epithelium and then into the capillaries of the vasa recta system; • lowering of the solute potential in the cuboidal epithelium and blood capillaries; • resultant osmotic gradient responsible for the bulk of water reabsorbed; • in the distal convoluted tubule/collecting ducts there is facultative reabsorption of water dependent on the permeability of the epithelial lining which, in turn, is dependent on the level of ADH in the blood.
(c) Endocrine control and osmoregulation	4.1.8 Appreciate (in outline only) the role of the Loop of Henlé: • creates a salt gradient, and thereby an increasingly negative solute potential, in the medulla tissue of the kidney; • potential for osmotic extraction from the filtrate in the descending limb of the Loop of Henlé, distal convoluted tubule and collecting duct.

Content	Learning Outcomes
4.1 Homeostasis **(c) Endocrine control and osmoregulation (cont.)**	Students should be able to: 4.1.9 Understand the mechanism of osmoregulation in a mammal: • osmoreceptors in the hypothalamus are sensitive to the solute potential of the blood; • variation in the synthesis of ADH by the hypothalamus in relation to the solute potential of the blood; • ADH stored and released from the pituitary gland into the bloodstream; • ADH increases the permeability of the distal convoluted tubule and collecting ducts to water. 4.1.10 Understand the principle of negative feedback as exemplified by the role of ADH in osmoregulation in mammals: • the solute potential of the blood is lowered during exercise; • the corrective mechanism involves increased ADH synthesis and release into the bloodstream; • consequent increased reabsorption of water from the filtrate into the blood; • increased solute potential of the blood results in decreased ADH secretion, thereby inactivating the corrective mechanism.
4.2 Immunity	4.2.1 Appreciate the natural barriers to infection in humans: • skin, acid, tears and mucus (containing lysozyme). 4.2.2 Understand the terms antigen and antibody: • antigens as chemicals capable of provoking the production of specific and complementary antibodies; • antibodies as globular proteins which are specific and complementary to particular antigens and which can react with antigens leading to their destruction (details of antibody structure and classification of antibody types NOT required).

Content	Learning Outcomes
4.2 Immunity (cont.)	Students should be able to: 4.2.3 Distinguish between antibody-mediated and cell-mediated immunity: • antibody-mediated immunity involving division of particular B-lymphocytes after exposure to foreign antigens to form; - plasma cells capable of synthesising and secreting specific antibodies - memory cells providing long-term immunity • concept of delay in such antibody-mediated reactions and consequences for the infected individual; • cell-mediated immunity involving the role of T-lymphocytes; • Division of T-lymphocytes sensitised by viral antigens, abnormal self antigens (tumours) or transplanted foreign tissue antigens to form a pool of different types of T-lymphocytes; - killer T-cells capable of direct enzymatic destruction of foreign invading antigens - helper T-cells which co-operate with B-cells in the formation of some types of antibody - memory T-cells providing long-term immunity to specific antigens. 4.2.4 Describe an antigen-antibody reaction: • agglutination involving formation of a specific antigen/antibody complex; • phagocytosis of this complex by polymorphs; • destruction of the antigen by intracellular digestion involving lysosomal enzymes. 4.2.5 Contrast active and passive immunity (in outline only): • active immunity involves an individual's own immune system producing specific antibodies, t-cells and memory cells to particular foreign antigens; • passive immunity involves donation of antibody from another source, including; - placental (uterine) transfer - colostral transfer - transfer from an individual convalescing from a clinical infection/another animal following vaccination • active immunity providing long-term immunity whereas passive immunity provides short-term immunity only.

Content	Learning Outcomes
4.2 Immunity (cont.)	Students should be able to: 4.2.6 Understand the concept of transplant rejection: • transplanted/transfused tissue from a donor exposes a recipient's immune system to foreign antigens; • production of specific T-cells/B-cells which attack and destroy the introduced tissue. 4.2.7 Understand the principle of immunosuppression and its consequences: • inactivation of specific B- and T-cell responses using irradiation by X-rays or using drugs which inhibit DNA replication; • introduced foreign antigens not recognised and therefore no immune response; • individual with a suppressed immune system is more susceptible to infection. 4.2.8 Understand human blood antigens and the basis of blood group polymorphism: • blood group specified by the antigen type present on the surface membrane of erythrocytes; • four blood groups recognised in the ABO system (A, B, AB, O); • individuals possessing a particular type of antigen cannot possess complementary antibody in their plasma; • rhesus antigen (antigen D) may also occur on the surface membrane of erythrocytes; • anti-rhesus antibodies do not naturally occur in any individual; • production of anti-rhesus antibodies; - Transfusion error where a rhesus negative individual is given rhesus positive blood and the consequence thereof - a rhesus negative mother is exposed to the rhesus antigens of her rhesus positive baby and the consequences for that child and future children. 4.2.9 Appreciate the principles of blood transfusion compatibility: • comparison of donor antigens and recipient's plasma antibodies to determine compatibility; • antibodies in donated blood have a negligible effect on the recipient's erythrocytes. 4.2.10 Appreciate the consequences of transfusion incompatibility: • formation of antigen/antibody complexes resulting in agglutination of erythrocytes; • potential for blockage of the blood/O_2 supply to a tissue and the consequence thereof.

Content	Learning Outcomes
4.3 Coordination and Control **(a) Plants**	Students should be able to: 4.3.1 Understand the role of phytochromes in the control of flowering in long-day and short-day plants: • phytochromes as pigments found in the leaves of flowering plants; • phytochromes occur in two interchangeable forms - P_{660} which absorbs red light and rapidly converts to P_{730} - P_{730} which absorbs far-red light and slowly converts to P_{660} • concept of a critical length of night (dark period) required to remove P_{730}; • appreciate that removal of P_{730} is required for short-day plants to flower; • appreciate that non-removal of P_{730} allows long-day plants to flower; • appreciate that artificial manipulation of the photo-period (and the consequent effect on the levels of P_{660}/P_{730} present in the leaves) allows plants to flower out-of-season. 4.3.2 Understand the role of plant growth substances (hormones) in stem elongation: • auxins promote cell elongation; • cytokinins promote cell division; • gibberellins promote elongation of internodal regions. 4.3.3 Understand the role of auxins in phototropism: • directional light stimulus results in the lateral displacement of auxin to the non-illuminated side of the shoot; • a differential growth response results in positive phototropism; • appreciate the significance of positive phototropism in the shoots of plants; • appreciate (in outline only) the experimental evidence for the role of auxins in phototropism (Darwin's experiments, Boysen-Jensen's experiments, Went's experiments).

Content	Learning Outcomes
4.3 Coordination and Control **(b) Animals**	Students should be able to: 4.3.4 Describe the structure of a neurone: • recognise the following components in LM and TEM photographs and diagrams; - dendrons/dendrites - cell body - axon - Schwann cell/myelin sheath - node of Ranvier. 4.3.5 Understand the generation and transmission of nerve impulses: • resting potential/polarisation of the axon; • concept of a threshold stimulus; • all-or-nothing law; • depolarisation and development of an action potential; • propagation of action potentials along an axon by a flow of current in a series of localised circuits; • concept of a refractory period following the development of an action potential when a further stimulus will not elicit another action potential; • requirement of repolarisation before a further action potential can develop; • appreciation of factors which influence the speed of impulse conduction; - diameter of the axon - myelination of the axon and saltatory conduction (The ionic bases for neurone resting and action potentials NOT required).

Content	Learning Outcomes
4.3 Coordination and Control **(b) Animals (cont.)**	Students should be able to: 4.3.6 Describe the structure and functioning of a synapse: • recognise the following components in LM and TEM photographs and diagrams; - synaptic bulb - synaptic vesicles (containing neurotransmitter chemical) - pre-synaptic membrane - synaptic cleft - post-synaptic membrane • exocytosis of neurotransmitter (acetylcholine, noradrenaline) from the pre-synaptic membrane on arrival of an impulse; • diffusion of neurotransmitter across the synaptic cleft; • specific receptors on post-synaptic membrane; • development of an excitatory post-synaptic potential, depolarisation and an action potential in the post-synaptic membrane; • role of acetylcholinesterase. 4.3.7 Understand the gross structure of the mammalian eye and the functioning of its component parts in normal vision: • conjunctiva, cornea, iris, pupil, lens, ciliary body and suspensory ligaments, aqueous and vitreous humour, retina, fovea, choroid, sclera, blind spot, optic nerve, rods and cones; • role of circular and radial muscles in the iris in the control of pupil diameter; • role of the ciliary body and suspensory ligaments in alteration of the curvature of the lens, and thereby achieving the refraction required for accommodation when viewing near and distant objects; • role of the pigment in the choroid layer preventing internal reflection; • appreciate the relative distribution of rods and cones in the retina.

Content	Learning Outcomes
4.3 Coordination and Control **(b) Animals (cont.)**	Students should be able to: • convergence of rods allowing summation of subthreshold light stimuli and thereby increased visual sensitivity; • appreciate that convergence of rods results in decreased visual acuity; • visual acuity provided by cones; • dark adaptation in rods involving the resynthesis of rhodopsin which had been broken down during exposure to light; • binocular vision allowing; - good distance and depth perception - wide visual fields - stereoscopic vision. 4.3.8 Practical Work: *Examine prepared slides/photographs of the mammalian eye:* • *recognise the following components;* • *conjunctiva, cornea, iris, pupil, ciliary body, suspensory ligaments, aqueous and vitreous humours, retina, choroid, sclera, blind spot, optic nerve, rods and cones.* 4.3.9 Understand the structure and function of voluntary (skeletal) muscle as an effector: • recognise the components of a sarcomere (A-band, I-band, H-band, Z-lines, M-line) in LM and TEM photographs and/or diagrams; • appreciate the changes in these components which occur within a sarcomere on contraction/relaxation; • the sliding filament theory of contraction including - attachment of myosin heads to actin filaments in the presence of calcium ions in the sarcoplasm - change in orientation of myosin heads resulting in movement of actin filaments over myosin rods - process requires ATP expenditure (the role of other proteins NOT required).

Content	Learning Outcomes
4.3 Coordination and Control **(b) Animals (cont.)**	Students should be able to: 4.3.10 Practical Work: *Examine prepared slides/photographs of skeletal muscle, cardiac muscle and smooth muscle:* • *recognise the characteristic features of skeletal muscle and cardiac muscle using LM and TEM photographs and smooth muscle using LM photographs.*
4.4 Ecosystems **(a) Populations**	4.4.1 Understand how populations grow: • the phases of population growth to include; - lag phase - exponential (log) phase - stationary phase - decline phase • competition for resources and/or accumulation of waste in influencing the exponential and stationary phases; • the availability of resources (renewable or non-renewable) in influencing the stationary and decline phases; • ecological terms to include; - population - resource - competition - biotic potential - carrying capacity - environmental resistance. 4.4.2 Distinguish between r- and K-selected species: • features of r-selected species; • features of K-selected species; • growth curves for r- and K-selected species (population growth equations NOT required). 4.4.3 Understand the ways in which populations may interact: • competition as a -/- interaction which generally leads to the elimination of one species; • mutualism as a +/+ interaction; • predation, parasitism and grazing as +/- interactions; • the effect of inter-specific competition and predator-prey interaction on growth curves.

Content	Learning Outcomes
	Students should be able to:
4.4 Ecosystems	
(a) Populations (cont.)	4.4.4 Understand the general principles of biological control of pest species: • definition of a pest species; • use of predators or competitors as biological control organisms; • advantages of biological control over chemical control; • features of effective biological control. 4.4.5 Understand the dynamics of populations: • changes in population size determined by; - birth - death - immigration - emigration • factors influencing population size seasonally and from year to year. 4.4.6 Practical Work: *Investigate the growth of a yeast population using a haemocytometer:* • *components of a culture medium for a yeast population;* • *use of a haemocytometer to include counting cells over a grid of determined volume and the calculation of cell density.* *Estimation of the size of an animal population using a simple mark/recapture technique:* • *marking techniques;* • *assumptions made when using a mark/recapture technique;* • *estimation of population size using the Lincoln index (Peterson estimate).*
(b) Communities	4.4.7 Understand the concept of an ecological community: • a community as the biotic component of an ecosystem and involving interactions between autotrophic and heterotrophic populations. 4.4.8 Understand the concept of an ecosystem: • a community of different species which are interdependent and interact with each other and their abiotic environment, involving energy flow, nutrient and gas exchanges.

Content	Learning Outcomes
4.4 Ecosystems **(b) Communities (cont.)**	Students should be able to: 4.4.9 Understand the process of community development: • initial colonisation of a habitat by pioneer species; • succession as a change in the species composition in a community with time culminating in a climax community; • climax community as the stable end stage of a succession which is in equilibrium with the environment; • biotic and climatic climaxes; • primary succession as a relatively slow process of community development in a previously unoccupied area; • secondary succession as a predictable, repeatable and faster process of community development in an area where the climax community was destroyed by fire, flooding, wind damage or human interference; • appreciate that complex communities are relatively more stable when compared with simple communities.
(c) Ecological energetics	4.4.10 Understand food chains and food webs: • the role of producers and consumers (herbivores and carnivores) in grazing food chains and, additionally, the role of detritivores and decomposers in detritus food chains. 4.4.11 Understand trophic levels: • primary producers as the first trophic level; • net primary production as the gross primary production less respiration; • other trophic levels to include primary, secondary and tertiary consumers, and detritivores and decomposers.

Content	Learning Outcomes
4.4 Ecosystems	Students should be able to:
(c) Ecological energetics (cont.)	4.4.12 Understand the quantitative relationship between trophic levels: • pyramid relationships and their relative usefulness; - pyramids of numbers - pyramids of biomass - pyramids of energy (productivity) • calculation of the efficiency of energy transfer through trophic levels; • reasons for the low percentage of solar radiation absorbed by plants in photosynthesis; • reasons for the reduction in energy at progressive trophic levels; - losses to the decomposer food chain - losses through egestion and excretion - the difficulty of digesting plant material (eg cellulose) and the relatively high losses via egestion in primary consumers (herbivores) - losses through respiration (with energy dissipated as heat) - the relatively high losses via respiration in endotherms (mammals and birds). 4.4.13 appreciate the implications for agriculture: • extra energy cost of producing animal products; • aspects of intensive farming methods to include; - the use of fertilisers to increase primary productivity - confinement to improve respiration/production ratio - the use of high energy foods such as silage and high protein foods.
(d) Nutrient cycling	4.4.14 Explain the cycling of carbon in the ecosystem: • respiration, combustion and decomposition as processes which add CO_2 from the atmospheric pool; • Photosynthesis removes CO_2 from the atmospheric pool.

Content	Learning Outcomes
	Students should be able to:
(d) Nutrient cycling (cont.)	• the role of decomposers, nitrifying bacteria and N_2-fixing bacteria in provision of nitrogen in a suitable form for plants: - decomposers releasing ammonium compounds; - nitrifying bacteria oxidising ammonium to nitrate; - N_2-fixing bacteria synthesising organic nitrogen-containing compounds (amino acids); - dentrification returning N_2 to the atmospheric pool.
(e) Adverse impact of human activity on the environment	4.4.15 State the source/cause of specific pollutants and understand the effects of these pollutants on food chains/the environment and human health: • global warming; - increased levels of CO_2 in the atmosphere due to combustion of fossil fuels - melting of polar ice caps and the consequent rise in sea levels and coastal flooding - change in climatic patterns • ozone depletion; - use of CFCs as aerosol propellants and coolants in refrigeration units - increased penetration of UV light - increased risk of skin cancer and eye cataracts • acid rain; - combustion of fossil fuels releasing SO_2/NO_2 into the atmosphere where reaction with water forms acid rain - defoliation of trees - acidification of waterways releasing aluminium from bedrock which causes mucus to coagulate on fish gills and consequent asphyxiation • appreciate remedies for the above aspects of pollution.

Content	Learning Outcomes
4.4 Ecosystems **(e) Adverse impact of human activity on the environment (cont.)**	Students should be able to: 4.4.16 Appreciate traditional farming methods: • use of a wide variety of crops; • use of crop rotation and its advantages including; - reduced risk of development of mineral deficient soils - reduced risk of problems with pests • use of mixed livestock; • use of organic fertiliser (especially farmyard manure) and its careful application provide advantages including; - improved soil crumb structure and thereby improved soil aeration and drainage (detail of soil structure NOT required) - reduced risk of eutrophication of water bodies. 4.4.17 Appreciate the adverse impact of intensive farming methods: • increased use of monocultures resulting in; - increased problems with weeds - infestations of pests and diseases - reduced biodiversity • increased dependency on artificial fertiliser resulting in; - loss of soil crumb structure - increased risk of eutrophication of water bodies - reduced biodiversity • removal of hedgerows resulting in; - increased risk of soil erosion - reduced biodiversity • increased dependency on pesticides; - concept of a 'pest' species - consequences of the use of broad spectrum, non-biodegradable pesticides to eradicate a pest (bioaccumulation in food chains and the potential for target pest resurgence) • problems of disposal of the large quantities of slurry produced by intensively farmed animals; - contains suspended solids (increased turbidity and so smothering aquatic vegetation) - may contain toxic residues of veterinary medicines - slurry may cause population explosions of bacteria in water bodies resulting in increased BOD and thereby reduced biodiversity.

Content	Learning Outcomes
4.4 Ecosystems **(e) Adverse impact of human activity on the environment (cont.)**	Students should be able to: 4.4.18 Understand the particular problems of agricultural pollution in NI: • eutrophication; - mineral enrichment of water bodies such as Lough Neagh and Lough Erne - lowland agriculture as the major source of nitrate input to Lough Neagh and to the rivers of the Lough Erne catchment - many soils are overloaded with phosphate from artificial fertiliser (while there is additional phosphate from household waste though this may be removed in sewage works) - algal blooms (loss of water transparency and problems with odours) - decomposition of algae increases the BOD - reduced biodiversity - loss of fisheries - health risks from contamination of drinking water by toxic algae and the cost of their removal • organic pollution by slurry and silage effluent; - effect on BOD values in water bodies - effect on flora/fauna/biodiversity in water bodies • appreciate the need for monitoring of water bodies, eg the use of aquatic invertebrates as 'Indicator Species'; • appreciate issues with slurry application including; - need for optimal soil/weather conditions to minimise the risk of pollution - the need for 'closed periods' • appreciate the potential use of constructed reed beds to treat lightly contaminated farm waste.

Content	Learning Outcomes
4.4 Ecosystems **(e) Adverse impact of human activity on the environment (cont.)**	Students should be able to: 4.4.19 Appreciate strategies to reduce the risk of eutrophication in water bodies due to leaching of artificial fertilisers: • careful calculation of application levels so that 'supply does not exceed demand' in the target crop; • only apply artificial fertiliser immediately prior to or during periods of vigorous plant growth; • do not apply artificial fertiliser when heavy rain is forecast; • do not apply artificial fertiliser adjacent to water bodies; • appreciate the existence of governmental guidelines (details NOT required); - DARD NI Code of Good Agricultural Practice for the Prevention of Pollution of Water - EC Nitrates Directive Action Programme (NI is a total territory designation for this EC Nitrates Directive). 4.4.20 Understand that sustainable farming depends on the effective management of the conflict between increased food production and the need for environmental conservation: • promote increased use of polyculture instead of monoculture resulting in; - greater biodiversity - greater difficulty for pest populations to become established • increased use of organic fertiliser (farmyard manure); - improves existing soil crumb structure, aeration and drainage - reduces risk of soil erosion - reduces risk of leaching and thereby reduces risk of eutrophication • improved maintenance of existing hedgerows/replanting of hedgerows; - decreases the risk of soil erosion - improves biodiversity • terracing/ploughing across slopes to reduce soil erosion.

Content	Learning Outcomes
(e) Adverse impact of human activity on the environment (cont.)	Students should be able to: • use of photodegradable plastic around/between crop plants (eg maize) to prevent growth of weeds and reduce dependence on herbicides; • integrated Pest Management Systems that include use of; - specific, natural predators/parasites of pests - non-persistent pesticides - sterile males of pest species - crop rotation (more difficult for pest species to become established) - selective breeding/genetically modified varieties of crops with improved pest/disease resistance. 4.4.21 Understand the concept of managed timber production as a sustainable resource: • timber as a renewable resource with a sustainable yield; • 'set-aside' land schemes; • coppicing allows harvesting of wood eg ash and willow, while maintaining the forest ecosystem; • appreciate the advantages/disadvantages of softwood and hardwood forests; - softwood forests eg larch and spruce grow more quickly - the high density of softwood forest planting decreases biodiversity - indigenous hardwood forest, eg ash and oak provides greater variety of habitats and increased biodiversity compared to introduced larch and spruce.

3.5 Unit A2 2: Biochemistry, Genetics and Evolutionary Trends

This unit deals with Respiration, Photosynthesis, DNA as the Genetic Code, Gene Technology, Genes and Patterns of Inheritance, Mechanism of Change, Kingdom Plantae, and Kingdom Animalia.

Content	Learning Outcomes
5.1 Respiration	Students should be able to: 5.1.1 Recognise 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. 5.1.2 Understand glycolysis: • as a process common to aerobic and anaerobic respiration; • occurs in the cytoplasm; • 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 (2 ATP per glucose molecule). 5.1.3 Understand 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. 5.1.4 Understand 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.

Content	Learning Outcomes
5.1 Respiration (cont.)	Students should be able to: 5.1.5 Understand 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. 5.1.6 Understand 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. 5.1.7 Compare aerobic and anaerobic respiration: • the larger yield of ATP from aerobic than anaerobic respiration, though dependent on the availability of oxygen; • the significance of anaerobic respiration in providing ATP without the use of oxygen; • the different strategies for anaerobic respiration in animals, and in plants and fungi: in animals extra ATP is generated rapidly, over and above that produced aerobically (for a burst of activity over a short period of time) and results in an oxygen debt; in plants and fungi anaerobic respiration allows survival for some time in anaerobic conditions; • oxygen debt as the additional oxygen required to further metabolise accumulated lactic acid and/or resynthesise depleted ATP. 5.1.8 Understand the respiratory quotient: • measuring the RQ as the ratio of CO_2 produced to oxygen consumed in a respiring organism; • used to identify respiratory substrates and in detecting anaerobic respiration.

Content	Learning Outcomes
5.1 Respiration (cont.)	Students should be able to: 5.1.9 *Practical Work:* *Refer to the use of a simple respirometer in 2.1 (b).* *Demonstrate the role of hydrogen acceptors using redox indicator (such as methylene blue or tetrazolium chloride):* • *calculation of RQ values.*
5.2 Photo-synthesis	5.2.1 Describe the sites in the chloroplast where the reactions of photosynthesis occur: • light-dependent stage on the thylakoids; • light-independent stage in the stroma. 5.2.2 Understand 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) (Cyclic photophosphorylation NOT required); • 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^-) resulting from the dissociation of water with the concomitant release of oxygen. 5.2.3 Understand 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). 5.2.4 Appreciate that light is absorbed by chlorophyll and associated pigments: • absorption spectra to show peak absorption by different pigments; • action spectrum showing which wavelengths of light promote the optimum rate of photosynthesis.

Content	Learning Outcomes
5.2 Photo-synthesis (cont.)	Students should be able to: 5.2.5 Understand external factors limiting the rate of photosynthesis: • photosynthesis measured as CO_2 – uptake or O_2 – production; • gross photosynthesis, net photosynthesis and the compensation point; • light availability, CO_2 availability and temperature limiting the rate of photosynthesis. 5.2.6 Practical Work: *Refer to the use of the Audus apparatus in 2.1 (b):* • *the effect of light intensity and CO_2 concentration on the rate of photosynthesis;* *Carry out paper chromatography of plant pigments:* • *preparation and running of the chromatogram;* • *calculation of R_f values;* *Demonstrate the role of hydrogen acceptors using redox indicator (such as DCPIP).*
5.3 DNA as the Genetic Code	5.3.1 Understand the nature of the genetic code: • understand that a gene is a sequence of bases on the DNA molecule which codes for a sequence of amino acids in a polypeptide chain; • the genetic code as a non-overlapping, degenerate, three base code. 5.3.2 Understand the process of transcription in the synthesis of proteins: • 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 (which acts as the template); • the structure of mRNA and the role of RNA transcriptase. 5.3.3 Understand the process of translation in the synthesis of proteins: • 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 (peptidyl and aminoacyl) for condensation to form a polypeptide or protein; • outline the structure and function of tRNA and ribosomes.

Content	Learning Outcomes
5.3 DNA as the Genetic Code (cont.)	Students should be able to: 5.3.4 Explain the one gene/one polypeptide theory: • a gene codes for one polypeptide; • enzymes as proteins whose synthesis is controlled by DNA (and since they control metabolic pathways they influence the phenotype of an organism).
5.4 Gene Technology	5.4.1 Explain the stages involved in gene transfer: • methods used to obtain donor DNA, eg use of restriction endonucleases and reverse transcriptase; • use of DNA probes to locate the DNA fragment with the desired gene; • incorporation of donor genes into a 'vector', eg bacteriophages and bacterial plasmids; • transformation of recipient cells, eg *Escherichia coli*, *Saccharomyces cerevisiae;* • method used to check that the recipient cell contains the recombinant DNA eg use of marker (antibiotic resistance) genes; • selection and cloning of transformed cells. 5.4.2 Appreciate the range of substances produced by genetically engineered micro-organisms: • insulin, human growth hormone (HGH), enzymes, adhesives, lung surfactant protein, interferon (details of production NOT required). 5.4.3 Appreciate the role of 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; • production of substances of medical value, eg interferon, blood-clotting factors, alpha-1-antitrypsin, human serum albumin, haemoglobin, vaccines; • 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.

Content	Learning Outcomes
5.4 Gene Technology (cont.)	Students should be able to: 5.4.4 Explain gene therapy, showing an appreciation of advantages and problems: • an appreciation that genetic disease may be caused by an absent or faulty gene; • the introduction of a functional gene to restore 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. 5.4.5 Understand genome sequencing projects: • genome of an organism as the complete DNA sequence (on one set of chromosomes in diploid, eukaryotic organisms); • genome sequencing as the determination of the order of nucleotides (bases) and so the genetic code; • appreciate that sequencing projects have been undertaken for a range of organisms such as the virus phage λ, the bacterium *Escherichia coli*, the plant *Arabidopsis thaliana*, the fruit fly *Drosophila melanogaster* and humans; • understand that a knowledge of the genetic code allows the primary structure of proteins to be determined (and that molecular modelling software can then predict secondary, tertiary and quaternary protein structure); • the Human Genome Project organised to map and sequence 3 million nucleotides in the human genome and to identify all the genes (approximately 25 000) present in it (details of the technology is NOT required); • appreciate that the creation of a genome library has implications for the study of genetic disorders and, ultimately, supports; - the use of gene therapy, eg to treat cystic fibrosis; - genetic testing using 'DNA chips' to determine if an individual is a carrier of a genetic disorder, eg sickle-cell anaemia; - improved diagnostics to test for the presence of genes that increase susceptibility of an individual to eg cancer or heart disease; - development of 'designer' drugs matched to an individual's genetic profile.

Content	Learning Outcomes
5.4 Gene Technology (cont.)	Students should be able to: 5.4.6 Appreciate that the inactivation or replacement of genes facilitates the understanding of gene and organism function: • understand that genes may be made inoperative (disabled or removed – details of the techniques not required) or replaced with defective alleles; • understand that these strategies allow the gene's role in protein production and subsequently in metabolism to be assessed; • the mouse (knockout mouse and knockin mouse) as a model organism for the study of genes; • these techniques can be used to study the development of genetic disorders and drug therapies. 5.4.7 Appreciate social, legal, ecological and ethical issues regarding the benefits and risks of gene technology: • the social and ethical implications of gene technology; • the potential risks associated with genetically modifying organisms; • safety precautions currently employed, eg use of bacterial strains ill-adapted to the human physiology, 'suicide genes', containment mechanisms; • the limitations of gene transfer (transferring the gene to sufficient target cells) and potential dangers of gene transfer (possible disruptive effects on host DNA causing cancer); • the need for legislation.
5.5 Genes and Patterns of Inheritance	5.5.1 Understand the terms genotype and phenotype: • definition of the terms genotype and phenotype; • the role of the genotype and the environment in determining an organism's phenotype; • homozygosity and heterozygosity. 5.5.2 Understand the relationship between chromosomes, genes and alleles: • definition of the term gene; • genes are located on chromosomes; • alleles as alternative forms of the same gene; • alleles are located at the same locus on homologous chromosomes in diploid organisms.

Content	Learning Outcomes
5.5 Genes and Patterns of Inheritance (cont.)	Students should be able to: 5.5.3 Understand the inheritance of traits showing discontinuous variation: • monohybrid inheritance; • mendel's first law of inheritance as the law of segregation of factors; • dominance and recessiveness; • codominance and incomplete dominance; • lethal allelic combinations; • multiple alleles; • test crosses as crossing with the recessive individual to ascertain the genotype of an individual with a more dominant trait; • dihybrid inheritance; • mendel's second law of inheritance as the law of independent assortment of factors; • mendel's laws and meiosis; • solving inheritance patterns; - genetic diagrams using a standard format - punnett square when appropriate (when there is more than one type of gamete possible from both parents). 5.5.4 Understand sex determination and sex linkage: • autosomes and sex chromosomes; • sex determination in mammals (xx and xy); • the inheritance of sex-linked characters (recessive and dominant). 5.5.5 Gene interaction: • gene interaction including epistasis; • the inheritance of traits showing gene interaction. 5.5.6 Understand the inheritance of traits showing continuous variation (polygenic inheritance): • continuous variation as due to the additive effects of genes (polygenes); • the effects of the environment in contributing to continuous variation.

Content	Learning Outcomes
5.6 Mechanism of Change	Students should be able to: 5.6.1 Understand the concept of the gene pool: • the gene pool as the total sum of the alleles of and genotype and allele frequencies of a gene in a population; • phenotype and genotype frequencies; • allele frequencies. 5.6.2 Understand the Hardy-Weinberg equation and apply it to calculate allele and genotype frequencies in an outbreeding population: • the allele frequencies as p and q for alleles A and a respectively; • the Hardy-Weinberg equation as $p^2 + 2pq + q^2 = 1$, and its use; • the genotype frequencies as p^2, 2pq and q^2 for genotypes AA, Aa and aa respectively; • determination of the allele and genotype frequencies from the frequency of the recessive trait (q^2); • the Hardy-Weinberg principle as the situation in which a genetic equilibrium is maintained and in which, at fertilisation, alleles combine randomly; • the conditions which must be met for the application of the Hardy-Weinberg equation; • the influence of mutation, non-random fertilisation, migration and selection on allele and/or genotype frequencies. 5.6.3 Understand the source and maintenance of genetic variation: • heterozygotes as important reservoirs of genetic variation in populations; • mutation as a source of genetic variation; • gene mutation (limited to base deletions and substitutions); • chromosome mutation (aneuploidy and polyploidy) • mutagenic agents; • the significance of polyploidy in plant breeding; • sexual reproduction with cross-fertilisation as a means of maintaining genetic variation.

Content	Learning Outcomes
5.6 Mechanism of Change (cont.)	Students should be able to: 5.6.4 Understand selection and its contribution to the maintenance of polymorphic populations and evolutionary change in populations: • selection as a process operating on the genetic variation in a population; • selection as the differential perpetuation of alleles to subsequent generations, and involving both survival and reproduction; • types of selection confined to stabilising and directional selection; • stabilising selection favouring the modal/intermediate variants in a population; • directional selection favouring one extreme variant in a population; • polymorphic populations as a means of investigating stabilising and directional selection; • evolutionary change as the change in the frequencies of alleles in a population; • examples of directional selection in action leading to evolutionary change in populations. 5.6.5 Understand the concept of species and the process of speciation: • a species as a group of organisms which (at least potentially) forms an interbreeding collection of populations unable to breed freely with other species; • allopatric speciation leading to new species diverging genetically when geographically isolated; • reproductive isolating mechanisms maintaining the genetic divergence; • the significance of polyploidy in plant speciation (eg *spartina* species).

Content	Learning Outcomes
5.7 Kingdom Plantae	Students should be able to: 5.7.1 Describe the form (level of organisation) and life cycle in 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 multicelluar plants showing the 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. 5.7.2 Describe the form (level of organisation) and life cycle in 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).

Content	Learning Outcomes
5.7 Kingdom Plantae (cont.)	Students should be able to: Form: • these are multicellular plants showing differentiation into true roots, stems 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 embryosac which produces the egg nucleus and polar nuclei by mitosis; • both the male and female gametes are protected from desiccation; • double fertilisation producing a diploid zygote and a triploid primary endosperm nucleus. 5.7.3 Compare the divisions of Plantae: • the divisions listed above should be studied to illustrate progression in the level of organisation and of the life cycles.

Content	Learning Outcomes
5.8 Kingdom Animalia	Students should be able to: 5.8.1 Describe the body form and feeding in Phylum Cnidaria: • diploblastic animals showing little differentiation; • example: *hydra.* Form: • 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 following endocytosis. 5.8.2 Describe the body form and feeding in Phylum Platyhelminthes: • triploblastic animals showing tissue differentiation but no body cavity; • example: a planarian. Form: • 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. 5.8.3 Describe the body form and feeding in Phylum Annelida: • triploblastic animals with a body cavity (coelomate) and well developed tissue differentiation; • example: an earthworm.

Content	Learning Outcomes
5.8 Kingdom Animalia (cont.)	Students should be able to: Form: • there are three body layers (ectoderm, mesoderm, 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; • 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. 5.8.4 Describe the body form and feeding in Phylum Chordata: • triploblastic, coelomate animals with an internal skeleton; • example: a small mammal. Form: • there are three body layers (ectoderm, mesoderm, 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; • mammals may be active predators, omnivores or herbivores. Feeding: • the gut has both a mouth and an anus and well developed specialised regions; • digestion is extracellular. 5.8.5 *Practical Work:* *Study appropriate living and preserved specimens, prepared slides and photographs.*

3.6 Unit A2 3: Assessment of Investigational and Practical Skills in Biology

Introduction

The problem solving/investigational skills of each candidate will be demonstrated by means of a practical investigation that is 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.

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

Skill Area	Description	Marks
Al	Developing a hypothesis using biological knowledge	10
A2	Planning a procedure to test the hypothesis	10
A3	Planning for analysis	10
B1	Implementing a procedure	10
B2	Recording and communicating in the form of a table	10
C1	Statistical analysis (or graphical analysis)	10
C2	Interpretation of the results	10
C3	Evaluation of the practical procedures	10
		Maximum 80

A1 Developing a hypothesis

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

- Outline your biological knowledge or research related to the problem under investigation. 2 marks
- Use appropriate biological knowledge and understanding. 2 marks
- Select ideas from the information relevant to the investigation. 2 marks
- Link your ideas together to suggest an explanation. 2 marks
- State precisely in a hypothesis the most appropriate explanation. 2 marks

Total 10 marks

A2 Planning a procedure

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

- Use suitable equipment and materials. 2 marks
- Select a suitable range for the independent variable or suggest conditions for the experimental treatment. 2 marks
- Communicate an ordered sequence to follow as a procedure. 2 marks
- Provide a fair test. 2 marks
- Predict the result of the test of the hypothesis. 2 marks

Total 10 marks

A3 Planning for analysis

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

- Clearly state what must be recorded. 2 marks
- Specify the format to be used to present the results. 2 marks
- Decide which method of analysis will be most appropriate and justify your selection. 2 marks
- Decide how much replication is required for successful analysis. 2 marks
- Consider the feasibility of replication, considering the time and materials available. 2 marks

Total 10 marks

B1 Implementing

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

- Skilful handling of apparatus and materials 2 marks
- Appropriate safety procedures and care of living organisms they observed 2 marks
- Organised and methodical carrying out of the practical procedure 2 marks
- Adhering to the sequence of planned actions and making modifications as appropriate 2 marks
- Measurements at the level of precision required 2 marks

Total 10 marks

B2 Recording and communicating

The following must be included to satisfy the mark scheme for **tabulation** of raw and derived data when a table is the most appropriate form of communication of the data:

- Organisation of the raw data with the dependent variable in the body of the table and treatments or range of the independent variable as columns/rows 2 marks
- A caption, which is a concise statement identifying the variables included in the table and states the biological material used as the source of the data 2 marks
- Logical construction of the table (organised for analysis) 2 marks
- Explanatory column headings 2 marks
- Units for all variables and calculated values 2 marks

Total 10 marks

C1 Analysis

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

- A table of statistical parameters 2 marks
- Statement of an appropriate null hypothesis 2 marks
- Accurate calculation of statistic 2 marks
- Correct determination of probability value 2 marks
- Correct decision regarding the null hypothesis 2 marks

Total 10 marks

or

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

- A table of statistical parameters 2 marks
- Accurate calculation of confidence limits 2 marks
- A caption fully explaining the data plotted 2 marks
- Appropriate scale and labels for axes 2 marks
- Correct plotting of means and confidence limits 2 marks

Total 10 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 using statistical evidence 2 marks
- Comments about the reliability of the data 2 marks
- Trend(s) clearly identified using statistical evidence 2 marks
- Explanation of the trend(s) 2 marks
- Use of appropriate biological knowledge and understanding 2 marks

Total 10 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:

- Comments on the appropriateness of the range of the independent variable or the conditions for the experimental treatment 2 marks
- The procedures used to prevent variation of factors not under investigation 2 marks
- Comments on the appropriateness of the observations/measurement 2 marks
- Assessment of the validity of the implementation of the procedure 2 marks
- An outline of how another independent variable could be investigated 2 marks

Total 10 marks

Scheme of Marking

In each Skill Area, each of its subdivisions is to be assessed on the following scale:

A **score of 2** should be awarded to a candidate who shows competence, independence and, if necessary, initiative in the subdivision of the Skill Area under consideration. The actual criteria used in assessing these qualities will depend on the specific skill and on the category of practical exercise being carried out by the candidate.

A **score of 1** should be awarded to a candidate who falls short in one of the above qualities in the performance of the task required but who, nonetheless, shows satisfactory practical skills. For example, if it is necessary for the teacher to provide guidance to the candidate, a score of 1 is appropriate.

A **zero score** should not be awarded unless a candidate fails to attempt a task which would enable the skill to be assessed.

The teacher should ensure that, as far as possible, a candidate does not lose marks more than once as a consequence of a single error in practice or in calculation.

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.

Students should be made aware at the beginning of the course that their class practical work may 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 student 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 work must be annotated to show how marks have been awarded in relation to the relevant criteria.

Recording assessments

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

Moderation of assessments

Centres will be required to submit selected samples of students' internally assessed work to the Council for moderation. Samples from each centre, selected according to criteria supplied annually by us, will be required initially. We may, if necessary, require all students' work from a centre to be submitted during the moderation process. Prior to moderation, centres will ensure that a process of internal moderation has been carried out.

4 Scheme of Assessment

4.1 Assessment opportunities

Students can choose to be assessed in stages during their AS and A Level courses or to leave all assessment to the end of these courses. The availability of assessment units is shown in Section 2 of the specification.

Students can choose to resit AS and A2 assessment units. The best result for each assessment unit will count towards the AS and A Level qualifications.

Results for each assessment unit can continue to contribute to an AS or A Level qualification while the specification is offered.

4.2 Assessment objectives

The assessment objectives of the specification are listed below:

AO1: Knowledge and Understanding of Biology and of How Biology Works

Students should be able to:

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

AO2: Application of Knowledge and Understanding of Biology and of How Biology Works

Students should be able to:

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

AO3: How Biology Works

Students should be able to:

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

In the context of the assessment objectives, the following definitions apply:

- *Knowledge* includes facts, specialist vocabulary, principles, concepts, theories, models, practical techniques, studies and methods.

- *Issues* includes ethical, social, economic, environmental, cultural, political and technological.

- *Processes* includes collecting evidence, explaining, theorising, modelling, validating, interpreting, planning to test an idea and peer reviewing.

The skills, knowledge and understanding of how biology works include the requirements set out below. These requirements are integrated into the content listed in Section 3.

- Use theories, models and ideas to develop and modify biological explanations.

- Use knowledge and understanding to pose biological questions, define biological problems, and present biological arguments and biological ideas.

- Use appropriate methodology, including ICT, to answer biological questions and solve biological problems.

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

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

- Evaluate methodology, evidence and data, and resolve conflicting evidence.

- Appreciate the tentative nature of scientific knowledge.

- Communicate information and ideas in appropriate ways, using appropriate terminology.

- Consider the applications and implications of biology and appreciate their associated benefits and risks.

- Consider ethical issues in the treatment of humans, other organisms and the environment.

- Appreciate the role of the biology community in validating new knowledge and ensuring integrity.

- Appreciate the ways in which society uses biology to inform decision-making.

Students will also need to be competent in the mathematical techniques set out in Section 4.6.

4.3 Assessment objective weightings

The assessment objective weightings for each assessment unit and the overall AS and A Level qualifications are set out in the table below. The actual percentages in the operational paper may cover a range conforming to those set out in the Science Criteria.

Assessment Objective	Assessment Unit					
	AS1	**AS2**	**AS3**	**A21**	**A22**	**A23**
AO1	42.5%	42.5%	20.0%	35.0%	35.0%	20.0%
AO2	42.5%	42.5%	20.0%	50.0%	50.0%	20.0%
AO3	15.0%	15.0%	60.0%	15.0%	15.0%	60.0%

Assessment Objective	Overall Weightings	
	AS	**A2**
AO1	35.0%	30.0%
AO2	35.0%	40.0%
AO3	30.0%	30.0%

Assessment Objective	A Level Award
AO1	32.5%
AO2	37.5%
AO3	30.0%

4.4 Quality of written communication

Assessment in AS and A Level Biology requires students to demonstrate their quality of written communication. In particular, students are required to:

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

Examiners assess the quality of students' written communication in their responses to questions or tasks that require extended writing. The examiners will make this assessment in any of the Assessment Units that include extended writing. The total marks for this assessment will be not more than one percent of the award.

4.5 Synoptic assessment

While an understanding of the links between topics is necessary at all levels (including AS), examiners will include synoptic assessment particularly in the A2 assessment units.

In GCE Biology, synoptic assessment requires students to demonstrate that they can:

- build on material first encountered in the AS Units;
- make and use connections between different areas of biology;
- apply knowledge and understanding of more than one area to a particular situation or context;
- use knowledge and understanding of the principles and concepts of biology in planning experimental work and in analysing and evaluating data; and
- use ideas and skills which permeate biology.

4.6 Background knowledge in mathematics, statistics and other sciences

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

To be able to develop the knowledge, understanding and skills in this specification, students need to be competent in the areas of mathematics set out below.

We will not set questions that are mainly about mathematical, statistical, physical or chemical processes, but students may need to use this knowledge to answer biological problems in the examination.

Mathematical and statistical knowledge

Items in bold type are for Advanced GCE only.

- 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 $x^n, \frac{1}{x}$ and $\sqrt{x}$.
- 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

- Solids, liquids and gases.
- Density.
- Change of state: evaporation, cooling by evaporation; saturated vapour pressure and relative humidity.
- Relation between pressure, volume and temperature of a gas.
- Partial pressures of gases.
- Solubility of gases; effects of temperature and pressure on solubility.
- Diffusion of gases and solutes. Osmosis.

We will use the following terms and symbols 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 cell, Ψ_{cell}: this term will be used to describe the algebraic sum of the solute and pressure potentials associated with the cell.

$\Psi_{cell} = \Psi_s + \Psi_p$

- Surface area to volume ratio.
- Temperature.
- Heat as a form of energy, transference of heat energy by conduction, convection and radiation.
- The electromagnetic spectrum. Colour in terms of wavelengths; filters, pigments.
- Basic principles of the compound optical microscope and electron microscope. Understanding of resolving power.

Chemical knowledge

Items in bold type are for Advanced GCE only:

- In general, we will name elements and compounds according to the current rules of the IUPAC, but we will also give familiar trivial names where appropriate.
- Recognition of the chemical symbols for atoms and ions featured in the syllabus content. (Chemical formulae will **not** be required **except** where indicated.)
- pH scale as a measure of hydrogen ion concentration.
- Acids and bases.
- Exergonic and endergonic reactions.
- Isotopes as tracers.
- **Oxidation and reduction: significance of addition or removal of oxygen or hydrogen or electrons.**

4.7 Practical work

We will expect students to have personal experience of the practical procedures listed below. Students should carry out all practical work according to current recommendations on safety in the laboratory and in the field.

When taking specimens from the field, students should have proper regard for:

- safety;
- the laws protecting wildlife; and
- the specialist advice published by the various conservation agencies.

No animal should be wounded or mutilated or deliberately infected with a disease or condition that is likely to cause pain or distress.

Practical work:

- accurate and critical observation of appropriate living and preserved specimens;
- setting up and using a light microscope to view slides of suitable tissues and cells up to ×400 magnification;
- using a haemocytometer;
- qualitative biochemical tests, including: use of iodine solution, Benedict's reagent, Clinistix, Biuret reagent and bicarbonate indicator, and paper chromatography;
- using a colorimeter, and probes/sensors for temperature, pH, light and oxygen;
- setting up and using a simple respirometer, J-tube apparatus and Audus apparatus;
- setting up simple Mendelian crosses using *Drosophila*; and
- using sampling procedures and devices in ecological investigations.

You will find suitable practical tasks at the end of the sub-sections in Section 3 of this specification.

The investigation, A2 3, should allow students 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. Students will use biological skills to plan procedures and statistical analyses to test the hypothesis. They will need a similar blend of knowledge, understanding and skills to fully analyse, interpret and evaluate the outcomes of the implemented procedures.

4.8 Stretch and challenge

The A2 assessment units will include opportunities for stretch and challenge. This will be achieved by:

- including questions constructed with a deliberate incline of difficulty and a decrease in structuring;
- use of a variety of stems in questions to elicit a full range of response types;
- ensuring connectivity between sections of questions;
- providing opportunities for extended writing;
- using a wide range of question types to address different skills; and
- using synoptic assessment.

4.9 Reporting and grading

We report the results of individual assessment units on a uniform mark scale that reflects the assessment weighting of each unit.

AS qualifications are awarded on a five grade scale from A to E with A being the highest. A Level qualifications are awarded on a six grade scale from A* to E with A* being the highest. We determine the AS and A Level grades awarded by aggregating the uniform marks obtained on individual assessment units. To be awarded an A*, candidates will need to achieve a grade A on their full A Level qualification and an A* on the aggregate of their A2 units. For students who fail to attain a grade E, we report their results as unclassified (U).

The grades we award match the performance descriptions published by the regulatory authorities (see Section 5.4).

5 Links

5.1 Support materials

CCEA currently provides the following materials to support this specification:

- specimen papers;
- mark schemes;
- resource list; and
- notes for guidance.

We will expand our range of support materials through a coordinated science programme to include:

- support days for teachers;
- launch events; and
- a microsite.

Details of our Annual Support Programme of events, and materials for GCE Biology, can be found on our website: www.ccea.org.uk.

5.2 Curriculum objectives

This specification addresses and builds upon the broad curriculum objectives for Northern Ireland, England and Wales. In particular it enables students to:

- study living organisms which includes their structure, functioning, origin, evolution, classification, interrelationships and distribution;

- address the spiritual, moral, ethical, environmental, social and cultural issues which arise from this study and which are met in certain parts of the specification:

  DNA Technology (1.3)
  Viruses (1.4)
  Human impact on biodiversity (2.3(b))
  Immunity (4.2)
  Ecosystems (4.4)
  Gene technology (5.4)
  Genes and patterns of inheritance (5.5)
  Mechanism of change (5.6)

- pay particular attention to health and safety considerations throughout their practical work, including fieldwork and coursework; and

- obtain a prerequisite qualification to gain entry to higher education in the field of Biology, or prepare for direct employment in the fields of science, engineering, medicine, communications, computers and information technology.

5.3 Key skills

This specification provides opportunities for students to develop Key Skills and generate evidence for assessing the following nationally recognised Key Skills:

- Communication: C3.1a, C3.1b, C3.2, C3.3 – all Units
- Information and Communication Technology: IT3.1, IT3.2, IT3.3 – all Units
- Application of Number: N3.1, N3.2, N3.3 – all Units
- Working with Others: WO3.1, WO3.2, WO3.3 – all Units
- Improving own Learning and Performance: LP3.1, LP3.2, LP3.3 – all Units
- Problem-Solving: PS3.1, PS3.2, PS3.3 – all Units.

You can find details of the current standards and guidance for each of these skills on the QCA website: www.qca.org.uk.

5.4 Performance descriptions

You can find performance descriptions for the AS and A2 judgemental A/B and E/U boundaries on the QCA website: www.qca.org.uk.

5.5 Examination entries

The following entry codes apply to individual assessment units and the overall AS and A Level cash-ins in Biology:

AS 1:	AAB11
AS 2:	AAB12
AS 3:	AAB13
AS cash-in:	S1012
A2 1:	AAB21
A2 2:	AAB22
A2 3:	AAB23
A Level cash-in:	A1012

You can view details of how to make entries on our website. Alternatively, you can contact our Entries Team using the details provided in Section 5.8.

5.6 Students with particular requirements

We have designed this specification to minimise the need to adjust the assessment of students who have particular requirements. Details of the arrangements you can make for such students are available in the Joint Council for Qualifications document *Access Arrangements and Special Consideration: Regulations and Guidance Relating to Candidates Who Are Eligible for Adjustments in Examinations.*

5.7 Disability Discrimination Act (DDA)

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

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

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Access Arrangements and Special Consideration: Regulations and Guidance Relating to Candidates Who are Eligible for Adjustments in Examinations.*

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

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

5.8 Contact details

The following list provides contact details for relevant members of our staff:

- Specification Support Officer: Catriona Skelton
  (telephone: (028) 9026 1200, extension 2292, email: cskelton@ccea.org.uk)

- Officer with Subject Responsibility: Robert Maguire
  (telephone: (028) 9026 1200, email: rmaguire@ccea.org.uk)

- Examination Entries, Results and Certification: Nicola Laight
  (telephone: (028) 9026 1262, email: nlaight@ccea.org.uk)

- Examiner Recruitment
  (telephone: (028) 9026 1243, email: appointments@ccea.org.uk)

- Distribution (past papers and support materials)
  (telephone: (028) 9026 1228, email: smurray@ccea.org.uk)

- Support Events Administration: Events Information Service
  (telephone: (028) 9026 1401, email: events@ccea.org.uk)

- Information Section (including Freedom of Information requests)
  (telephone: (028) 9026 1200, email: info@ccea.org.uk)

- Business Assurance (appeals): Jeffrey Hamilton
  (telephone: (028) 9026 1205, email: jhamilton@ccea.org.uk).

Appendix 1: Glossary of terms used in written examinations

The GCE Biology (A/AS) examining and revising teams have produced this glossary to help you understand what we are looking for when we use certain terms in an examination question. The glossary includes commonly used terms and phrases, but is not intended to be a complete list.

Remember: you **must** carefully study each question as a whole until you are sure exactly what the question is asking of you. The mark allocations will often be a good guide as to how much detail we are expecting in an answer.

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

Account

When writing an account you must use continuous prose.

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

In an **illustrated account**, you should use diagrams to supplement the prose account.

Example: Give an illustrated account of meiosis.

Calculate

Show all the stages involved in solving a numerical problem. Make sure the answer stands out clearly, and use the correct units if appropriate.

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

Comment on

Point out the features that are worth noting in a structure, process or set of results. Give brief explanation(s) where appropriate.

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

Compare

State the similarities and/or differences 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 a term.

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' tells you that you need to describe a practical procedure. You must give an account of the essential features of experimental design for the procedure called for by the question.

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

Determine

Use the information given to arrive at the correct answer by reasoning. You won't necessarily have to include 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 picture representing 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.

Use clear pencil lines to show the essential features represented in the diagram or observed in the photograph. Label these features, 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, you should give brief explanatory notes 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 ileum.

A **flow diagram** is an abbreviated account of a process, using arrows to show the 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 that 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 your 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 written 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 enough.

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

Outline

Present the essential points in the form of sentences.

Example: Outline three distinct differences between probaryotes and eubaryotes.

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 means 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 is asking you to give your understanding of a biological phenomenon. The mark value will tell you how much detail is needed.

Example: What is meant by 'alternation of generations'?

Appendix 2: Data sheets: statistical formulae and tables

Statistical formulae and tables

1 Definition of symbols

$x =$ individual values of the variable being measured

$\Sigma x =$ sum of values of x

$\Sigma(x^2) =$ sum of the squares of x taken singly

$n =$ sample size

$\bar{x} =$ sample mean

2 Practical formulae

2.1 *Estimation of population parameters using sample statistics*

Best estimate of population variance ($\hat{\sigma}^2$)

$$\hat{\sigma}^2 = \frac{\Sigma(x-\bar{x})^2}{(n-1)}$$

$\hat{\sigma}^2$ is normally determined using a calculator with statistical functions.

If using a calculator with only arithmetic function, the term $\Sigma(x-\bar{x})^2$ is more readily determined from the simpler form: $\Sigma(x^2)-\frac{(\Sigma x)^2}{n}$

2.2 *Best estimate of the standard deviation of the mean*

$$\hat{\sigma}_{\bar{x}} = \sqrt{\frac{\hat{\sigma}^2}{n}}$$

3 Tests

3.1 *Student's test*

Different samples are denoted by subscripts; thus $\overline{x}_1$ and $\overline{x}_2$ are the sample means of sample 1 and sample 2 respectively.

The following formula for *t* is used in A Level examinations.

$$t = \frac{\overline{x}_1 - \overline{x}_2}{\sqrt{\hat{\sigma}_{\overline{x}_1}^{\ 2} + \hat{\sigma}_{\overline{x}_2}^{\ 2}}}$$

with $n_1 + n_2 - 2$ degrees of freedom.

3.2 *Confidence limits for population mean*

$$\overline{x} \pm t\sqrt{\frac{\hat{\sigma}^2}{n}}$$

where *t* is taken from *t* tables for the appropriate probability and $n - 1$ degrees of freedom.

3.3 *Chi squared test*

$$\chi^2 = \Sigma\frac{(O-E)^2}{E}$$

where O is the observed frequency
E is the expected frequency
with $n - 1$ degrees of freedom (where n is the number of categories)

Table 1: Student's *t* values

d.f.	$p = 0.1$	0.05	0.02	0.01	0.002	0.001
1	6.314	12.706	31.821	63.657	318.31	636.62
2	2.920	4.303	6.965	9.925	22.327	31.598
3	2.353	3.182	4.541	5.841	10.214	12.924
4	2.132	2.776	3.747	4.604	7.173	8.610
5	2.015	2.571	3.365	4.032	5.893	6.869
6	1.943	2.447	3.143	3.707	5.208	5.959
7	1.895	2.365	2.998	3.499	4.785	5.408
8	1.860	2.306	2.896	3.355	4.501	5.041
9	1.833	2.262	2.821	3.250	4.297	4.781
10	1.812	2.228	2.764	3.169	4.144	4.587
11	1.796	2.201	2.718	3.106	4.025	4.437
12	1.782	2.179	2.681	3.055	3.930	4.318
13	1.771	2.160	2.650	3.012	3.852	4.221
14	1.761	2.145	2.624	2.977	3.787	4.140
15	1.753	2.131	2.602	2.947	3.733	4.073
16	1.746	2.120	2.583	2.921	3.686	4.015
17	1.740	2.110	2.567	2.898	3.646	3.965
18	1.734	2.101	2.552	2.878	3.610	3.922
19	1.729	2.093	2.539	2.861	3.579	3.883
20	1.725	2.086	2.528	2.845	3.552	3.850
21	1.721	2.080	2.518	2.831	3.527	3.819
22	1.717	2.074	2.508	2.819	3.505	3.792
23	1.714	2.069	2.500	2.807	3.485	3.767
24	1.711	2.064	2.492	2.797	3.467	3.745
25	1.708	2.060	2.485	2.787	3.450	3.725
26	1.706	2.056	2.479	2.779	3.435	3.707
27	1.703	2.052	2.473	2.771	3.421	3.690
28	1.701	2.048	2.467	2.763	3.408	3.674
29	1.699	2.045	2.462	2.756	3.396	3.659
30	1.697	2.042	2.457	2.750	3.385	3.646
40	1.684	2.021	2.423	2.704	3.307	3.551
60	1.671	2.000	2.390	2.660	3.232	3.460
120	1.658	1.980	2.358	2.617	3.160	3.373
∞	1.645	1.960	2.326	2.576	3.090	3.291

Table 2: χ^2 values

d.f.	p = 0.900	0.500	0.100	0.050	0.010	0.001
1	0.016	0.455	2.71	3.84	6.63	10.83
2	0.211	1.39	4.61	5.99	9.21	13.82
3	0.584	2.37	6.25	7.81	11.34	16.27
4	1.06	3.36	7.78	9.49	13.28	18.47
5	1.61	4.35	9.24	11.07	15.09	20.52
6	2.20	5.35	10.64	12.59	16.81	22.46
7	2.83	6.35	12.02	14.07	18.48	24.32
8	3.49	7.34	13.36	15.51	20.09	26.13
9	4.17	8.34	14.68	16.92	21.67	27.88
10	4.87	9.34	15.99	18.31	23.21	29.59
11	5.58	10.34	17.28	19.68	24.73	31.26
12	6.30	11.34	18.55	21.03	26.22	32.91
13	7.04	12.34	19.81	22.36	27.69	34.53
14	7.79	13.34	21.06	23.68	29.14	36.12
15	8.55	14.34	22.31	25.00	30.58	37.70
16	9.31	15.34	23.54	26.30	32.00	39.25
17	10.09	16.34	24.77	27.59	33.41	40.79
18	10.86	17.34	25.99	28.87	34.81	42.31
19	11.65	18.34	27.20	30.14	36.19	43.82
20	12.44	19.34	28.41	31.41	37.57	45.32
21	13.24	20.34	29.62	32.67	38.93	46.80
22	14.04	21.34	30.81	33.92	40.29	48.27
23	14.85	22.34	32.01	35.17	41.64	49.73
24	15.66	23.34	33.20	36.42	42.98	51.18
25	16.47	24.34	34.38	37.65	44.31	52.62
26	17.29	25.34	33.56	38.89	45.64	54.05
27	18.11	26.34	36.74	40.11	46.96	55.48
28	18.94	27.34	37.92	41.34	48.28	56.89
29	19.77	28.34	39.09	42.56	49.59	58.30
30	20.60	29.34	40.26	43.77	50.89	59.70
40	29.05	39.34	51.81	55.76	63.69	73.40
50	37.69	49.33	63.17	67.50	76.15	86.66
60	46.46	59.33	74.40	79.08	88.38	99.61
70	55.33	69.33	85.53	90.53	100.43	112.32
80	64.28	79.33	96.58	101.88	112.33	124.84
90	73.29	89.33	107.57	113.15	124.12	137.21
100	82.36	99.33	118.50	123.34	135.81	149.45

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