

A Level

***BIOLOGY A***

**H420**

For first teach in 2016­

[**www.ocr.org.uk/biology**](http://www.ocr.org.uk/biology)

**Student revision checklist**

Version 1

**Specification overview**

For more information please see the [OCR A Level Biology specification](https://www.ocr.org.uk/Images/171736-specification-accredited-a-level-gce-biology-a-h420.pdf).

Learners must complete all components (01,02, 03 and 04) to be awarded the OCR A Level in Biology A.

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| **Content Overview** | **Assessment Overview** | |
| Content is split into six teaching modules:  **Module 1** – Development of practical skills in biology  **Module 2** – Foundations in biology  **Module 3** – Exchange and transport  **Module 4** – Biodiversity, evolution and disease  **Module 5** – Communication, homeostasis and energy  **Module 6** – Genetics, evolution and ecosystems  Component 01 assesses content from modules 1, 2, 3 and 5.  Component 02 assesses content from modules 1, 2, 4 and 6.  Component 03 assesses content from all modules (1 to 6). | * Biological processes   (01)   * 100 marks * 2 hour 15 minutes * written paper | **37% of total A level** |
| * Biological diversity   (02)   * 100 marks * 2 hour 15 minutes * written paper | **37% of total A level** |
| * Unified biology   (03)   * 70 marks * 1 hour 30 minutes * written paper | **26%**  **of total A level** |
| * Practical Endorsement   in biology (04)  (non-exam assessment) | **Reported separately**  (see section 5f of the specification) |

#### **Revision checklists**

The tables below can be used as a revision checklist.

A checklist of the learning outcomes for this qualification and the content you need to cover and work on.

The table headings are explained below:

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| **Assessable learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| Here is a list of the learning outcomes for this qualification and the content you need to cover and work on. | You can use the columns to show when you have revised an item and how confident you feel about it.  R = **RED** means you are really unsure and lack confidence; you might want to focus your revision here and possibly talk to your teacher for help.  A = **AMBER** means you are reasonably confident but need some extra practice.  G = **GREEN** means you are very confident.  As your revision progresses, you can concentrate on the **RED** and **AMBER** items in order to turn them into **GREEN** items.  You might find it helpful to highlight each topic in red, orange or green to help you prioritise. | | | You can use the comments column to:   * add more information about the details for each point * add formulae or notes * include a reference to a useful resource * highlight areas of difficulty or things that you need to talk to your teacher about or look up in a textbook. |

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| **Module 1 Development of practical skills in biology** | | | | |
| * + 1. **Planning** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. experimental design, including to solve problems set in a practical context   Including selection of suitable apparatus, equipment and techniques for the proposed experiment.  Learners should be able to apply scientific knowledge based on the content of the specification to the practical context. |  |  |  |  |
| 1. identification of variables that must be controlled, where appropriate. |  |  |  |  |
| 1. evaluation that an experimental method is appropriate to meet the expected outcomes. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| * + 1. **Implementing** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) how to use a wide range of practical apparatus and techniques correctly.  As outlined in the content of the specification and the skills required for the Practical Endorsement. |  |  |  |  |
| (b) appropriate units for measurements. |  |  |  |  |
| (c) presenting observations and data in an appropriate format. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| * + 1. **Analysis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) processing, analysing and interpreting qualitative and quantitative experimental results.  Including reaching valid conclusions, where appropriate. |  |  |  |  |
| 1. use of appropriate mathematical skills for analysis of quantitative data. |  |  |  |  |
| 1. appropriate use of significant figures. |  |  |  |  |
| 1. plotting and interpreting suitable graphs from experimental results, including: 2. selection and labelling of axes with appropriate scales, quantities and units. 3. Measurement of gradients and intercepts. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| * + 1. **Evaluation** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) how to evaluate results and draw conclusions. |  |  |  |  |
| (b) the identification of anomalies in experimental measurements. |  |  |  |  |
| (c) the limitations in experimental procedures. |  |  |  |  |
| (d) precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus. |  |  |  |  |
| (e) the refining of experimental design by suggestion of improvements to the procedures and apparatus. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.1 Practical skills** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| **Independent thinking**  (a) apply investigative approaches and methods to practical work.  Including how to solve problems in a practical context. |  |  |  |  |
| **Use and application of scientific methods and practices**  (b) safely and correctly use a range of practical equipment and materials.  Including identification of potential hazards.  Learners should understand how to minimise the risks involved. |  |  |  |  |
| (c) follow written instructions. |  |  |  |  |
| (d) make and record observations/measurements. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.1 Practical skills** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) keep appropriate records of experimental activities. |  |  |  |  |
| (f) present information and data in a scientific way. |  |  |  |  |
| (g) use appropriate software and tools to process data, carry out research and report findings. |  |  |  |  |
| **Research and referencing**  (h) use online and offline research skills including websites, textbooks and other printed scientific sources of information. |  |  |  |  |
| (i) correctly cite sources of information.  The Practical Skills Handbook provides guidance on appropriate methods for citing information. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.1 Practical skills** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| **Instruments and equipment**  (j) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding including in the specification. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.2 Use of apparatus and techniques** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH). |  |  |  |  |
| 1. use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.2 Use of apparatus and techniques** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions. |  |  |  |  |
| 1. use of a light microscope at high power and low power, including use of a graticule. |  |  |  |  |
| 1. production of scientific drawings from observations with annotations. |  |  |  |  |
| 1. use of qualitative reagents to identify biological molecules. |  |  |  |  |
| 1. separation of biological compounds using thin layer/paper chromatography or electrophoresis. |  |  |  |  |
| 1. safe and ethical use of organisms to measure:   (i) plant or animal responses  (ii) physiological functions. |  |  |  |  |

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| **Module 1 Development of practical skills in biology** | | | | |
| **1.2.2 Use of apparatus and techniques** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. use of microbiological aseptic techniques, including the use of agar plats and broth. |  |  |  |  |
| 1. safe use of instruments for dissection of an animal or plant organ. |  |  |  |  |
| 1. use of sampling techniques in fieldwork. |  |  |  |  |
| 1. use of ICT such as computer modelling, or a data logger to collect data, or use of software to process data. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.1 Cell structure** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. the use the use of microscopy to observe and investigate different types of cell and cell structure in a range of eukaryotic organisms   To include an appreciation of the images produced by a range of microscopes; light microscope, transmission electron microscope, scanning electron microscope and laser scanning confocal microscope. |  |  |  |  |
| 1. the preparation and examination of microscope slides for use in light microscopy.   Including the use of an eye piece graticule and stage micrometer. |  |  |  |  |
| 1. The use of staining in light microscopy.   To include the use of differential staining to identify different cellular components and cell types. |  |  |  |  |
| 1. the representation of cell structure as seen under the light microscope using drawings and annotated diagrams of whole cells or cells in sections of tissue. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.1 Cell structure** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. the use and manipulation of the magnification formula.   magnification = image size  object size |  |  |  |  |
| 1. the difference between magnification and resolution.   To include an appreciation of the differences in resolution and magnification that can be achieved by a light microscope, a transmission electron microscope and a scanning electron microscope. |  |  |  |  |
| 1. the ultrastructure of eukaryotic cells and the functions of the different cellular components.   To include the following cellular components and an outline of their functions: nucleus, nucleolus, nuclear envelope, rough and smooth endoplasmic reticulum (ER), Golgi apparatus, ribosomes, mitochondria, lysosomes, chloroplasts, plasma membrane, centrioles, cell wall, flagella and cilia. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.1 Cell structure** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. Photomicrographs of cellular components in a range of eukaryotic cells.   To include interpretation of transmission and scanning electron microscope images. |  |  |  |  |
| 1. the interrelationship between the organelles involved in the production and secretion of proteins.   No detail of protein synthesis is required. |  |  |  |  |
| 1. the importance of the cytoskeleton.   To include providing mechanical strength to cells, aiding transport within cells and enabling cell movement. |  |  |  |  |
| 1. the similarities and differences in the structure and ultrastructure of prokaryotic and eukaryotic cells. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water for living organisms.   A range of roles that relate to the properties of water, including solvent, transport medium, coolant and as a habitat  **AND**  roles illustrated using examples of prokaryotes and eukaryotes. |  |  |  |  |
| 1. the concept of monomers and polymers and the importance of condensation and hydrolysis reactions in a range of biological molecules. |  |  |  |  |
| 1. the chemical elements that make up biological molecules.   To include  C, H and O for carbohydrates  C, H and O for lipids  C, H, O, N and S for proteins  C, H, O, N and P for nucleic acids. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the ring structure and properties of glucose as an example of a hexose monosaccharide and the structure of ribose as an example of a pentose monosaccharide.  To include the structural difference between an α- and a β-glucose molecule  **AND**  the difference between a hexose and a pentose monosaccharide. |  |  |  |  |
| 1. the synthesis and breakdown of a disaccharide and polysaccharide by the formation and breakage of glycosidic bonds.   To include the disaccharides sucrose, lactose and maltose. |  |  |  |  |
| (f) the structure of starch (amylose and amylopectin), glycogen and cellulose molecules. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) how the structures and properties of glucose, starch, glycogen and cellulose molecules relate to their functions in living organisms. |  |  |  |  |
| (h) the structure of a triglyceride and a phospholipid as examples of macromolecules.  To include an outline of saturated and unsaturated fatty acids. |  |  |  |  |
| (i) the synthesis and breakdown of triglycerides by the formation (esterification) and breakage of ester bonds between fatty acids and glycerol. |  |  |  |  |
| (j) how the properties of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms.  To include hydrophobic and hydrophilic regions and energy content  **AND**  illustrated using examples of prokaryotes and eukaryotes. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (k) the general structure of an amino acid. |  |  |  |  |
| (l) the synthesis and breakdown of dipeptides and polypeptides, by the formation and breakage of peptide bonds. |  |  |  |  |
| 1. the levels of protein structure.   To include primary, secondary, tertiary and quaternary structure  **AND**  hydrogen bonding, hydrophobic and hydrophilic interactions, disulfide bonds and ionic bonds. |  |  |  |  |
| (n) the structure and function of globular proteins including a conjugated protein.  To include haemoglobin as an example of a conjugated protein (globular protein with a prosthetic group), a named enzyme and insulin.  An opportunity to use computer modelling to investigate the levels of protein structure within the molecule. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (o) the properties and functions of fibrous proteins.  To include collagen, keratin and elastin (no details of structure are required). |  |  |  |  |
| (p) the key inorganic ions that are involved in biological processes.  To include the correct chemical symbols for the following cations and anions:  cations: calcium ions (Ca2+), sodium ions (Na+), potassium ions (K+), hydrogen ions (H+), ammonium ions (NH4+)  anions: nitrate (NO3–),  hydrogencarbonate (HCO3–), chloride  (C𝑙–), phosphate (PO43–), hydroxide, (OH–). |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (q) how to carry out and interpret the results of the following chemical tests:   * biuret test for proteins * Benedict’s test for reducing and non-reducing sugars * reagent test strips for reducing sugars * iodine test for starch * emulsion test for lipids. |  |  |  |  |
| (r) quantitative methods to determine the concentration of a chemical substance in a solution.  To include colorimetry and the use of biosensors (an outline only of the mechanism is required). |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.2 Biological molecules** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (s) (i) the principles and uses of paper and thin layer chromatography to separate biological molecules / compounds.  To include calculation of retention (Rf) values.  Rf = distance moved by the solute  distance moved by the solvent    (ii) practical investigations to analyse biological solutions using paper or thin layer chromatography.  For example, the separation of proteins, carbohydrates, vitamins or nucleic acids. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.3 Nucleotides and nucleic acids** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the structure of a nucleotide as the monomer from which nucleic acids are made.  To include the differences between RNA and DNA nucleotides, the identification of the purines and pyrimidines and the type of pentose sugar.  An opportunity to use computer modelling to investigate nucleic acid structure. |  |  |  |  |
| (b) the synthesis and breakdown of polynucleotides by the formation and breakage of phosphodiester bonds. |  |  |  |  |
| (c) the structure of ADP and ATP as phosphorylated nucleotides.  Comprising a pentose sugar (ribose), a nitrogenous base (adenine) and inorganic phosphates. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.3 Nucleotides and nucleic acids** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) (i) the structure of DNA (deoxyribonucleic acid).  (ii) practical investigations into the purification of DNA by precipitation.  To include how hydrogen bonding between complementary base pairs (A to T, G to C) on two antiparallel DNA polynucleotides leads to the formation of a DNA molecule, and how the twisting of DNA produces its ‘double-helix’ shape. |  |  |  |  |
| (e) semi-conservation DNA replication.  To include the roles of the enzymes helicase and DNA polymerase, the importance of replication in conserving genetic information with accuracy and the occurrence of random, spontaneous mutations. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.3 Nucleotides and nucleic acids** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. the nature of the genetic code.   To include the triplet, non-overlapping,  degenerate and universal nature of the code and how a gene determines the sequence of amino acids in a polypeptide (the primary  structure of a protein). |  |  |  |  |
| 1. transcription and translation of genes resulting in the synthesis of polypeptides.   To include, the roles of RNA polymerase, messenger (m)RNA, transfer (t)RNA, ribosomal (r)RNA. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.4 Enzymes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the role of enzymes in catalysing reactions that affect metabolism at a cellular and whole organism level.  To include the ideas that enzymes affect both structure and function. |  |  |  |  |
| (b) the role of enzymes in catalysing both intracellular and extracellular reactions.  To include catalase as an example of an enzyme that catalyses intracellular reactions and amylase and trypsin as examples of enzymes that catalyse extracellular reactions. |  |  |  |  |
| (c) the mechanism of enzyme action.  To include the tertiary structure, specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex, product formation and lowering of activation energy. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.4 Enzymes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) (i) the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity.  To include reference to the temperature coefficient (Q10).  *Q*10 = *R*2  *R*1  (ii) practical investigations into the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity.  An opportunity for serial dilutions. |  |  |  |  |
| (e) the need for coenzymes, cofactors and prosthetic groups in some enzyme-controlled reactions.  To include C𝑙– as a cofactor for amylase, Zn2+ as a prosthetic group for carbonic anhydrase and vitamins as a source of coenzymes. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.4 Enzymes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the effects of inhibitors on the rate of enzyme- controlled reactions.  To include competitive and non-competitive and reversible and non-reversible inhibitors with reference to the action of metabolic poisons and some medicinal drugs, and the role of product inhibition  **AND**  inactive precursors in metabolic pathways (covered at A level only). |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.5 Biological membranes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the roles of membranes within cells and at the surface of cells.  To include the roles of membranes as   * partially permeable barriers between the cell and its environment, between organelles and the cytoplasm and within organelles * sites of chemical reactions * sites of cell communication (cell signalling). |  |  |  |  |
| (b) the fluid mosaic model of membrane structure and the roles of its components.  To include phospholipids, cholesterol, glycolipids, proteins and glycoproteins  **AND**  the role of membrane-bound receptors as sites where hormones and drugs can bind. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.5 Biological membranes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) (i) factors affecting membrane structure and permeability.   1. practical investigations into factors affecting   membrane structure and permeability.  To include the effects of temperature and solvents. |  |  |  |  |
| 1. (i) the movement of molecules across membranes. 2. practical investigations into the factors   affecting diffusion rates in model cells.  To include diffusion and facilitated diffusion as passive methods  **AND**  active transport, endocytosis and exocytosis as processes requiring adenosine triphosphate (ATP) as an immediate source of energy. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.5 Biological membranes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. (i) the movement of water across membranes by osmosis and the effects that solutions of different water potential can have on plant and animal cells   (ii) practical investigations into the effects of solutions of different water potential on plant and animal cells.  Osmosis to be explained in terms of a water potential gradient across a partially- permeable membrane. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.6 Cell division, cell diversity and cellular organisation** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the cell cycle.  To include the processes taking place during interphase (G1, S and G2), mitosis and cytokinesis, leading to genetically identical cells. |  |  |  |  |
| (b) how the cell cycle is regulated.  To include an outline of the use of checkpoints to control the cycle. |  |  |  |  |
| (c) the main stages of mitosis.  To include the changes in the nuclear envelope, chromosomes, chromatids, centromere, centrioles, spindle fibres and cell membrane. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.6 Cell division, cell diversity and cellular organisation** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) sections of plant tissue showing the cell cycle and stages of mitosis.  To include the examination of stained sections and squashes of plant tissue and the production of labelled diagrams to show the stages observed. |  |  |  |  |
| (e) the significance of mitosis in life cycles.  To include growth, tissue repair and asexual reproduction in plants, animals and fungi. |  |  |  |  |
| (f) the significance of meiosis in life cycles.  To include the production of haploid cells and genetic variation by independent assortment and crossing over. |  |  |  |  |
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| **Module 2 Foundations in biology** | | | | |
| **2.1.6 Cell division, cell diversity and cellular organisation** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) the main stages of meiosis.  To include interphase, prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, telophase 2 (no details of the names of the stages within prophase 1 are required) and the term *homologous chromosomes*. |  |  |  |  |
| (h) how cells of multicellular organisms are specialised for particular functions.  To include erythrocytes, neutrophils, squamous and ciliated epithelial cells, sperm cells, palisade cells, root hair cells and guard cells. |  |  |  |  |

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| **Module 2 Foundations in biology** | | | | |
| **2.1.6 Cell division, cell diversity and cellular organisation** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (i) the organisation of cells into tissues, organs and organ systems.  To include squamous and ciliated epithelia, cartilage, muscle, xylem and phloem as examples of tissues. |  |  |  |  |
| (j) the features and differentiation of stem cells.  To include stem cells as a renewing source of undifferentiated cells. |  |  |  |  |
| (k) the production of erythrocytes and neutrophils derived from stem cells in bone marrow. |  |  |  |  |
| (l) the production of xylem vessels and phloem sieve tubes from meristems. |  |  |  |  |
| (m) the potential uses of stem cells in research and  medicine.  To include the repair of damaged tissues, the treatment of neurological conditions such as Alzheimer’s and Parkinson’s, and research into developmental biology. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.1 Exchange surfaces** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the need for specialised exchange surfaces.  To include surface area to volume ratio (SA:V), metabolic activity, single-celled and multicellular organisms.  Ratio = Surface Area  Volume |  |  |  |  |
| (b) the features of an efficient exchange surface.  To include   * increased surface area – root hair cells * thin layer – alveoli * good blood supply/ventilation to maintain gradient – gills/alveolus. |  |  |  |  |
| (c) the structures and functions of the components of the mammalian gaseous exchange system.  To include the distribution and functions of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.1 Exchange surfaces** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the mechanism of ventilation in mammals.  To include the function of the rib cage, intercostal muscles (internal and external) and diaphragm. |  |  |  |  |
| (e) the relationship between vital capacity, tidal volume, breathing rate and oxygen uptake.  To include analysis and interpretation of primary and secondary data e.g. from a data logger or spirometer. |  |  |  |  |
| (f) the mechanisms of ventilation and gas exchange in bony fish and insects.  To include   * bony fish – changes in volume of the buccal cavity and the functions of the operculum, gill filaments and gill lamellae (gill plates), countercurrent flow * insects – spiracles, trachea, thoracic and abdominal movement to change body volume, exchange with tracheal fluid. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.1 Exchange surfaces** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) the dissection, examination and drawing of the gaseous exchange system of a bony fish and/or insect trachea. |  |  |  |  |
| (h) the examination of microscope slides to show the histology of exchange surfaces. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.2 Transport in animals** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the need for transport systems in multicellular animals.  To include an appreciation of size, metabolic rate and surface area to volume ratio (SA:V). |  |  |  |  |
| (b) the different types of circulatory systems.  To include the single, double, open and closed circulatory systems in insects, fish and mammals. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.2 Transport in animals** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) the structure and functions of arteries, arterioles, capillaries, venules and veins.  To include the distribution of different tissues within the vessel walls. |  |  |  |  |
| (d) the formation of tissue fluid from plasma.  To include reference to hydrostatic pressure, oncotic pressure and an explanation of the differences in the composition of blood, tissue fluid and lymph. |  |  |  |  |
| (e) (i) the external and internal structure of the mammalian heart.  (ii) the dissection, examination and drawing of the external and internal structure of the mammalian heart. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.2 Transport in animals** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the cardiac cycle.  cardiac output = heart rate x stroke volume.  To include the role of valves and the pressure changes occurring in the heart and associated vessels. |  |  |  |  |
| (g) how heart action is initiated and coordinated.  To include the roles of the sino-atrial node (SAN), atrio-ventricular node (AVN), purkyne tissue and the myogenic nature of cardiac muscle (no detail of hormonal and nervous control is required at AS level). |  |  |  |  |
| 1. the use and interpretation of electrocardiogram (ECG) traces.   To include normal and abnormal heart activity e.g. tachycardia, bradycardia, fibrillation and ectopic heartbeat. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.2 Transport in animals** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| 1. the role of haemoglobin in transporting oxygen and carbon dioxide.   To include the reversible binding of oxygen molecules, carbonic anhydrase, haemoglobinic acid, HCO3– and the chloride shift. |  |  |  |  |
| 1. the oxygen dissociation curve for fetal and adult human haemoglobin.   To include the significance of the different affinities for oxygen  **AND**  the changes to the dissociation curve at different carbon dioxide concentrations (the Bohr effect). |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.3 Transport in plants** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the need for transport systems in multicellular plants.  To include an appreciation of size, metabolic rate and surface area to volume ratio (SA:V). |  |  |  |  |
| (b) (i) the structure and function of the vascular system in the roots, stems and leaves of herbaceous dicotyledonous plants  To include xylem vessels, sieve tube elements and companion cells.  (ii) the examination and drawing of stained sections of plant tissue to show the distribution of xylem and phloem   1. the dissection of stems, both longitudinally   and transversely, and their examination to demonstrate the position and structure of xylem vessels. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.3 Transport in plants** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) (i) the process of transpiration and the environmental factors that affect transpiration rate.  To include an appreciation that transpiration is a consequence of gaseous exchange.  (ii) practical investigations to estimate transpiration rates.  To include the use of a potometer. |  |  |  |  |

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| **Module 3 Exchange and transport** | | | | |
| **3.1.3 Transport in plants** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the transport of water into the plant, through the plant and to the air surrounding the leaves.  To include details of pathways taken by water  **AND**  the mechanisms of movement, in terms of water potential, adhesion, cohesion and the transpiration stream. |  |  |  |  |
| (e) Adaptations of plants to the availability of water in their environment.  To include xerophytes (cacti and marram grass) and hydrophytes (water lilies). |  |  |  |  |
| 1. the mechanism of translocation.  To include translocation as an energy- requiring process transporting assimilates, especially sucrose, in the phloem between sources (e.g. leaves) and sinks (e.g. roots, meristem)   **AND**  details of active loading at the source and removal at the sink. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.1.1 Communicable diseases, disease prevention and the immune system** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the different types of pathogen that can cause communicable diseases in plants and animals.  To include   * bacteria – tuberculosis (TB), bacterial meningitis, ring rot (potatoes, tomatoes) * viruses – HIV/AIDS (human), influenza (animals), Tobacco Mosaic Virus (plants) * protoctista – malaria, potato/tomato late blight * fungi – black sigatoka (bananas), ringworm (cattle), athlete’s foot (humans). |  |  |  |  |
| (b) the means of transmission of animal and plant communicable pathogens.  To include direct and indirect transmission, reference to vectors, spores and living conditions – e.g. climate, social factors (no detail of the symptoms of specific diseases is required). |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.1.1 Communicable diseases, disease prevention and the immune system** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) plant defences against pathogens.  To include production of chemicals  **AND**  plant responses that limit the spread of the pathogen (e.g. callose deposition). |  |  |  |  |
| (d) the primary non-specific defences against pathogens in animals.  Non-specific defences to include skin, blood clotting, wound repair, inflammation, expulsive reflexes and mucous membranes (no detail of skin structure or all the steps involved in the clotting cascade are required). |  |  |  |  |
| (e) (i) the structure and mode of action of phagocytes.  (ii) examination and drawing of cells observed in blood smears.  To include neturophils and antigen- presenting cells  **AND**  the roles of cytokines, opsonins, phagosomes and lysosomes. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.1.1 Communicable diseases, disease prevention and the immune system** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the structure, different roles and modes of action of B and T lymphocytes in the specific immune response.  To include the significance of cell signalling (reference to interleukins), clonal selection and clonal expansion, plasma cells, T helper cells, T killer cells and T regulator cells. |  |  |  |  |
| (g) the primary and secondary immune responses.  To include T memory cells and B memory cells. |  |  |  |  |
| (h) the structure and general functions of antibodies.  To include the general protein structure of an antibody molecule. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.1.1 Communicable diseases, disease prevention and the immune system** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (i) an outline of the action of opsonins, agglutinins and anti-toxins. |  |  |  |  |
| (j) the differences between active and passive immunity, and between natural and artificial immunity.  To include examples of each type of immunity. |  |  |  |  |
| (k) autoimmune diseases.  To include an appreciation of the term *autoimmune disease* and a named example e.g. arthritis, lupus. |  |  |  |  |
| (l) the principles of vaccination and the role of vaccination programmes in the prevention of epidemics.  To include routine vaccinations  **AND**  reasons for changes to vaccines and vaccination programmes (including global issues). |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.1.1 Communicable diseases, disease prevention and the immune system** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (m) possible sources of medicines.  To include examples of microorganisms and plants (and so the need to maintain biodiversity)  **AND**  the potential for personalised medicines and synthetic biology. |  |  |  |  |
| (n) the benefits and risks of using antibiotics to manage bacterial infection.  To include the wide use of antibiotics following the discovery of penicillin in the mid-20th century  **AND**  the increase in bacterial resistance to antibiotics (examples to include *Clostridium difficile* and MRSA) and its implications. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.1 Biodiversity** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) how biodiversity may be considered at different levels.  To include habitat biodiversity (e.g. sand dunes, woodland, meadows, streams), species biodiversity (species richness and species evenness) and genetic biodiversity (e.g. different breeds within a species). |  |  |  |  |
| (b) (i) how sampling is used in measuring the biodiversity of a habitat and the importance of sampling  (ii) practical investigations collecting random and non-random samples in the field.  To include how sampling can be carried out i.e. random sampling and non-random sampling (e.g. opportunistic, stratified and systematic) and the importance of sampling the range of organisms in a habitat.  Techniques to include use of sweeping nets, pitfall traps, pooters, Tullgren funnel and kick-sampling for collecting different samples. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.1 Biodiversity** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) how to measure species richness and species evenness in a habitat. |  |  |  |  |
| (d) the use and interpretation of Simpson’s Index of Diversity (D) to calculate the biodiversity of a habitat.  The formula will be provided where needed in assessments and does not need to be recalled    **AND**  the interpretation of both high and low values of Simpson’s Index of Diversity (D). |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.1 Biodiversity** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) how genetic biodiversity may be assessed, including calculations.  To include calculations of genetic diversity within isolated populations, for example the percentage of gene variants (alleles) in a genome.    proportion of polymorphic gene loci =  number of polymorphic gene loci  total number of loci    Suitable populations include zoos (captive breeding), rare breeds and pedigree animals. |  |  |  |  |
| (f) the factors affecting biodiversity.  To include human population growth, agriculture (monoculture) and climate change. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.1 Biodiversity** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) the ecological, economic and aesthetic reasons for maintaining biodiversity.   * Ecological, including protecting keystone species (interdependence of organisms) and maintaining genetic resource * economic, including reducing soil depletion (continuous monoculture) * aesthetic, including protecting landscapes. |  |  |  |  |
| (h) *in situ* and *ex situ* methods of maintaining biodiversity.   * *In situ* conservation including marine conservation zones and wildlife reserves * *ex situ* conservation including seed banks, botanic gardens and zoos. |  |  |  |  |
| (i) international and local conservation agreements made to protect species and habitats.  Historic and/or current agreements, including the Convention on International Trade in Endangered Species (CITES), the Rio Convention on Biological Diversity (CBD) and the Countryside Stewardship Scheme (CSS). |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.2 Classification and evolution** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the biological classification of species.  To include the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species.  **AND**  domain. |  |  |  |  |
| (b) the binomial system of naming species and the advantage of such a system. |  |  |  |  |
| (c) (i) the features used to classify organisms into the five kingdoms: Prokaryotae, Protoctista, Fungi, Plantae, Animalia.  To include the use of similarities in observable features in original classification. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.2 Classification and evolution** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) (ii) the evidence that has led to new classification systems, such as the three domains of life, which clarifies relationships.  To include the more recent use of similarities in biological molecules and other genetic evidence  **AND**  details of the three domains and a comparison of the kingdom and domain classification systems. |  |  |  |  |
| (d) the relationship between classification and phylogeny.  Cladistics and phylogenetic definition of species not covered at AS level. |  |  |  |  |
| (e) the evidence for the theory of evolution by natural selection.  To include the contributions of Darwin and Wallace in formulating the theory of evolution by natural selection  **AND**  fossil, DNA (only genomic DNA at AS level) and molecular evidence. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.2 Classification and evolution** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the different types of variation.  To include intraspecific and interspecific variation  **AND**  the differences between continuous and discontinuous variation, using examples of a range of characteristics found in plants, animals and microorganisms  **AND**  both genetic and environmental causes of variation.  An opportunity to use standard deviation to measure the spread of a set of data  **and/or**  Student’s *t*-test to compare means of data values of two populations  **and/or**  the Spearman’s rank correlation coefficient to consider the relationship of the data. |  |  |  |  |

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| **Module 4 Biodiversity, evolution and disease** | | | | |
| **4.2.2 Classification and evolution** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) the different types of adaptations of organisms to their environment.  Anatomical, physiological and behavioural adaptations  **AND**  why organisms from different taxonomic groups may show similar anatomical features, including the marsupial mole and placental mole. |  |  |  |  |
| (h) the mechanism by which natural selection can affect the characteristics of a population over time.  To include an appreciation that genetic variation, selection pressure and reproductive success (or failure) results in an increased proportion of the population possessing the advantageous characteristic(s). |  |  |  |  |
| (i) how evolution in some species has implications for human populations.  To include the evolution of pesticide resistance in insects and drug resistance in microorganisms. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.1 Communication and homeostasis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the need for communication systems in multicellular organisms  To include the need for animals and plants to respond to changes in the internal and external environment and to coordinate the activities of different organs. |  |  |  |  |
| (b) the communication between cells by cell signalling.  To include signalling between adjacent cells and signalling between distant cells. |  |  |  |  |
| (c) the principles of homeostasis.  To include the differences between receptors and effectors, and the difference between negative feedback and positive feedback. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.1 Communication and homeostasis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the physiological and behavioural responses involved in temperature control in ectotherms and endotherms.  To include   * endotherms – peripheral temperature receptors, the role of the hypothalamus and effectors in skin and muscles; behavioural responses * ectotherms – behavioural responses.   An opportunity to monitor physiological functions in ectotherms and/or endotherms. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.2 Excretion as an example of homeostatic control** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the term *excretion* and its importance in maintaining metabolism and homeostasis.  To include reference to the importance of removing metabolic wastes, including carbon dioxide and nitrogenous waste, from the body. |  |  |  |  |
| (b) (i) the structure and functions of the mammalian liver.  (ii) the examination and drawing of stained sections to show the histology of liver tissue.  To include the gross structure and histology of the liver  **AND**  the roles of the liver in storage of glycogen, detoxification and the formation of urea (the ornithine cycle covered in outline only). |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.2 Excretion as an example of homeostatic control** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) (i) the structure, mechanisms of action and functions of the mammalian kidney.  To include the gross structure and histology of the kidney including the detailed structure of a nephron and its associated blood vessels  **AND**  the processes of ultrafiltration, selective reabsorption and the production of urine  (ii) the dissection, examination and drawing of the external and internal structure of the kidney.  (iii) the examination and drawing of stained sections to show the histology of nephrons. |  |  |  |  |
| (d) the control of the water potential of the blood.  To include the role of osmoreceptors in the hypothalamus, the posterior pituitary gland, ADH and its effect on the walls of the collecting ducts. |  |  |  |  |
| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.2 Excretion as an example of homeostatic control** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) the effects of kidney failure and its potential treatments.  To include the problems that arise from kidney failure including the effect on glomerular filtration rate (GFR) and electrolyte balance  **AND**  the use of renal dialysis (both haemodialysis and peritoneal dialysis) and transplants for the treatment of kidney failure. |  |  |  |  |
| (f) how excretory products can be used in medical diagnosis.  To include the use of urine samples in diagnostic tests, with reference to the use of monoclonal antibodies in pregnancy testing and testing for anabolic steroids and drugs. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.3 Neuronal communication** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the roles of mammalian sensory receptors in converting different types of stimuli into nerve impulses.  To include an outline of the roles of sensory receptors (e.g. Pacinian corpuscle) in responding to specific types of stimuli and their roles as transducers. |  |  |  |  |
| (b) the structure and functions of sensory, relay and motor neurones.  To include differences between the structure and function of myelinated and non- myelinated neurones. |  |  |  |  |
| (c) the generation and transmission of nerve impulses in mammals.  To include how the resting potential is established and maintained and how an action potential is generated (including reference to positive feedback) and transmitted in a myelinated neurone  **AND**  the significance of the frequency of impulse transmission. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.3 Neuronal communication** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the structure and roles of synapses in neurotransmission.  To include the structure of a cholinergic synapse  **AND**  the action of neurotransmitters at the synapse and the importance of synapses in summation and control, including inhibitory and excitatory synapses. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.4 Hormonal communication** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) endocrine communication by hormones.  To include secretion of hormones into the blood, transport by the blood, and detection by target cells or tissues. |  |  |  |  |
| (b) the structure and functions of the adrenal glands.  Adrenal glands as an example of endocrine glands, to include the hormones secreted by the cortex and medulla and their functions. |  |  |  |  |
| (c) (i) the histology of the pancreas  To include the endocrine tissues.  (ii) the examination and drawing of stained sections of the pancreas to show the histology of the endocrine tissues. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.4 Hormonal communication** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) how blood glucose concentration is regulated.  To include the action of insulin and glucagon as an example of negative feedback, and the role of the liver  **AND**  the control of insulin secretion, with reference to potassium channels and calcium channels in the beta cells of the pancreas. |  |  |  |  |
| (e) the differences between Type 1 and Type 2 diabetes mellitus.  To include the causes of Type 1 and Type 2 diabetes and the treatments for each. |  |  |  |  |
| (f) the potential treatments for diabetes mellitus.  To include the use of insulin produced by genetically modified bacteria and the potential use of stem cells to treat diabetes mellitus. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.5 Plant and animal responses** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) (i) the types of plant responses  To include the response to abiotic stress and herbivory e.g. chemical defences (such as tannins, alkaloids and pheromones), folding in response to touch (*Mimosa pudica*)  **AND**  The range of tropisms in plants.  (ii) practical investigations into phototropism and geotropism. |  |  |  |  |
| (b) the roles of plant hormones.  To include the role of hormones in leaf loss in deciduous plants, seed germination and stomatal closure. |  |  |  |  |
| (c) the experimental evidence for the role of auxins in the control of apical dominance. |  |  |  |  |
| (d) the experimental evidence for the role of gibberellin in the control of stem elongation and seed germination. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.5 Plant and animal responses** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) practical investigations into the effect of plant hormones on growth.  An opportunity for serial dilution. An opportunity to use standard deviation to measure the spread of a set of data. |  |  |  |  |
| (f) the commercial use of plant hormones.  To include the use of hormones to control ripening, the use of rooting powders and hormonal weed killers. |  |  |  |  |
| (g) the organisation of the mammalian nervous system.  To include the structural organisation of the nervous system into the central and peripheral systems  **AND**  the functional organisation into the somatic and autonomic nervous systems. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.5 Plant and animal responses** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (h) the structure of the human brain and the functions of its parts.  To include the gross structure of the human brain  **AND**  the functions of the cerebrum, cerebellum, medulla oblongata, hypothalamus and pituitary gland. |  |  |  |  |
| (i) reflex actions.  To include knee jerk reflex and blinking reflex, with reference to the survival value of reflex actions. |  |  |  |  |
| (j) the coordination of responses by the nervous and endocrine systems.  To include the ‘fight or flight’ response to environmental stimuli in mammals  **AND**  the action of hormones in cell signalling (studied in outline only) with reference to adrenaline (first messenger), activation of adenylyl cyclase, and cyclic AMP (second messenger). |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.5 Plant and animal responses** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (k) the effects of hormones and nervous mechanisms on heart rate.  An opportunity to monitor physiological functions, for example with pulse rate measurements before, during and after exercise or sensors to record electrical activity in the heart.  An opportunity to use standard deviation to measure the spread of a set of data and/or Student’s *t*-test to compare means of data values of two sets of data. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.1.5 Plant and animal responses** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (l) (i) the structure of mammalian muscle and the mechanism of muscular contraction  (ii) the examination of stained sections or photomicrographs of skeletal muscle.  To include the structural and functional differences between skeletal, involuntary and cardiac muscle  **AND**  the action of neuromuscular junctions  **AND**  the sliding filament model of muscular contraction and the role of ATP, and how the supply of ATP is maintained in muscles by creatine phosphate.  An opportunity to monitor muscle contraction and fatigue using sensors to record electrical activity. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.1 Photosynthesis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the interrelationship between the process of photosynthesis and respiration.  To include the relationship between the raw materials and products of the two processes. |  |  |  |  |
| (b) the structure of a chloroplast and the sites of the two main stages of photosynthesis.  The components of a chloroplast including outer membrane, lamellae, grana, thylakoid, stroma and DNA. |  |  |  |  |
| (c) (i) the importance of photosynthetic pigments in photosynthesis  To include reference to light harvesting systems and photosystems.  (ii) practical investigations using thin layer chromatography (TLC) to separate photosynthetic pigments. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.1 Photosynthesis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the light-dependent stage of photosynthesis.  To include how energy from light is harvested and used to drive the production of chemicals which can be used as a source of energy for other metabolic processes (ATP and reduced NADP) with reference to electron carriers and cyclic and non-cyclic photophosphorylation  **AND**  the role of water. |  |  |  |  |
| (e) the fixation of carbon dioxide and the light- independent stage of photosynthesis.  To include how the products of the light- dependent stage are used in the light- independent stage (Calvin cycle) to produce triose phosphate (TP) with reference to ribulose bisphosphate (RuBP), ribulose bisphosphate carboxylase (RuBisCO) and glycerate 3-phosphate (GP) – **no** other biochemical detail is required. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.1 Photosynthesis** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the uses of triose phosphate (TP).  To include the use of TP as a starting material for the synthesis of carbohydrates, lipids and amino acids  **AND**  the recycling of TP to regenerate the supply of RuBP. |  |  |  |  |
| (g) (i) factors affecting photosynthesis.  To include limiting factors in photosynthesis with reference to carbon dioxide concentration, light intensity and temperature, and the implications of water stress (stomatal closure)  **AND**  the effect on the rate of photosynthesis, and on levels of GP, RuBP and TP, of changing carbon dioxide concentration, light intensity and temperature.  (ii) practical investigations into factors affecting the rate of photosynthesis.  An opportunity to use sensors, data loggers and software to process data. |  |  |  |  |

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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.2 Respiration** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the need for cellular respiration.  To include examples of why plants, animals and microorganisms need to respire (suitable examples could include active transport and an outline of named metabolic reactions). |  |  |  |  |
| (b) the structure of the mitochondrion.  The components of a mitochondrion including inner and outer mitochondrial membranes, cristae, matrix and mitochondrial DNA. |  |  |  |  |
| (c) the process and site of glycolysis.  To include the phosphorylation of glucose to hexose bisphosphate, the splitting of hexose bisphosphate into two triose phosphate molecules and further oxidation to pyruvate  **AND**  the production of a small yield of ATP and reduced NAD. |  |  |  |  |
| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.2 Respiration** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) the link reaction and its site in the cell.  To include the formation of Acetyl CoA by the decarboxylation of pyruvate and the reduction of NAD to NADH. |  |  |  |  |
| (e) the process and site of the Krebs cycle.  To include the formation of citrate from the acetyl group of acetyl CoA and oxaloacetate and the reconversion of citrate to oxaloacetate (names of intermediate compounds are not required)  **AND**  the importance of decarboxylation, dehydrogenation, the reduction of NAD and FAD, and substrate level phosphorylation. |  |  |  |  |
| (f) the importance of coenzymes in cellular respiration.  With reference to NAD, FAD and coenzyme A. |  |  |  |  |
| (g) the process and site of oxidative phosphorylation.  To include the roles of electron carriers, oxygen and the mitochondrial cristae. |  |  |  |  |
| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.2 Respiration** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (h) the chemiosmotic theory.  To include the electron transport chain, proton gradients and ATP synthase in oxidative phosphorylation and photophosphorylation. |  |  |  |  |
| (i) (i) the process of anaerobic respiration in eukaryotes.  To include anaerobic respiration in mammals and yeast and the benefits of being able to respire anaerobically  **AND**  why anaerobic respiration produces a much lower yield of ATP than aerobic respiration.  (ii) practical investigations into respiration rates in yeast, under aerobic and anaerobic conditions.  An opportunity to use sensors, data loggers and software to process data. |  |  |  |  |
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| **Module 5 Communication, homeostasis and energy** | | | | |
| **5.2.2 Respiration** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (j) the difference in relative energy values of carbohydrates, lipids and proteins as respiratory substrates. |  |  |  |  |
| (k) the use and interpretation of the respiratory quotient (*RQ*).  To include calculating the respiratory quotient (*RQ*) using the formula:  *RQ* = CO2 produced  O2 consumed |  |  |  |  |
| (l) practical investigations into the effect of factors such as temperature, substrate concentration and different respiratory substrates on the rate of respiration.  For example, the use of respirometers.    An opportunity to use sensors, data loggers and software to process data.  An opportunity to use standard deviation to measure the spread of a set of data and/or Student’s *t*-test to compare means of data values of two sets of data. |  |  |  |  |
| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.1 Cellular control** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) types of gene mutations and their possible effects on protein production and function.  To include substitution, insertion or deletion of one or more nucleotides  **AND**  the possible effects of these gene mutations (i.e. beneficial, neutral or harmful). |  |  |  |  |
| (b) the regulatory mechanisms that control gene expression at the transcriptional level, post- transcriptional level and post-translational level.  To include control at the   * transcriptional level: *lac* operon, and transcription factors in eukaryotes * post-transcriptional level: the editing of primary mRNA and the removal of introns to produce mature mRNA * post-translational level: the activation of proteins by cyclic AMP. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.1 Cellular control** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) the genetic control of the development of body plans in different organisms.  Homeobox gene sequences in plants, animals and fungi are similar and highly conserved  **AND**  the role of Hox genes in controlling body plan development. |  |  |  |  |
| (d) the importance of mitosis and apoptosis as mechanisms controlling the development of body form.  To include an appreciation that the genes which regulate the cell cycle and apoptosis are able to respond to internal and external cell stimuli e.g. stress. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.2 Patterns of inheritance** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) (i) the contribution of both environmental and genetic factors to phenotypic variation.  To include examples of both genetic and environmental contributions – environmental examples could include diet in animals and etiolation or chlorosis in plants.  (ii) how sexual reproduction can lead to genetic variation within a species.  Meiosis and the random fusion of gametes at fertilisation. |  |  |  |  |
| (b) (i) genetic diagrams to show patterns of inheritance.  To include monogenic inheritance, dihybrid inheritance, multiple alleles, sex linkage and codominance.  (ii) the use of phenotypic ratios to identify linkage (autosomal and sex linkage) and epistasis.  To include explanations of linkage and epistasis. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.2 Patterns of inheritance** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) using the chi-squared test to determine the significance of the difference between observed and expected results.  The formula for the chi-squared test will be provided. |  |  |  |  |
| (d) the genetic basis of continuous and discontinuous variation.  To include reference to the number of genes that influence each type of variation. |  |  |  |  |
| (e) the factors that can affect the evolution of a species.  To include stabilising selection and directional selection, genetic drift, genetic bottleneck and founder effect. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.2 Patterns of inheritance** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the use of the Hardy-Weinberg principle to calculate allele frequencies in populations.  The equations for the Hardy–Weinberg principle will be provided where needed in assessments and do not need to be recalled.  *p2* + *2pq* + *q2* = 1  *p* + *q* = 1 |  |  |  |  |
| (g) the role of isolating mechanisms in the evolution of new species.  To include geographical mechanisms (allopatric speciation) and reproductive mechanisms (sympatric speciation). |  |  |  |  |
| (h) (i) the principles of artificial selection and its uses.  To include examples of selective breeding in plants and animals  **AND**  an appreciation of the importance of maintaining a resource of genetic material for use in selective breeding including wild types. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.2 Patterns of inheritance** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (h) (ii) the ethical considerations surrounding the use of artificial selection.  To include a consideration of the more extreme examples of the use of artificial selection to ‘improve’ domestic species e.g. dog breeds. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.3 Manipulating genomes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the principles of DNA sequencing and the development of new DNA sequencing techniques.  To include the rapid advancements of the techniques used in sequencing, which have increased the speed of sequencing and allowed whole genome sequencing e.g. high-throughput sequencing. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.3 Manipulating genomes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (b) (i) how gene sequencing has allowed for genome-wide comparisons between individuals and between species  (ii) how gene sequencing has allowed for the sequences of amino acids in polypeptides to be predicted  (iii) how gene sequencing has allowed for the development of synthetic biology.  With reference to bioinformatics and computational biology and how these fields are contributing to biological research into genotype–phenotype relationships, epidemiology and searching for evolutionary relationships. |  |  |  |  |
| (c) the principles of DNA profiling and its uses.  To include forensics and analysis of disease risk. |  |  |  |  |
| (d) the principles of the polymerase chain reaction (PCR) and its application in DNA analysis. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.3 Manipulating genomes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) the principles and uses of electrophoresis for separating nucleic acid fragments or proteins.  Opportunity for practical use of electrophoresis. |  |  |  |  |
| (f) (i) the principles of genetic engineering.  To include the isolation of genes from one organism and the placing of these genes into another organism using suitable vectors.    (ii) the techniques used in genetic engineering.  To include the use of restriction enzymes, plasmids and DNA ligase to form recombinant DNA with the desired gene and electroporation. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.1.3 Manipulating genomes** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (g) the ethical issues (both positive and negative) relating to the genetic manipulation of animals (including humans), plants and microorganisms.  To include insect resistance in genetically modified soya, genetically modified pathogens for research and ‘pharming’ i.e. genetically modified animals to produce pharmaceuticals  **AND**  issues relating to patenting and technology transfer e.g. making genetically modified seed available to poor farmers. |  |  |  |  |
| (h) the principles of, and potential for, gene therapy in medicine.  To include the differences between somatic cell gene therapy and germ line cell gene therapy. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.2.1 Cloning and biotechnology** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) (i) natural clones in plants and the production of natural clones for use in horticulture  To include examples of natural cloning and the methods used to produce clones (various forms of vegetative propagation).  (ii) how to take plant cuttings as an example of a simple cloning technique.  Dissection of a selection of plant material to produce cuttings. |  |  |  |  |
| (b) (i) the production of artificial clones of plants by micropropagation and tissue culture.  To include an evaluation of the uses of plant cloning in horticulture and agriculture.  (ii) the arguments for and against artificial cloning in plants. |  |  |  |  |
| (c) natural clones in animal species.  To include examples of natural clones (twins formed by embryo splitting). |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.2.1 Cloning and biotechnology** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (d) (i) how artificial clones in animals can be produced by artificial embryo twinning or by enucleation and somatic cell nuclear transfer (SCNT).  To include an evaluation of the uses of animal cloning (examples including in agriculture and medicine, and issues of longevity of cloned animals).  (ii) the arguments for and against artificial cloning in animals. |  |  |  |  |
| (e) the use of microorganisms in biotechnological processes.  To include reasons why microorganisms are used e.g. economic considerations, short life cycle, growth requirements  **AND**  processes including brewing, baking, cheese making, yoghurt production, penicillin production, insulin production and bioremediation. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.2.1 Cloning and biotechnology** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (f) the advantages and disadvantages of using microorganisms to make food for human consumption.  To include bacterial and fungal sources. |  |  |  |  |
| (g) (i) how to culture microorganisms effectively, using aseptic techniques  An opportunity for serial dilutions and culturing on agar plates.  (ii) the importance of manipulating the growing conditions in batch and continuous fermentation in order to maximise the yield of product required. |  |  |  |  |
| (h) (i) the standard growth curve of a microorganism in a closed culture  To include the formula for number of individual organisms  *N* = *N*0 x 2*n*  An opportunity for serial dilutions and the use of broth.  (ii) practical investigations into the factors affecting the growth of microorganisms. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.2.1 Cloning and biotechnology** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (i) the uses of immobilised enzymes in biotechnology and the different methods of immobilisation.  To include methods of enzyme immobilisation  **AND**  an evaluation of the use of immobilised enzymes in biotechnology  examples could include:   * glucose isomerase for the conversion of glucose to fructose * penicillin acylase for the formation of semi-synthetic penicillins (to which some penicillin-resistant organisms are not resistant) * lactase for the hydrolysis of lactose to glucose and galactose * aminoacylase for production of pure samples of L-amino acids * glucoamylase for the conversion of dextrins to glucose. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.3.1 Ecosystems** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) ecosystems, which range in size, are dynamic and are influenced by both biotic and abiotic factors.  To include reference to a variety of ecosystems of different sizes (e.g. a rock pool, a playing field, a large tree) and named examples of biotic and abiotic factors. |  |  |  |  |
| (b) biomass transfers through ecosystems.  To include how biomass transfers between trophic levels can be measured  **AND**  the efficiency of biomass transfers between trophic levels  efficiency = biomass transferred x 100  biomass intake  **AND**  how human activities can manipulate the transfer of biomass through ecosystems. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.3.1 Ecosystems** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (c) recycling within ecosystems.  To include the role of decomposers and the roles of microorganisms in recycling nitrogen within ecosystems (including *Nitrosomonas*, *Nitrobacter*, *Azotobacter* and *Rhizobium*)  **AND**  the importance of the carbon cycle to include the role of organisms (decomposition, respiration and photosynthesis) and physical and chemical effects in the cycling of carbon within ecosystems. |  |  |  |  |
| (d) the process of primary succession in the development of an ecosystem.  To include succession from pioneer species to a climax community  **AND**  deflected succession. |  |  |  |  |
| (e) (i) how the distribution and abundance of organisms in an ecosystem can be measured.  (ii) the use of sampling and recording methods to determine the distribution and abundance of organisms in a variety of ecosystems. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.3.2 Populations and sustainability** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (a) the factors that determine size of a population.  To include the significance of limiting factors in determining the carrying capacity of a given environment and the impact of these factors on final population size. |  |  |  |  |
| (b) interactions between populations.  To include predator–prey relationships considering the effects on both predator and prey populations  **AND**  interspecific and intraspecific competition. |  |  |  |  |
| (c) the reasons for, and differences between, conservation and preservation.  To include the economic, social and ethical reasons for conservation of biological resources. |  |  |  |  |
| (d) how the management of an ecosystem can provide resources in a sustainable way.  Examples to include timber production and fishing. |  |  |  |  |

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| **Module 6 Genetics, evolution and ecosystems** | | | | |
| **6.3.2 Populations and sustainability** | | | | |
| **Learning outcomes**  You will be required to show and apply knowledge and understanding of: | **R** | **A** | **G** | **Comments** |
| (e) the management of environmental resources and the effects of human activities.  To include how ecosystems can be managed to balance the conflict between conservation/preservation and human needs e.g. the Masai Mara region in Kenya and the Terai region of Nepal, peat bogs  **AND**  the effects of human activities on the animal and plant populations and how these are controlled in environmentally sensitive ecosystems e.g. the Galapagos Islands, Antarctica, Snowdonia National Park, the Lake District. |  |  |  |  |

[](https://www.surveymonkey.co.uk/r/ZL5Z53B)

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