

A Level Biology Checklist

Content covered in Year 12

Notes



Revised

Module 2: Foundations in Biology

2.1.1 Cell Structure

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) 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*
- (b) the preparation and examination of microscope slides for use in light microscopy *Including the use of an eyepiece graticule and stage micrometer [PAG1](#)*
- (c) the use of staining in light microscopy. *To include the use of differential staining to identify different cellular components and cell types [PAG1](#)*
- (d) 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 [PAG1](#)
- (e) the use and manipulation of the magnification formula
 $\text{magnification} = \text{image size} \div \text{object size}$
- (f) 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*
- (g) 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.*
- (h) photomicrographs of cellular components in a range of eukaryotic cells. *To include interpretation of transmission and scanning electron microscope images.*
- (i) the interrelationship between the organelles involved in the production and secretion of proteins. *No detail of protein synthesis is required.*
- (j) the importance of the cytoskeleton. *To include providing mechanical strength to cells, aiding transport within cells and enabling cell movement.*
- (k) the similarities and differences in the structure and ultrastructure of prokaryotic and eukaryotic cells. [PAG1](#)

2.1.2 Biological Molecules

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) 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.*
- (b) the concept of monomers and polymers and the importance of condensation and hydrolysis reactions in a range of biological molecules
- (c) 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
- (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.*
- (e) 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.

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(f) the structure of starch (amylose and amylopectin), glycogen and cellulose molecules					
(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. <i>To include an outline of saturated and unsaturated fatty acids.</i>					
(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. <i>To include hydrophobic and hydrophilic regions and energy content AND illustrated using examples of prokaryotes and eukaryotes.</i>					
(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					
(m) the levels of protein structure. <i>To include primary, secondary, tertiary and quaternary structure AND hydrogen bonding, hydrophobic and hydrophilic interactions, disulfide bonds and ionic bonds.</i>					
(n) the structure and function of globular proteins including a conjugated protein <i>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. PAG10</i>					
(o) the properties and functions of fibrous proteins <i>To include collagen, keratin and elastin (no details of structure are required).</i>					
(p) the key inorganic ions that are involved in biological processes <i>including: cations: calcium ions (Ca^{2+}), sodium ions (Na^+), potassium ions (K^+), hydrogen ions (H^+), ammonium ions (NH_4^+); anions: nitrate (NO_3^-), hydrogencarbonate (HCO_3^-), chloride (Cl^-), phosphate (PO_4^{3-}), hydroxide, (OH^-).</i>					
(q) how to carry out and interpret the results of the following chemical tests: <ul style="list-style-type: none"> • 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 PAG9 					
(r) quantitative methods to determine the concentration of a chemical substance in a solution <i>To include colorimetry and the use of biosensors (an outline only of the mechanism is required). PAG5</i>					
(s) (i) the principles and uses of paper and thin layer chromatography to separate biological molecules / compounds <i>To include calculation of retention (R_f) values.</i> (ii) practical investigations to analyse biological solutions using paper or thin layer chromatography. <i>For example the separation of proteins, carbohydrates, vitamins or nucleic acids. PAG6</i>					
2.1.3 Nucleotides and Nucleic Acids					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the structure of a nucleotide as the monomer from which nucleic acids are made <i>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. PAG10</i>					
(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 <i>Comprising a pentose sugar (ribose), a nitrogenous base (adenine) and inorganic phosphates.</i>					

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(d) (i) the structure of DNA (deoxyribonucleic acid) (ii) practical investigations into the purification of DNA by precipitation <i>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. PAG9</i>					
(e) semi-conservative DNA replication <i>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.</i>					
(f) the nature of the genetic code <i>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).</i>					
(g) transcription and translation of genes resulting in the synthesis of polypeptides. <i>To include, the roles of RNA polymerase, messenger (m)RNA, transfer (t)RNA, ribosomal (r)RNA.</i>					
2.1.4 Enzymes					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the role of enzymes in catalysing reactions that affect metabolism at a cellular and whole organism level <i>To include the idea that enzymes affect both structure and function.</i>					
(b) the role of enzymes in catalysing both intracellular and extracellular reactions <i>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.</i>					
(c) the mechanism of enzyme action <i>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.</i>					
(d) (i) the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity <i>To include reference to the temperature coefficient (Q10).</i> (ii) practical investigations into the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity PAG4					
(e) the need for coenzymes, cofactors and prosthetic groups in some enzyme-controlled reactions <i>To include Cl⁻ as a cofactor for amylase, Zn²⁺ as a prosthetic group for carbonic anhydrase and vitamins as a source of coenzymes. PAG4</i>					
(f) the effects of inhibitors on the rate of enzyme controlled reactions. <i>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). PAG4</i>					
2.1.5 Biological membranes					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the roles of membranes within cells and at the surface of cells <i>To include the roles of membranes as,</i> • <i>partially permeable barriers between the cell and its environment, between organelles and the cytoplasm and within organelles</i> • <i>sites of chemical reactions</i> • <i>sites of cell communication (cell signalling).</i>					
(b) the fluid mosaic model of membrane structure and the roles of its components <i>To include phospholipids, cholesterol, glycolipids, proteins and glycoproteins AND the role of membrane-bound receptors as sites where hormones and drugs can bind.</i>					
(c) (i) factors affecting membrane structure and permeability (ii) practical investigations into factors affecting membrane structure and permeability <i>To include the effects of temperature and solvents. PAG8</i>					
(d) (i) the movement of molecules across membranes (ii) practical investigations into the factors affecting diffusion rates in model cells <i>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. PAG8</i>					

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<p>(e) (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</p> <p>(ii) practical investigations into the effects of solutions of different water potential on plant and animal cells.</p> <p><i>Osmosis to be explained in terms of a water potential gradient across a partially-permeable membrane.</i></p> <p>PAG8</p>					
2.1.6 Cell division, cell diversity and cellular organisation <i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
<p>(a) the cell cycle</p> <p><i>To include the processes taking place during interphase (G₁, S and G₂), mitosis and cytokinesis, leading to genetically identical cells.</i></p>					
<p>(b) how the cell cycle is regulated</p> <p><i>To include an outline of the use of checkpoints to control the cycle.</i></p>					
<p>(c) the main stages of mitosis</p> <p><i>To include the changes in the nuclear envelope, chromosomes, chromatids, centromere, centrioles, spindle fibres and cell membrane.</i></p>					
<p>(d) sections of plant tissue showing the cell cycle and stages of mitosis</p> <p><i>To include the examination of stained sections and squashes of plant tissue and the production of labelled diagrams to show the stages observed. PAG1</i></p>					
<p>(e) the significance of mitosis in life cycles</p> <p><i>To include growth, tissue repair and asexual reproduction in plants, animals and fungi.</i></p>					
<p>(f) the significance of meiosis in life cycles</p> <p><i>To include the production of haploid cells and genetic variation by independent assortment and crossing over.</i></p>					
<p>(g) the main stages of meiosis</p> <p><i>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. PAG1</i></p>					
<p>(h) how cells of multicellular organisms are specialised for particular functions</p> <p><i>To include erythrocytes, neutrophils, squamous and ciliated epithelial cells, sperm cells, palisade cells, root hair cells and guard cells.</i></p>					
<p>(i) the organisation of cells into tissues, organs and organ systems</p> <p><i>To include squamous and ciliated epithelia, cartilage, muscle, xylem and phloem as examples of tissues.</i></p>					
<p>(j) the features and differentiation of stem cells</p> <p><i>To include stem cells as a renewing source of undifferentiated cells.</i></p>					
<p>(k) the production of erythrocytes and neutrophils derived from stem cells in bone marrow</p>					
<p>(l) the production of xylem vessels and phloem sieve tubes from meristems</p>					
<p>(m) the potential uses of stem cells in research and medicine.</p> <p><i>To include the repair of damaged tissues, the treatment of neurological conditions such as Alzheimer's and Parkinson's, and research into developmental biology.</i></p>					

Module 3: Exchange and transport

3.1.1 Exchange surfaces

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the need for specialised exchange surfaces <i>To include surface area to volume ratio (SA:V), metabolic activity, single-celled and multicellular organisms.</i>					
(b) the features of an efficient exchange surface <i>To include,</i> •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 <i>To include the distribution and functions of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli. PAG1</i>					
(d) the mechanism of ventilation in mammals <i>To include the function of the rib cage, intercostal muscles (internal and external) and diaphragm.</i>					
(e) the relationship between vital capacity, tidal volume, breathing rate and oxygen uptake <i>To include analysis and interpretation of primary and secondary data e.g. from a data logger or spirometer. PAG10</i>					
(f) the mechanisms of ventilation and gas exchange in bony fish and insects <i>To include:</i> •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.					
(g) the dissection, examination and drawing of the gaseous exchange system of a bony fish and/or insect trachea PAG2					
(h) the examination of microscope slides to show the histology of exchange surfaces. PAG1					

3.1.2 Transport in animals

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the need for transport systems in multicellular animals <i>To include an appreciation of size, metabolic rate and surface area to volume ratio (SA:V).</i>					
(b) the different types of circulatory systems <i>To include single, double, open and closed circulatory systems in insects, fish and mammals.</i>					
(c) the structure and functions of arteries, arterioles, capillaries, venules and veins <i>To include the distribution of different tissues within the vessel walls. PAG2</i>					
(d) the formation of tissue fluid from plasma <i>To include reference to hydrostatic pressure, oncotic pressure and an explanation of the differences in the composition of blood, tissue fluid and lymph.</i>					
(e) (i) the external and internal structure of the mammalian heart PAG2 (ii) the dissection, examination and drawing of the external and internal structure of the mammalian heart					
(f) the cardiac cycle To include the role of the valves and the pressure changes occurring in the heart and associated vessels.					
(g) how heart action is initiated and coordinated <i>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).</i>					
(h) the use and interpretation of electrocardiogram (ECG) traces <i>To include normal and abnormal heart activity e.g. tachycardia, bradycardia, fibrillation and ectopic heartbeat.</i>					
(i) the role of haemoglobin in transporting oxygen and carbon dioxide <i>To include the reversible binding of oxygen molecules, carbonic anhydrase, haemoglobin acid, HCO_3^- and the chloride shift.</i>					

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(j) the oxygen dissociation curve for fetal and adult human haemoglobin. <i>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).</i>					
3.1.3 Transport in plants					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the need for transport systems in multicellular plants <i>To include an appreciation of size, metabolic rate and surface area to volume ratio (SA:V).</i>					
(b) (i) the structure and function of the vascular system in the roots, stems and leaves of herbaceous dicotyledonous plants (ii) the examination and drawing of stained sections of plant tissue to show the distribution of xylem and phloem PAG1 (iii) the dissection of stems, both longitudinally and transversely, and their examination to demonstrate the position and structure of xylem vessels <i>To include xylem vessels, sieve tube elements and companion cells. PAG2</i>					
(c) (i) the process of transpiration and the environmental factors that affect transpiration rate (ii) practical investigations to estimate transpiration rates <i>To include an appreciation that transpiration is a consequence of gaseous exchange. To include the use of a potometer. PAG5, PAG11</i>					
(d) the transport of water into the plant, through the plant and to the air surrounding the leaves <i>To include details of the pathways taken by water AND the mechanisms of movement, in terms of water potential, adhesion, cohesion and the transpiration stream.</i>					
(e) adaptations of plants to the availability of water in their environment <i>To include xerophytes (cacti and marram grass) and hydrophytes (water lilies).</i>					
(f) the mechanism of translocation. <i>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.</i>					

Module 4: Biodiversity, evolution and disease

4.1 Communicable diseases, disease prevention and the immune system

4.1.1 Communicable diseases, disease prevention and the immune system

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the different types of pathogen that can cause communicable diseases in plants and animals <i>To include,</i> •bacteria – tuberculosis (TB), bacterial meningitis, ring rot (potatoes, tomatoes) •virus – HIV/AIDS (human), influenza (animals), Tobacco Mosaic Virus (plants) •protocista – malaria, potato/tomato late blight •fungi – black sigatoka (bananas), ring worm (cattle), athlete's foot (humans).					
(b) the means of transmission of animal and plant communicable pathogens <i>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).</i>					
(c) plant defences against pathogens <i>To include production of chemicals AND plant responses that limit the spread of the pathogen (e.g. callose deposition).</i>					
(d) the primary non-specific defences against pathogens in animals <i>Non-specific defences to include skin, blood clotting, wound repair, inflammation, expulsive reflexes and mucous membranes (no detail of skin structure is required).</i>					
(e) (i) the structure and mode of action of phagocytes (ii) examination and drawing of cells observed in blood smears <i>To include neutrophils and antigen-presenting cells AND the roles of cytokines, opsonins, phagosomes and lysosomes. PAG1</i>					
(f) the structure, different roles and modes of action of B and T lymphocytes in the specific immune response <i>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.</i>					
(g) the primary and secondary immune responses <i>To include T memory cells and B memory cells.</i>					
(h) the structure and general functions of antibodies <i>To include the general structure of an antibody molecule.</i>					
(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 <i>To include examples of each type of immunity.</i>					
(k) autoimmune diseases <i>To include an appreciation of the term autoimmune disease and a named example e.g. arthritis, lupus.</i>					
(l) the principles of vaccination and the role of vaccination programmes in the prevention of epidemics <i>To include routine vaccinations AND reasons for changes to vaccines and vaccination programmes (including global issues).</i>					
(m) possible sources of medicines <i>To include examples of microorganisms and plants (and so the need to maintain biodiversity) AND the potential for personalised medicines and synthetic biology.</i>					
(n) the benefits and risks of using antibiotics to manage bacterial infection. <i>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.</i>					

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4.2 Biodiversity					
4.2.1 Biodiversity					
Learners should be able to demonstrate and apply their knowledge and understanding of:					
(a) how biodiversity may be considered at different levels <i>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).</i>					
(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 <i>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.</i> <i>Techniques to include use of sweeping nets, pitfall traps, pooters, Tullgren funnel and kick-sampling for collecting different samples. PAG3</i>					
(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 <i>To include the formula: $D = 1 - (\sum(n/N)^2)$ AND the interpretation of both high and low values of Simpson's Index of Diversity (D).</i>					
(e) how genetic biodiversity may be assessed, including calculations <i>To include calculations of genetic diversity within isolated populations, for example the percentage of gene variants (alleles) in a genome.</i> <i>proportion of polymorphic gene loci = number of polymorphic gene loci/total number of loci</i> <i>Suitable populations include zoos (captive breeding), rare breeds and pedigree animals.</i>					
(f) the factors affecting biodiversity <i>To include human population growth, agriculture (monoculture) and climate change.</i>					
(g) the ecological, economic and aesthetic reasons for maintaining biodiversity <i>Ecological, including protecting keystone species (interdependence of organisms) and maintaining genetic resource</i> •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. <i>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).</i>					
4.2.2 Classification and evolution					
Learners should be able to demonstrate and apply their knowledge and understanding of:					
(a) the biological classification of species <i>To include the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species AND domain.</i>					
(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, Protocista, Fungi, Plantae, Animalia <i>To include the use of similarities in observable features in original classification.</i> (ii) the evidence that has led to new classification systems, such as the three domains of life, which clarifies relationships <i>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.</i>					
(d) the relationship between classification and phylogeny (covered in outline only at AS level)					
(e) the evidence for the theory of evolution by natural selection <i>To include the contribution 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.</i>					

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<p>(f) the different types of variation</p> <p><i>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.</i></p>					
<p>(g) the different types of adaptations of organisms to their environment</p> <p><i>Anatomical, physiological and behavioural adaptations AND why organisms from different taxonomic groups may show similar anatomical features, including the marsupial mole and placental mole.</i></p>					
<p>(h) the mechanism by which natural selection can affect the characteristics of a population over time</p> <p><i>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></p>					
<p>(i) how evolution in some species has implications for human populations.</p> <p><i>To include the evolution of pesticide resistance in insects and drug resistance in microorganisms.</i></p>					

A Level Biology Checklist

Content covered in Year 13

Notes



Revised

Module 5: Communication, homeostasis and energy

5.1.1 Communication and homeostasis

Learners should be able to demonstrate and apply their knowledge and understanding of:

(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 differences between negative feedback and positive feedback.

(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. [PAG11](#)

5.1.2 Excretion as an example of homeostatic control

Learners should be able to demonstrate and apply their knowledge and understanding of:

(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). [PAG1](#)

(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.

[PAG1](#), [PAG2](#)

(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.

(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 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. [PAG9](#)

5.1.3 Neuronal communication

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the roles of mammalian sensory receptors in converting different types of stimuli into nerve impulses <i>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.</i>					
(b) the structure and functions of sensory, relay and motor neurones <i>To include differences between the structure and function of myelinated and non-myelinated neurones.</i>					
(c) the generation and transmission of nerve impulses in mammals <i>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.</i>					
(d) the structure and roles of synapses in neurotransmission. <i>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.</i>					

5.1.4 Hormonal communication

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) endocrine communication by hormones <i>To include secretion of hormones into the blood, transport by the blood, and detection by target cells or tissues.</i>					
(b) the structure and functions of the adrenal glands <i>Adrenal glands as an example of endocrine glands, to include the hormones secreted by the cortex and medulla and their functions.</i>					
(c) (i) the histology of the pancreas <i>To include the endocrine tissues. PAG1</i> (ii) the examination and drawing of stained sections of the pancreas to show the histology of the endocrine tissues					
(d) how blood glucose concentration is regulated <i>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.</i>					
(e) the differences between Type 1 and Type 2 diabetes mellitus <i>To include the causes of Type 1 and Type 2 diabetes and the treatments used for each.</i>					
(f) the potential treatments for diabetes mellitus. <i>To include the use of insulin produced by genetically modified bacteria and the potential use of stem cells to treat diabetes mellitus.</i>					

5.1.5 Plant and animal responses

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) (i) the types of plant responses (ii) practical investigations into phototropism and geotropism <i>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. PAG11</i>					
(b) the roles of plant hormones <i>To include the role of hormones in leaf loss in deciduous plants, seed germination and stomatal closure.</i>					
(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					
(e) practical investigations into the effect of plant hormones on growth <i>An opportunity for serial dilution. An opportunity to use standard deviation to measure the spread of a set of data. PAG11</i>					
(f) the commercial use of plant hormones <i>To include the use of hormones to control ripening, the use of rooting powders and hormonal weed killers.</i>					

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(g) the organisation of the mammalian nervous system <i>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.</i>					
(h) the structure of the human brain and the functions of its parts <i>To include the gross structure of the human brain AND the functions of the cerebrum, cerebellum, medulla oblongata, hypothalamus and pituitary gland.</i>					
(i) reflex actions <i>To include knee jerk reflex and blinking reflex, with reference to the survival value of reflex actions.</i> PAG11					
(j) the coordination of responses by the nervous and endocrine systems <i>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).</i>					
(k) the effects of hormones and nervous mechanisms on heart rate <i>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.</i> PAG10 , PAG11					
(l) (i) the structure of mammalian muscle and the mechanism of muscular contraction (ii) the examination of stained sections or photomicrographs of skeletal muscle. <i>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.</i> PAG1 , PAG10 , PAG11					
5.2.1 Photosynthesis					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the interrelationship between the process of photosynthesis and respiration <i>To include the relationship between the raw materials and products of the two processes.</i>					
(b) the structure of a chloroplast and the sites of the two main stages of photosynthesis <i>The components of a chloroplast including outer membrane, lamellae, grana, thylakoid, stroma and DNA.</i>					
(c) (i) the importance of photosynthetic pigments in photosynthesis (ii) practical investigations using thin layer chromatography (TLC) to separate photosynthetic pigments <i>To include reference to light harvesting systems and photosystems..4</i> PAG6					
(d) the light-dependent stage of photosynthesis <i>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.</i>					
(e) the fixation of carbon dioxide and the light independent stage of photosynthesis <i>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 biphosphate (RuBP), ribulose biphosphate carboxylase (RuBisCO) and glycerate 3-phosphate (GP) – no other biochemical detail is required.</i>					
(f) the uses of triose phosphate (TP) <i>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.</i>					
(g) (i) factors affecting photosynthesis (ii) practical investigations into factors affecting the rate of photosynthesis. <i>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. An opportunity to use sensors, data loggers and software to process data.</i> PAG4 , PAG10 , PAG11					

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5.2.2 Respiration					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the need for cellular respiration <i>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).</i>					
(b) the structure of the mitochondrion <i>The components of a mitochondrion including inner and outer mitochondrial membranes, cristae, matrix and mitochondrial DNA.</i>					
(c) the process and site of glycolysis <i>To include the phosphorylation of glucose to hexose biphosphate, the splitting of hexose biphosphate into two triose phosphate molecules and further oxidation to pyruvate AND the production of a small yield of ATP and reduced NAD.</i>					
(d) the link reaction and its site in the cell <i>To include the decarboxylation of pyruvate to acetate, the reduction of NAD, and the combination of acetate with coenzyme A.</i>					
(e) the process and site of the Krebs cycle <i>To include the formation of citrate from acetate 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.</i>					
(f) the importance of coenzymes in cellular respiration <i>With reference to NAD, FAD and coenzyme A.</i>					
(g) the process and site of oxidative phosphorylation <i>To include the roles of electron carriers, oxygen and the mitochondrial cristae.</i>					
(h) the chemiosmotic theory <i>To include the electron transport chain, proton gradients and ATP synthase in oxidative phosphorylation and photophosphorylation.</i>					
(i) (i) the process of anaerobic respiration in eukaryotes (ii) practical investigations into respiration rates in yeast, under aerobic and anaerobic Conditions <i>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. An opportunity to use sensors, data loggers and software to process data. PAG4, PAG10, PAG11</i>					
(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) <i>To include calculating the respiratory quotient (RQ) using the formula: $RQ = \frac{CO_2 \text{ produced}}{O_2 \text{ consumed}}$</i>					
(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. <i>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. PAG4, PAG10, PAG11</i>					

Module 6: Genetics, evolution and ecosystems

6.1.1 Cellular control

Learners should be able to demonstrate and apply their knowledge and understanding of:

(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, posttranscriptional 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.

(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.

6.1.2 Patterns of inheritance

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) (i) the contribution of both environmental and genetic factors to phenotypic variation

(ii) how sexual reproduction can lead to genetic variation within a species

To include examples of both genetic and environmental contributions – environmental examples could include diet in animals and etiolation or chlorosis in plants. 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.

(c) using the chi-squared (χ^2) test to determine the significance of the difference between observed and expected results

The formula for the chi-squared (χ^2) test will be provided. M0.3, M1.4, M1.9, M2.1

(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.

(f) the use of the Hardy–Weinberg principle to calculate allele frequencies in populations

The equations for the Hardy–Weinberg principle will be provided.

(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.

(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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6.1.3 Manipulating genomes					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the principles of DNA sequencing and the development of new DNA sequencing techniques <i>To include the rapid advancements of the techniques used in sequencing, which have increased the speed of sequencing and allowed whole genome e.g. high-throughput sequencing.</i>					
(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 <i>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. PAG10</i>					
(c) the principles of DNA profiling and its uses <i>To include forensics and analysis of disease risk.</i>					
(d) the principles of the polymerase chain reaction (PCR) and its application in DNA analysis					
(e) the principles and uses of electrophoresis for separating nucleic acid fragments or proteins <i>Opportunity for practical use of electrophoresis. PAG6</i>					
(f) (i) the principles of genetic engineering <i>To include the isolation of genes from one organism and the placing of these genes into another organism using suitable vectors.</i> (ii) the techniques used in genetic engineering <i>To include the use of restriction enzymes, plasmids and DNA ligase to form recombinant DNA with the desired gene and electroporation.</i>					
(g) the ethical issues (both positive and negative) relating to the genetic manipulation of animals (including humans), plants and microorganisms <i>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.</i>					
(h) the principles of, and potential for, gene therapy in medicine. <i>To include the differences between somatic cell gene therapy and germ line cell gene therapy.</i>					
6.2.1 Cloning and biotechnology					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) (i) natural clones in plants and the production of natural clones for use in horticulture (ii) how to take plant cuttings as an example of a simple cloning technique <i>To include examples of natural cloning and the methods used to produce clone (various forms of vegetative propagation). Dissection of a selection of plant material to produce cuttings. PAG2</i>					
(b) (i) the production of artificial clones of plants by micropropagation and tissue culture (ii) the arguments for and against artificial cloning in plants <i>To include an evaluation of the uses of plant cloning in horticulture and agriculture.</i>					
(c) natural clones in animal species <i>To include examples of natural clones (twins formed by embryo splitting).</i>					
(d) (i) how artificial clones in animals can be produced by artificial embryo twinning or by enucleation and somatic cell nuclear transfer (SCNT) (ii) the arguments for and against artificial cloning in animals <i>To include an evaluation of the uses of animal cloning (examples including in agriculture and medicine, and issues of longevity of cloned animals).</i>					
(e) the use of microorganisms in biotechnological processes <i>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.</i>					

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(f) the advantages and disadvantages of using microorganisms to make food for human consumption <i>To include bacterial and fungal sources.</i>					
(g) (i) how to culture microorganisms effectively, using aseptic techniques (ii) the importance of manipulating the growing conditions in batch and continuous fermentation in order to maximise the yield of product required <i>An opportunity for serial dilutions and culturing on agar plates. PAG7</i>					
(h) (i) the standard growth curve of a microorganism in a closed culture <i>To include the formula for number of individual organisms</i> $N = N_0 \times 2^n$ <i>An opportunity for serial dilutions and the use of broth.</i> (ii) practical investigations into the factors affecting the growth of microorganisms <i>An opportunity for serial dilutions and the use of broth. PAG7</i>					
(i) the uses of immobilised enzymes in biotechnology and the different methods of immobilisation. <i>To include methods of enzyme immobilisation AND an evaluation of the use of immobilised enzymes in Biotechnology examples could include:</i> <ul style="list-style-type: none"> • glucose isomerase for the conversion of glucose to fructose • penicillin acylase for the formation of semisynthetic 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 • nitrilase for the conversion of acrylonitrile to acrylamide (for use in the plastics industry). PAG4 					
6.3.1 Ecosystems					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) ecosystems, which range in size, are dynamic and are influenced by both biotic and abiotic factors <i>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.</i>					
(b) biomass transfers through ecosystems <i>To include how biomass transfers between trophic levels can be measured AND the efficiency of biomass transfers between trophic levels</i> $\text{efficiency} = \frac{\text{biomass transferred}}{\text{biomass intake}} \times 100$ <i>AND how human activities can manipulate the transfer of biomass through ecosystems.</i>					
(c) recycling within ecosystems <i>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.</i>					
(d) the process of primary succession in the development of an ecosystem <i>To include succession from pioneer species to a climax community AND deflected succession.</i>					
(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. PAG3					
6.3.2 Populations and sustainability					
<i>Learners should be able to demonstrate and apply their knowledge and understanding of:</i>					
(a) the factors that determine size of a population <i>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.</i>					
(b) interactions between populations <i>To include predator-prey relationships considering the effects on both predator and prey populations AND interspecific and intraspecific competition.</i>					
(c) the reasons for, and differences between, conservation and preservation <i>To include the economic, social and ethical reasons for conservation of biological resources.</i>					

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(d) how the management of an ecosystem can provide resources in a sustainable way <i>Examples to include timber production and fishing.</i>					
(e) the management of environmental resources and the effects of human activities. <i>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.</i>					
Forms of assessment					
<p>All three externally assessed components (01–03) contain some synoptic assessment, some extended response questions and some stretch and challenge questions.</p> <p>Stretch and challenge questions are designed to allow the most able learners the opportunity to demonstrate the full extent of their knowledge and skills.</p> <p>Stretch and challenge questions will support the awarding of A* grade at A level, addressing the need for greater differentiation between the most able learners.</p>					
Biological processes (Component 01)					
<p>This component is worth 100 marks, is split into two sections and assesses content from teaching modules 1, 2, 3 and 5. Learners answer all the questions.</p> <p>Section A contains multiple choice questions. This section of the paper is worth 15 marks.</p> <p>Section B includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 85 marks.</p>					
Biological diversity (Component 02)					
<p>This component is worth 100 marks, is split into two sections and assesses content from teaching modules 1, 2, 4 and 6. Learners answer all the questions.</p> <p>Section A contains multiple choice questions. This section of the paper is worth 15 marks.</p> <p>Section B includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 85 marks.</p>					
Unified biology (Component 03)					
<p>This component assesses content from across all teaching modules 1 to 6. Learners answer all the questions. This component is worth 70 marks. Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.</p>					
Practical endorsement in biology (Component 04)					
<p>Performance in this component is reported separately to the performance in the A level as measured through externally assessed components 01 to 03. This non-exam assessment component rewards the development of practical competency for biology and is teacher assessed.</p> <p>Learners complete a minimum of 12 assessed experiments covering the technical skills (together with the use of apparatus and practical techniques) specified in Section 5g.</p> <p>Learners may work in groups but must be able to demonstrate and record independent evidence of their competency.</p> <p>Teachers who award a pass to their learners need to be confident that the learner consistently and routinely exhibits the competencies listed in Section 5g before completion of the A level course.</p>					