**Year 12 Biology Checklist**

**Module 2 Foundations in Biology**

|  |  |
| --- | --- |
| **Cell structure** |  |
| **The use of microscopy to observe and investigate different types of cell and cell structure in a range of eukaryotic organisms.**  an appreciation of the images produced by a range of microscopes: light microscope, transmission electron microscope, scanning electron microscope and laser scanning confocal microscope |  |
| **The preparation and examination of microscope slides for use in light microscopy**  **Including the use of an eyepiece graticule and stage micrometer** |  |
| **The use of staining in light microscopy**  the use of differential staining to identify different cellular components and cell types |  |
| **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** |  |
| **The use and manipulation of the magnification formula**  **magnification=image size/object size** |  |
| **The difference between magnification and resolution**  an appreciation of the differences in resolution and magnification that can be achieved by a light microscope, a transmission and scanning electron microscope |  |
| **The ultrastructure of eukaryotic cells and the functions of the different cellular components**  nucleus, nucleolus, nuclear envelope, rough and smooth endoplasmic reticulum (ER), Golgi apparatus, ribosomes, mitochondria, lysosomes, chloroplasts, plasma membrane, centrioles, cell wall, flagella and cilia. |  |
| **Photomicrographs of cellular components in a range of eukaryotic cells**  interpretation of transmission and scanning electron microscope images. |  |
| **The interrelationship between the organelles involved in the production and secretion of protein** |  |
| **The importance of the cytoskeleton**  providing mechanical strength to cells, aiding transport within cells and enabling cell movement. |  |
| **The similarities and differences in the structure and ultrastructure of prokaryotic and eukaryotic cells.** |  |
| **Biological molecules** |  |
| **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  roles illustrated using examples of prokaryotes and eukaryotes |  |
| **The concept of monomers and polymers and the importance of condensation and hydrolysis reactions in a range of biological molecules** |  |
| **The chemical elements that make up biological molecules**  Cx(H2O)x 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. |  |
| **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**  the structural difference between an α- and a β-glucose molecule  the difference between a hexose and a pentose monosaccharide |  |
| **The synthesis and breakdown of a disaccharide and polysaccharide by the formation and breakage of glycosidic bonds**  the disaccharides sucrose, lactose and maltose. |  |
| **The structure of starch (amylose and amylopectin), glycogen and cellulose molecules** |  |
| **How the structures and properties of glucose, starch, glycogen and cellulose molecules relate to their functions in living organisms** |  |
| **The structure of a triglyceride and a phospholipid as examples of macromolecules**  **To include an outline of saturated and unsaturated fatty acids.** |  |
| **The synthesis and breakdown of triglycerides by the formation (esterification) and breakage of ester bonds between fatty acids and glycerol** |  |
| **How the properties of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms**  hydrophobic and hydrophilic regions and energy content  illustrated using examples of prokaryotes and eukaryotes |  |
| **The general structure of an amino acid** |  |
| **The synthesis and breakdown of dipeptides and polypeptides, by the formation and breakage of peptide bonds** |  |
| **The levels of protein structure**  To include primary, secondary, tertiary and quaternary structure  H bonding, hydrophobic/hydrophilic interactions, disulfide bonds and ionic bonds. |  |
| **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.** |  |
| **The properties and functions of fibrous proteins**  collagen, keratin and elastin (no details of structure are required). |  |
| **The key inorganic ions that are involved in biological processes**  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–). |  |
| **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 |  |
| **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). |  |
| **The principles and uses of paper and thin layer chromatography to separate biological molecules / compounds**  calculation of retention (Rf) values |  |
| **Practical investigations to analyse biological solutions using paper or thin layer chromatography.**  calculation of retention (Rf) values.  For example the separation of proteins, carbohydrates, vitamins or nucleic acids. |  |
| **Nucleotides and nucleic acids** |  |
| **The structure of a nucleotide as the monomer from which nucleic acids are** made  the differences between RNA and DNA nucleotides, the identification of the purines and pyrimidines and the type of pentose sugar. |  |
| **The synthesis and breakdown of polynucleotides by the formation and breakage of phosphodiester bonds** |  |
| **The structure of ADP and ATP as phosphorylated nucleotides**  **Comprising a pentose sugar (ribose), a nitrogenous base (adenine) and inorganic phosphates.** |  |
| **The structure of DNA (deoxyribonucleic acid)**  (ii) practical investigations into the purification of DNA by precipitation  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. |  |
| **Semi-conservative DNA replication**  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 |  |
| **The nature of the genetic code**  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). |  |
| **Transcription and translation of genes resulting in the synthesis of polypeptides**.  the roles of RNA polymerase, messenger (m)RNA, transfer (t)RNA, ribosomal (r)RNA. |  |
| **Enzymes** |  |
| **The role of enzymes in catalysing reactions that affect metabolism at a cellular and whole organism level**  the idea that enzymes affect both structure and function |  |
| **The role of enzymes in catalysing both intracellular and extracellular reactions**  catalase as an example of an enzyme that catalyses intracellular reactions and amylase and trypsin as examples of enzymes that catalyse extracellular reactions |  |
| **The mechanism of enzyme action**  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. |  |
| **The effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity**  (ii) practical investigations into the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity  reference to the temperature coefficient (Q10). |  |
| **The need for coenzymes, cofactors and prosthetic groups in some enzyme-controlled reactions**  Cl– as a cofactor for amylase,  Zn2+ as a prosthetic group for carbonic anhydrase  vitamins as a source of coenzymes. |  |
| **The effects of inhibitors on the rate of enzyme-controlled reactions.**  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  Inactive precursors in metabolic pathways (covered at A level only). |  |
| **Biological membranes** |  |
| **The roles of membranes within cells and at the surface of cells**  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). |  |
| **The fluid mosaic model of membrane structure and the roles of its components**  phospholipids, cholesterol, glycolipids, proteins and glycoproteins  the role of membrane-bound receptors as sites where hormones and drugs can bind. |  |
| **Factors affecting membrane structure and permeability**  (ii) practical investigations into factors affecting membrane structure and permeability  To include the effects of temperature and solvents. |  |
| **The movement of molecules across membranes**  (ii) practical investigations into the factors affecting diffusion rates in model cells  diffusion and facilitated diffusion as passive methods  active transport, endocytosis and exocytosis as processes requiring adenosine triphosphate (ATP) as an immediate source of energy. |  |
| **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 |  |
| **Cell division, cell diversity and cellular organisation** |  |
| **The cell cycle**  the processes taking place during interphase (G1, S and G2), mitosis and cytokinesis, leading to genetically identical cells. |  |
| **How the cell cycle is regulated**  an outline of the use of checkpoints to control the cycle. |  |
| **The main stages of mitosis**  changes in the nuclear envelope, chromosomes, chromatids, centromere, centrioles, spindle fibres and cell membrane. |  |
| **Sections of plant tissue showing the cell cycle and stages of mitosis**  examination of stained sections and squashes of plant tissue and the production of labelled diagrams to show the stages observed. |  |
| **The significance of mitosis in life cycles**  growth, tissue repair and asexual reproduction in plants, animals and fungi |  |
| **The significance of meiosis in life cycles**  the production of haploid cells and genetic variation by independent assortment and crossing over. |  |
| **The main stages of meiosis**  interphase, prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, telophase 2 and the term homologous chromosomes |  |
| **How cells of multicellular organisms are specialised for particular functions**  erythrocytes, neutrophils, squamous and ciliated epithelial cells, sperm cells, palisade cells, root hair cells and guard cells |  |
| **The organisation of cells into tissues, organs and organ systems**  squamous and ciliated epithelia, cartilage, muscle, xylem and phloem as examples of tissues |  |
| **The features and differentiation of stem cells**  stem cells as a renewing source of undifferentiated cells. |  |
| **The production of erythrocytes and neutrophils derived from stem cells in bone marrow** |  |
| **The production of xylem vessels and phloem sieve tubes from meristems** |  |
| **The potential uses of stem cells in research and medicine.**  the repair of damaged tissues, the treatment of neurological conditions such as Alzheimer’s and Parkinson’s, and research into developmental biology. |  |

**Module 3 Exchange and Transport**

|  |  |
| --- | --- |
| **Exchange surfaces** |  |
| **The need for specialised exchange surfaces**  surface area to volume ratio (SA:V), metabolic activity, single-celled and multicellular organisms. |  |
| **The features of an efficient exchange surface**  • increased surface area – root hair cells  • thin layer – alveoli  • good blood supply/ventilation to maintain gradient – gills/alveolus. |  |
| **The structures and functions of the components of the mammalian gaseous exchange system**  distribution and functions of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli. |  |
| **The mechanism of ventilation in mammals**  function of the rib cage, intercostal muscles (internal and external) and diaphragm. |  |
| **The relationship between vital capacity, tidal volume, breathing rate and oxygen uptake**  analysis and interpretation of primary and secondary data e.g. from a data logger or spirometer |  |
| **The mechanisms of ventilation and gas exchange in bony fish and insects**  • 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 |  |
| **Transport in animals** |  |
| **The need for transport systems in multicellular animals**  an appreciation of size, metabolic rate and surface area to volume ratio (SA:V). |  |
| **The different types of circulatory systems**  single, double, open and closed circulatory systems in insects, fish and mammals. |  |
| **The structure and functions of arteries, arterioles, capillaries, venules and veins**  distribution of different tissues within the vessel walls. |  |
| **The formation of tissue fluid from plasma**  reference to hydrostatic pressure, oncotic pressure and an explanation of the differences in the composition of blood, tissue fluid and lymph |  |
| **The cardiac cycle**  the role of the valves and the pressure changes occurring in the heart and blood vessels |  |
| **How heart action is initiated and coordinated**  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). |  |
| **The use and interpretation of electrocardiogram (ECG) traces**  normal and abnormal heart activity e.g. tachycardia, bradycardia, fibrillation and ectopic heartbeat |  |
| **The role of haemoglobin in transporting oxygen and carbon dioxide**  the reversible binding of oxygen molecules, carbonic anhydrase, haemoglobinic acid, HCO3– and the chloride shift. |  |
| **The oxygen dissociation curve for fetal and adult human haemoglobin**.  the significance of the different affinities for oxygen  the changes to the dissociation curve at different carbon dioxide concentrations (the Bohr effect). |  |
| **Transport in plants** |  |
| **The need for transport systems in multicellular plants**  an appreciation of size, metabolic rate and surface area to volume ratio (SA:V). |  |
| **The structure and function of the vascular system in the roots, stems and leaves of herbaceous dicotyledonous plants**  xylem vessels, sieve tube elements and companion cells |  |
| **The process of transpiration and the environmental factors that affect transpiration rate**  an appreciation that transpiration is a consequence of gaseous exchange. |  |
| **The transport of water into the plant, through the plant and to the air surrounding the leaves**  details of the pathways taken by water  the mechanisms of movement, in terms of water potential, adhesion, cohesion and the transpiration stream. |  |
| **Adaptations of plants to the availability of water in their environment**  xerophytes (cacti and marram grass) and hydrophytes (water lilies). |  |
| **The mechanism of translocation**.  translocation as an energy-requiring process transporting assimilates, especially sucrose, in the phloem between sources (e.g. leaves) and sinks (e.g. roots, meristem)  details of active loading at the source and removal at the sink. |  |

**Module 4 Biodiversity, evolution and Disease**

|  |  |
| --- | --- |
| **Communicable diseases, disease prevention and the immune system** |  |
| **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)  • virus – HIV/AIDS (human), influenza (animals), Tobacco Mosaic Virus (plants)  • protoctista – malaria, potato/tomato late blight  • fungi – black sigatoka (bananas), , ring worm (cattle), athlete’s foot (humans). |  |
| **The means of transmission of animal and plant communicable pathogens**  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). |  |
| **Plant defences against pathogens**  production of chemicals  plant responses that limit the spread of the pathogen (e.g. callose deposition). |  |
| **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 is required). |  |
| **The structure and mode of action of phagocytes**  (ii) examination and drawing of cells observed in blood smears  neutrophils and antigen-presenting cells  the roles of cytokines, opsonins, phagosomes and lysosomes. |  |
| **The structure, different roles and modes of action of B and T lymphocytes in the specific immune response**  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. |  |
| **The primary and secondary immune responses**  T memory cells and B memory cells. |  |
| **The structure and general functions of antibodies**  the general structure of an antibody molecule |  |
| **An outline of the action of opsonins, agglutinins and anti-toxins** |  |
| **The differences between active and passive immunity, and between natural and artificial immunity**  examples of each type of immunity |  |
| **Autoimmune diseases**  an appreciation of autoimmune disease and a named example e.g. arthritis, lupus. |  |
| **The principles of vaccination and the role of vaccination programmes in the prevention of epidemics**  routine vaccinations  reasons for changes to vaccines and vaccination programmes (including global issues). |  |
| **Possible sources of medicines**  examples of microorganisms and plants (and so the need to maintain biodiversity)  the potential for personalised medicines and synthetic biology. |  |
| **The benefits and risks of using antibiotics to manage bacterial infection.**  the wide use of antibiotics following the discovery of penicillin in the mid-20th century  the increase in bacterial resistance to antibiotics (examples to include Clostridium difficile and MRSA) and its implications. |  |
| **Biodiversity** |  |
| **How biodiversity may be considered at different levels**  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). |  |
| **How sampling is used in measuring the biodiversity of a habitat and the importance of sampling**  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. |  |
| **Practical investigations collecting random and non-random samples in the field** |  |
| **How to measure species richness and species evenness in a habitat** |  |
| **The use and interpretation of Simpson’s Index of Diversity (D) to calculate the biodiversity of a habitat**  To include the formula: **D = 1–(Σ(n/N)2)**  the interpretation of both high and low values of Simpson’s Index of Diversity (D). |  |
| **How genetic biodiversity may be assessed, including calculations**  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** |  |
| **The factors affecting biodiversity**  human population growth, agriculture (monoculture) and climate change. |  |
| **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 |  |
| **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. |  |
| **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).** |  |
| **Classification and evolution** |  |
| **The biological classification of species**  the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species  domain. |  |
| **The binomial system of naming species and the advantage of such a system** |  |
| **The features used to classify organisms into the five kingdoms: Prokaryotae, Protoctista, Fungi, Plantae, Animalia**  the use of similarities in observable features in original classification |  |
| **The evidence that has led to new classification systems, such as the three domains of life, which clarifies relationships**  the use of similarities in observable features in original classification.  the use of similarities in biological molecules and other genetic evidence  details of the three domains and a comparison of the 2 classification systems. |  |
| **The relationship between classification and phylogeny** |  |
| **The evidence for the theory of evolution by natural selection**  the contributions of Darwin and Wallace in formulating the theory of evolution by natural selection  fossil, DNA (only genomic DNA at AS level) and molecular evidence. |  |
| **The different types of variation**  intraspecific and interspecific variation  the differences between continuous and discontinuous variation, using examples of a range of characteristics found in plants, animals and microorganisms  both genetic and environmental causes of variation. |  |
| **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.** |  |
| **The mechanism by which natural selection can affect the characteristics of a population over time**  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). |  |
| **How evolution in some species has implications for human populations**.  the evolution of pesticide resistance in insects and drug resistance in microorganisms |  |