

1.1.1 Planning

Can you design an experiment, including solving practical problems set in a biological context?



Can you identify the independent, dependent and control variables, and explain how the control variables would be kept constant?



Can you evaluate whether an experimental method is appropriate to meet the expected outcomes?

**1.1.2 Implementing**

Can you describe how to use a wide range of practical apparatus and techniques correctly?



Can you use appropriate SI units for measurements?



Can you present observations and data in an appropriate format, such as tables with headings and units?

**1.1.3 Analysis**

Can you process, analyse and interpret qualitative and quantitative experimental results?



Can you use appropriate mathematical skills, such as means, percentages and rates, to analyse quantitative data?



Can you give answers to an appropriate number of significant figures?



Can you plot a graph with suitably labelled axes, sensible scales and units?



Can you measure the gradient of a line (including a tangent to a curve) and read off intercepts?

**1.1.4 Evaluation**

Can you evaluate results and draw conclusions that are supported by the data?



Can you identify anomalies in experimental measurements and explain how to deal with them?



Can you identify the limitations of an experimental procedure?



Can you distinguish between precision and accuracy, and calculate margins of error, percentage error and uncertainties?



Can you suggest refinements to an experimental design and explain how they would improve the results?



1.2.1 Practical skills

Can you apply investigative approaches and methods when carrying out practical work?	☐ ☐ ☐
Can you use a wide range of equipment and materials safely and correctly, including carrying out a risk assessment?	☐ ☐ ☐
Can you follow written instructions accurately?	☐ ☐ ☐
Can you make and record accurate observations and measurements?	☐ ☐ ☐
Can you keep appropriate records of experimental activities?	☐ ☐ ☐
Can you present information and data in a scientific way?	☐ ☐ ☐
Can you use appropriate software and tools to process data, carry out research and report findings?	☐ ☐ ☐
Can you use online and offline research skills, including websites, textbooks and other printed sources?	☐ ☐ ☐
Can you correctly cite sources of information?	☐ ☐ ☐
Can you use a wide range of experimental and practical instruments, equipment and techniques appropriate to biology?	☐ ☐ ☐

1.2.2 Use of apparatus and techniques

Can you use appropriate apparatus to record quantitative measurements of mass, time, volume, temperature, length and pH?	☐ ☐ ☐
Can you use instrumentation such as a colorimeter or a potometer?	☐ ☐ ☐
Can you use laboratory glassware for a range of techniques, including serial dilutions?	☐ ☐ ☐
Can you use a light microscope at high and low power, including use of a graticule?	☐ ☐ ☐
Can you produce scientific drawings from observations, with annotations?	☐ ☐ ☐
Can you use qualitative reagents to identify biological molecules?	☐ ☐ ☐
Can you separate biological compounds using thin layer or paper chromatography, or electrophoresis?	☐ ☐ ☐
Can you safely and ethically use organisms to measure plant or animal responses or physiological functions?	☐ ☐ ☐
Can you use microbiological aseptic techniques, including agar plates and broth?	☐ ☐ ☐
Can you safely use instruments to dissect animal or plant organs?	☐ ☐ ☐
Can you use sampling techniques in fieldwork?	☐ ☐ ☐

Can you use ICT, such as computer modelling or a data logger, to collect data or process it with software?



Microscopy and blood cells

Can you explain the use of microscopy in developing cell theory and observing cell structure, including light, transmission electron, scanning electron and laser scanning confocal microscopes?



Can you describe how to prepare a blood smear for light microscopy, following CLEAPSS safety guidelines?



Can you explain the use of differential staining, such as Leishman's stain, to identify different leucocytes?



Can you describe the structure of animal cells using blood cells as examples, including erythrocytes, platelets, neutrophils, lymphocytes and monocytes?



Can you observe, draw and annotate cells in a blood smear viewed under a light microscope?



Can you calculate linear dimensions of cells and use the formula $\text{magnification} = \frac{\text{image size}}{\text{actual size}}$?



Can you use a haemocytometer to count erythrocytes and convert counts to a concentration, allowing for dilutions?



Can you explain the principles and use of flow cytometry with fluorescent labels in analysing blood?



Can you calibrate an eyepiece graticule with a stage micrometer and use it to measure cells and calculate magnification?

**Cell ultrastructure**

Can you describe the ultrastructure of a eukaryotic animal cell such as a leucocyte, including the Golgi apparatus, RER, SER, ribosomes, lysosomes, mitochondria, cytoskeleton, centrioles, nucleus and nucleolus, and their functions?



Can you describe the ultrastructure of a palisade mesophyll cell and a prokaryotic cell, including chloroplasts, vacuole, tonoplast, cell wall, circular DNA, plasmids, mesosome, pili and flagella?



Can you compare the similarities and differences between plant and animal cells, and between eukaryotic and prokaryotic cells?



Can you explain how organelles work together in the production and secretion of proteins, including the cytoskeleton, motor proteins, ribosomes, RER, Golgi apparatus and vesicles?

**Membranes and transport**

Can you describe the structure of triglycerides and phospholipids (fatty acids, glycerol, ester bonds) and relate their hydrophobic and hydrophilic properties to their role in membranes?



Can you describe the fluid mosaic model of membrane structure, including phospholipids, intrinsic and extrinsic proteins, cholesterol, glycolipids and glycoproteins?



Can you distinguish passive movement across membranes (diffusion, facilitated diffusion) from movement that requires ATP (active transport, endocytosis, exocytosis)?



Can you describe a practical investigation into factors affecting diffusion, for example using beetroot as a model tissue?



Can you describe the roles of membranes within cells and at the cell surface?



2.1.2

Water and its importance in plants and animals

Water and body fluids

Can you explain how the polarity and hydrogen bonding of water make it a good solvent?



Can you explain the role of water as a major constituent of cytoplasm and body fluids and as a transport medium, including the transpiration stream, cell sap, turgor, plasma, serum, tissue fluid, lymph and urine?



Can you analyse secondary data on the composition of body fluids and plant extracts, including sugars, proteins and ions such as H^+ , K^+ , Na^+ , Cl^- , HCO_3^- and Mg^{2+} ?



Can you describe how reagent test strips and biosensors are used to detect and measure sugars and proteins?



Can you describe the method for, and interpret the results of, the Biuret test, Benedict's test and colorimetry?



Carbohydrates and osmosis

Can you explain hydrolysis and condensation reactions in metabolism and the concept of monomers and polymers?



Can you draw the ring structure of α -glucose and describe the structure of the disaccharide lactose?



Can you describe the formation of glycogen and starch (amylose and amylopectin) by condensation, including 1,4- and 1,6-glycosidic bonds and how branching affects solubility?



Can you describe how to test for starch with iodine and measure its concentration using colorimetry?



Can you explain osmosis as the movement of water down a water potential gradient, including the effect of solutes and electrolytes?



Can you describe a practical investigation into factors affecting osmosis in plant and animal cells?



2.1.3**Proteins and enzymes****Protein structure and enzymes**

Can you describe the basic structure of an amino acid and the formation of a peptide bond?



Can you describe how chromatography is used to separate and identify amino acids, including the safe use of ninhydrin following CLEAPSS guidelines?



Can you describe the primary, secondary and tertiary structure of globular proteins using enzymes, and the quaternary structure and prosthetic group of haemoglobin?



Can you explain how the structure of a globular protein enables an enzyme to catalyse a specific reaction, including active site specificity, enzyme-substrate complexes and lowering activation energy?



Can you explain how temperature, pH, enzyme concentration and substrate concentration affect the rate of enzyme-catalysed reactions?



Can you describe practical investigations into the factors affecting enzyme activity?

**Blood clotting and blood products**

Can you describe blood clotting as an enzyme-controlled cascade involving platelets, thromboplastin, calcium ions, prothrombin, thrombin, fibrinogen and fibrin?



Can you describe first aid procedures that promote clotting and prevent excessive blood loss?



Can you explain the use of enzymes and inhibitors in diagnosis (blood amylase, LDH) and treatment (streptokinase, aspirin, warfarin)?



Can you describe blood donation and the use of stored blood products, including blood groups, whole blood, leucodepleted blood, packed red cells, platelets, clotting factors and plasma?

**2.1.4****Nucleic acids****2.1.4 Nucleic acids**

Can you describe the structure of a nucleotide as the monomer of nucleic acids, including purines and pyrimidines, pentose sugars and phosphodiester bonds, and the differences between DNA and RNA nucleotides?



Can you describe ADP and ATP as phosphorylated nucleotides?



Can you describe the structure of DNA and the evidence for complementary base pairing, such as Chargaff's rules?



Can you describe how to purify DNA by precipitation?



Can you explain semi-conservative DNA replication, including the roles of helicase and DNA polymerase and the occurrence of random spontaneous mutations?



Can you describe the features of the genetic code (triplet, non-overlapping, degenerate, universal) and explain how a gene determines the sequence of amino acids in a polypeptide?



Can you describe the structure of RNA and how it differs from DNA?



Can you describe transcription and translation, including the roles of RNA polymerase, mRNA, tRNA and rRNA?



2.2.1

The heart and monitoring heart function

Heart structure and the cardiac cycle

Can you explain why mammals need a mass transport system, in terms of high basal metabolic rate, being multicellular and surface area to volume ratio?



Can you describe the internal and external structure of the mammalian heart?



Can you describe how to examine, dissect and draw a mammalian heart?



Can you describe the cardiac cycle, including the role of the valves and the pressure changes in the heart and associated vessels?



Can you explain how heart action is initiated and coordinated, including the SAN, AVN, Purkyne tissue and the myogenic nature of cardiac muscle?



Monitoring heart function

Can you describe practical investigations into factors affecting heart rate, including exercise?



Can you calculate cardiac output from heart rate and stroke volume and explain how heart rate affects cardiac output?



Can you measure pulse rate and interpret primary and secondary pulse rate data?



Can you interpret an ECG, including recognising tachycardia, bradycardia, S-T elevation and fibrillation?



Can you describe the emergency treatment for a suspected heart attack and for cardiac arrest, including first aid and the use of a defibrillator?



2.2.2**Transport systems in mammals****2.2.2 Transport systems in mammals**

Can you explain the importance of a closed double circulatory system, including blood pressure in the systemic and pulmonary circulations?



Can you describe and explain the structure and functions of arteries, arterioles, capillaries, venules and veins?



Can you identify transverse sections of arteries, veins and capillaries using a light microscope, prepared slides or photomicrographs?



Can you explain the formation and importance of tissue fluid in terms of hydrostatic pressure and oncotic pressure?



Can you use a sphygmomanometer (manual and electronic) to measure systolic and diastolic blood pressure?



Can you compare blood pressure readings taken in different ways or from different people?



Can you interpret systolic and diastolic readings, including hypertension and hypotension and their possible consequences?

**2.2.3****Gas exchange in mammals and plants****Mammalian gas exchange**

Can you describe the relationship between cells, tissues and organs in the mammalian gas exchange system, including squamous epithelium of the alveoli, ciliated epithelium, smooth muscle, cartilage and elastic fibres?



Can you identify gas exchange tissues using a microscope?



Can you explain gas exchange in the alveoli, including how ventilation, epithelium, smooth muscle, cartilage, elastic fibres, capillaries and surfactant maintain steep concentration gradients?



Can you explain how tidal volume, breathing rate, vital capacity, residual volume, PEFR and FEV₁ are used to describe pulmonary ventilation?



Can you describe expired air resuscitation for adults, children and babies in respiratory arrest, by manual and electronic methods?

**Plant gas exchange**

Can you describe gas exchange in terrestrial plants, including diffusion through stomata and lenticels?



Can you describe the structure of stomata and explain how they open and close, including changes in guard cell turgor and water potential and the need for ATP?



Can you describe the microscopic appearance of stomata in different terrestrial plants?



2.2.4 Transport systems in plants

2.2.4 Transport systems in plants

Can you explain why multicellular plants need transport systems, in terms of size, variation in metabolic rate and surface area to volume ratio?



Can you describe the structure, function and location of xylem vessels, sieve tube elements and companion cells in roots, stems and leaves of monocotyledonous (cereal) and dicotyledonous (e.g. carrot, potato) crops?



Can you observe, draw and annotate stained sections of plant tissue using a light microscope?



Can you dissect plant organs longitudinally and transversely to show the position and structure of vascular tissue?



Can you explain the entry and movement of water through a plant, including the apoplast and symplast pathways, adhesion, cohesion and the transpiration stream, in terms of water potential?



Can you describe transpiration and explain how environmental factors affect its rate?



Can you describe practical investigations to estimate transpiration rates, for example using a potometer?



Can you explain translocation as an energy-requiring process moving assimilates such as sucrose from sources to harvestable sinks, including active loading at the source and removal at the sink?



3.1.1

The developing cell: cell division and cell differentiation

Cell cycle and mitosis

Can you describe the cell cycle, including interphase (G1, S, G2), mitosis and cytokinesis, and explain how it produces genetically identical daughter cells?



Can you describe the changes in the nucleus and cell during mitosis in animals and plants, including the nuclear envelope, centrioles, spindle fibres, centromere, chromatids, chromosomes and the cell plate?



Can you identify the stages of mitosis in stained sections or root tip squashes viewed under a microscope?



Apoptosis and stem cells

Can you describe the main stages and features of apoptosis, including cell shrinkage, pyknosis, blebs, karyorrhexis, phosphatidylserine and macrophages?



Can you explain the importance of the balance between apoptosis (cell deletion) and mitosis (cell addition) in growth and repair?



Can you describe how totipotent, pluripotent and multipotent stem cells differentiate into specialised cells, including bone marrow stem cells forming blood cells?



Can you describe current applications and uses of stem cells, including bone marrow stem cells?



3.1.2

The developing individual: meiosis, growth and development

Meiosis

Can you explain the significance of meiosis in sexual reproduction, including producing haploid gametes and maintaining chromosome number?



Can you describe the stages of meiosis (prophase 1 to telophase 2) in plant and animal cells, using diagrams?



Can you explain how meiosis produces genetic variation through chiasma formation, crossing over and independent assortment in metaphase 1 and metaphase 2?



Fetal growth and antenatal care

Can you describe the UK antenatal care programme, including pre-conceptual and post-conceptual care?



Can you explain the dietary changes recommended in pregnancy for protein, calcium, iron, vitamin A, vitamin C, folic acid and energy, and the reasons for changes in DRVs?



Can you explain the effects of alcohol and smoking on fetal growth and development?



Can you describe how ultrasound is used to measure fetal growth, including biparietal diameter and crown-rump length?



Can you analyse secondary data from fetal growth charts?



Can you evaluate fetal ultrasonography, amniocentesis and chorionic villus sampling for assessing fetal development and detecting disorders?



Can you describe how karyotypes are produced and used, including identifying fetal sex and diagnosing Down's, Klinefelter's and Turner's syndromes?



3.1.3

The development of species: evolution and classification

Classification

Can you list the taxonomic hierarchy (domain, kingdom, phylum, class, order, family, genus, species) and outline the biological and phylogenetic species concepts?



Can you describe the types of evidence used in classification, including fossils and DNA for hominids, and explain how theories change as new evidence emerges?



Can you explain DNA barcoding, including why mitochondrial genes (e.g. cytochrome c oxidase 1) are used in animals and chloroplast genes in plants?



Can you interpret phylogenetic trees and genetic data showing the relatedness of extinct and extant hominids and hylobatids, including examples of conflicting evidence?



Adaptation, evolution and biodiversity

Can you give behavioural (tool use, cultural adaptations for social bonding), physiological (lactose tolerance, skin pigmentation) and anatomical (bipedalism, brain size) adaptations of Homo sapiens?



Can you describe plant adaptations to extremes of temperature, light and water?



Can you describe a practical investigation into the adaptations of plants to environmental factors?



Can you explain why the evolution of language is a scientific question with competing theories, including the 'mother tongues' and 'gossip' hypotheses, and why evidence is limited?



Can you explain how genetic variation, selection pressures and natural selection lead to adaptation and evolution?



Can you define biodiversity and describe how it is measured at genetic, species and ecosystem levels?



Can you calculate genetic diversity as the proportion of polymorphic gene loci (number of polymorphic loci / total number of loci)?



3.2.1 Pathogenic microorganisms

Pathogens, TB and HIV

Can you explain how bacteria (toxins), viruses (taking over cell metabolism) and fungi (secreting enzymes) cause communicable disease?



Can you describe the causes, transmission, symptoms and treatment of TB and HIV/AIDS, including droplet infection, primary and secondary TB and opportunistic infections?



Can you draw and label the structure of HIV, showing the position of its enzymes and genetic material?



Can you explain how Gram staining, cell morphology and colony morphology are used to identify bacteria?



Can you describe how to culture bacteria aseptically and use Gram staining to distinguish Gram-positive and Gram-negative bacteria?



Epidemiology

Can you explain endemic, epidemic and pandemic patterns of disease, using chickenpox in the UK, SARS in China (2002) and H₁N₁ influenza (2009)?



Can you calculate incidence, prevalence and mortality rates and explain their importance in epidemiology?



Can you analyse and evaluate epidemiological data and graphs on the impact of HIV and TB?



Can you explain the importance of reporting notifiable diseases and the role of Public Health England, giving examples of notifiable diseases?



Can you discuss the social, ethical, economic and biological factors involved in controlling and preventing HIV/AIDS and TB?



3.2.2 The immune system

3.2.2 The immune system

Can you describe primary defences (mucus and cilia, lysozyme in tears, stomach acid) and non-specific defences (phagocytosis, inflammation)?



Can you describe how phagocytes work, including cytokines, opsonins, phagosomes and lysosomes?



Can you explain the roles of B and T lymphocytes in the specific immune response, including clonal selection, clonal expansion, plasma cells, T helper, T killer and T regulatory cells?



Can you explain the secondary immune response and the role of T memory and B memory cells in long-term immunity?



Can you describe the structure and functions of antibodies, including their action as opsonins and agglutinins?



Can you describe antibody and antigen tests for TB and HIV and the Mantoux test for TB?



Can you distinguish between active and passive, natural and artificial immunity, with examples of each?



Can you describe the sequence of events in an allergic response such as hay fever caused by pollen?



3.2.3

Controlling communicable diseases

Vaccination

Can you explain the principles of vaccination using live vaccines, dead microorganisms and pathogen fragments, and the importance of boosters?



Can you explain how vaccination programmes prevent epidemics, including herd immunity?



Can you explain the biological problems of developing and using vaccines, including antigen variability (HIV, influenza), live vaccines, storage and distribution, and poor nutritional status of the population?



Can you discuss ethical issues in vaccine development and use, including the HPV vaccine for girls to prevent cervical cancer?



Antibiotics

Can you explain how antibiotics inhibit bacterial protein, DNA and cell wall synthesis, and why they affect bacteria but not human cells?



Can you explain how misuse of antibiotics leads to resistant strains, such as resistant TB and MRSA?



Can you describe a practical investigation into the effects of antibiotics on Gram-positive and Gram-negative bacteria, including bacteriostatic and bacteriocidal effects, and the effects of disinfectants and hygiene practices?



3.3.1**The cellular basis of cancer and treatment****Causes of cancer**

Can you describe the factors that increase the risk of non-communicable diseases such as cancers and asthma, including heredity, ageing, radiation, carcinogens, viruses and air pollution, and evaluate epidemiological evidence for correlations?



Can you outline the control of the cell cycle and explain how loss of control leads to tumours and metastases?



Can you explain how mutations in proto-oncogenes such as Ras and Myc can cause cancer?



Can you explain how mutations in tumour suppressor genes such as p53 can cause cancer?



Can you evaluate epidemiological evidence linking smoking with lung cancer, diet with bowel cancer and BRCA₁ mutations with breast cancer?

**Detection and treatment**

Can you describe the use of MRI, X-rays, mammography, CT scans, ultrasound, PET scans, biopsies and blood tests to detect cancers?



Can you discuss the ethical and economic issues of cancer screening and genetic testing, including harm, accuracy and cost of screening and the ethics of BRCA and HNPCC tests?



Can you describe cancer treatments, including surgery, chemotherapy, radiotherapy, immunotherapy with monoclonal antibodies, complementary therapies and hormone-related treatment?

**3.3.2****Respiratory diseases and treatment****3.3.2 Respiratory diseases and treatment**

Can you describe the short-term and long-term effects of tobacco smoke, asbestos and fungal spores on the respiratory system?



Can you describe the causes and symptoms of chronic bronchitis and emphysema (COPD), asthma and lung cancer?



Can you compare acute and chronic diseases?



Can you explain how asthma is treated with beta agonists and steroids?



Can you give examples of plant-derived drugs, including theophylline (Theobroma cacao), topotecan (Camptotheca acuminata), aspirin (Salix spp.) and quinine (Cinchona spp.)?



Can you describe the design of clinical trials, including the phases, recruitment and sample size, randomisation, placebos and double-blind trials?



Can you explain the role of NICE in producing guidance on clinical practice, health technologies and public health, including economic considerations?



4.1.1

Cellular respiration

4.1.1 Cellular respiration

Can you describe glycolysis, including the conversion of glucose to triose phosphate and pyruvate and the production of reduced NAD and ATP by substrate-level phosphorylation?



Can you describe the link reaction, in which pyruvate (3C) is converted to acetyl CoA (2C) by decarboxylation and dehydrogenation, reducing NAD?



Can you describe the Krebs cycle, including formation of citrate, decarboxylation, dehydrogenation and production of reduced NAD, reduced FAD and ATP?



Can you explain oxidative phosphorylation on the cristae, including electron carriers, the electron transport chain, proton gradients, ATP synthase and oxygen as the final electron acceptor?



Can you describe anaerobic respiration in muscle cells and yeast and explain why it yields much less ATP than aerobic respiration?



Can you compare the relative energy values of carbohydrates, proteins and lipids and calculate respiratory quotients?



Can you describe how respirometers and other methods are used to measure the rate of respiration?



Can you describe practical investigations into the effects of temperature, substrate concentration, anaerobic conditions and different substrates on respiration rate?



4.1.2

Metabolism and exercise

Exercise and fitness

Can you describe the immediate and long-term effects of exercise on the respiratory and cardiovascular systems and skeletal muscle?



Can you explain how age, gender and participation in exercise affect aerobic fitness?



Can you describe investigations into factors affecting resting heart rate, breathing rate or recovery time and analyse primary and secondary data?



Can you explain how training improves aerobic fitness using the F.I.T.T. principles (frequency, intensity, type, time)?



Can you describe investigations into the effects of F.I.T.T. on heart rate, breathing rate or recovery time?



Can you describe and evaluate performance enhancement methods, including carbohydrate loading, RhEPO, blood doping and steroids?



Can you explain VO_2 max as a measure of aerobic fitness?



Oxygen transport

Can you describe the role of haemoglobin in transporting oxygen?



Can you interpret oxygen dissociation curves for adult haemoglobin, fetal haemoglobin and myoglobin?



Can you explain how temperature, pH, carbon dioxide and carbonic anhydrase affect oxygen dissociation (the Bohr effect)?



Can you explain oxygen deficit and oxygen debt (EPOC) and the difference between them?



Skeletal muscle

Can you describe the histology and ultrastructure of skeletal muscle?



Can you describe light microscope observations of muscle tissue and its response to ATP and other solutions, for example using a chicken leg dissection?



Can you explain the sliding filament theory, including actin, myosin, troponin, tropomyosin, the power stroke, ATP and calcium ions?



4.2.1

Fertility and assisted reproduction

Gametes and hormones

Can you identify the parts of the male and female urogenital systems?



Can you describe the histology of the ovary and testis?



Can you identify ovary and testis tissue using a light microscope?



Can you describe oogenesis and spermatogenesis and link them to mitosis and meiosis?



Can you relate the structure of the secondary oocyte and the sperm to their functions?



Can you explain the roles of FSH, GnRH, LH, testosterone and inhibin in spermatogenesis, and FSH, LH, progesterone, oestrogen and GnRH in oogenesis?



Can you explain how LH, FSH, progesterone and oestrogen regulate the menstrual cycle?



Can you explain how fertilisation restores the diploid chromosome number and introduces variation?



Infertility and assisted reproduction

Can you explain how monoclonal antibodies are used in pregnancy testing?



Can you discuss the biological and ethical issues of infertility, including abnormal sperm, low sperm count, blocked vas deferens, ovulatory disorders, blocked oviducts, endometriosis and anti-sperm antibodies?



Can you describe assisted reproduction techniques, including IUI, IVF, ICSI, donor insemination, surgical sperm retrieval, ovulation induction, frozen embryo replacement and GIFT?



4.2.2 The effects of ageing on the reproductive system

4.2.2 The effects of ageing on the reproductive system

Can you describe the effects of ageing on the female reproductive system, including hormone changes, fertility and the menopause?



Can you evaluate HRT and alternative treatments for managing the effects of female reproductive ageing?



Can you describe the effects of ageing on the male reproductive system, including hormones, fertility, erectile function and benign prostate hyperplasia?



4.3.1 Photosynthesis, food production and management of the environment

Photosynthesis

Can you describe chloroplast ultrastructure and the location of the light-dependent (thylakoid membranes) and light-independent (stroma) stages?



Can you separate photosynthetic pigments by paper chromatography and calculate R_f values?



Can you explain how the light-dependent stage converts light energy into ATP and reduced NADP?



Can you describe the Calvin cycle, including CO₂, RuBisCO, RuBP, GP and TP and the use of ATP and reduced NADP?



Can you describe practical investigations into the effects of light wavelength, light intensity, duration of light, temperature and pH on photosynthesis?



Can you describe the Hill reaction using DCPIP?



Can you explain how TP and GP are used to make carbohydrates, lipids and amino acids, including the need for mineral ions such as nitrates and sulfates?



Can you explain why both plant and animal respiration depend on the products of photosynthesis?



Can you explain the biological significance of the compensation point for crop production?



Can you interpret data and graphs showing compensation points?



Can you compare leaf samples using hydrogencarbonate indicator?



Nitrogen cycle and food production

Can you explain the roles of Azotobacter, Nitrosomonas, Nitrobacter and Rhizobium in the nitrogen cycle, and the use of luminescent biosensors?



Can you describe how to culture Rhizobium in vitro?



Can you describe how to investigate root nodules in legumes?



Can you describe the transfer of biomass through food chains in food production?



Can you explain the efficiency of biomass transfer and its sustainability, using fish farming and maize fed to beef cattle as examples?



Can you explain how ruminants act as ecosystems, with microorganisms digesting cellulose, producing fatty acids and providing protein?



Farming, conservation and succession

Can you compare intensive and extensive farming, including hedgerow removal, use of chemicals, farm waste and the countryside stewardship scheme?



Can you discuss the conflict between agriculture and conservation?



Can you explain succession from colonisation to climax community and how forestry and agriculture cause deflected succession?



Can you describe how to measure biodiversity using random and systematic sampling?



4.3.2 The impact of population increase

4.3.2 The impact of population increase

Can you explain how food production, medical technology and disease control alter birth and death rates, and interpret demographic charts?



Can you describe the impact of human population growth on ecosystems and biodiversity, including climate, soils, water quality and biotic change?



Can you explain the ecological, economic and scientific importance of biodiversity and calculate Simpson's Diversity Index?



Can you discuss global food security, including sustainable production and consumption, food safety, food fraud and crime, consumer trust and the roles of the FAO, FCC and EMPRES?



4.4.1 Plant reproduction

4.4.1 Plant reproduction

Can you explain how flowering is controlled by vernalisation and phytochrome?



Can you compare the adaptations of wind-pollinated (cereal) and insect-pollinated (legume) flowers?



Can you outline fertilisation and seed formation, including pollen tube growth, embryo formation and endosperm formation?



Can you describe seed germination?



Can you describe investigations into factors affecting germination, including the role of gibberellin as a signalling molecule?



Can you explain the importance of cereals such as rice, maize and wheat as staple foods for food security and sustainability?



5.1.1 Patterns of inheritance

5.1.1 Patterns of inheritance

Can you explain monohybrid inheritance using the terms gene, allele, locus, phenotype, genotype, dominant, recessive, heterozygous, homozygous and codominant?	☐ ☐ ☐
Can you describe gene mutations causing cystic fibrosis, sickle cell anaemia, PKU and Huntington's disease?	☐ ☐ ☐
Can you explain codominance and multiple alleles using blood groups and HLA antigens?	☐ ☐ ☐
Can you explain sex linkage (haemophilia) and autosomal linkage (ABO blood group and nail-patella syndrome)?	☐ ☐ ☐
Can you explain dihybrid inheritance using model organisms such as <i>Drosophila melanogaster</i> and use the chi-squared test?	☐ ☐ ☐
Can you explain how non-disjunction and translocations cause Turner's, Klinefelter's and Down's syndromes?	☐ ☐ ☐
Can you describe the role of a genetic counsellor, including pedigree analysis, genetic testing and the ethical issues involved?	☐ ☐ ☐

5.1.2 Population genetics and epigenetics

5.1.2 Population genetics and epigenetics

Can you explain how natural selection changes allele frequencies, using malaria and the sickle cell allele, including the phenotypes of the three genotypes?	☐ ☐ ☐
Can you explain how a change in amino acid sequence affects the structure and properties of a protein such as haemoglobin?	☐ ☐ ☐
Can you use the Hardy-Weinberg equations to calculate allele and genotype frequencies?	☐ ☐ ☐
Can you explain how the founder effect and genetic bottlenecks change allele frequencies, using blood group distributions and Ellis-van Creveld syndrome?	☐ ☐ ☐
Can you explain the roles of geographical and reproductive isolation in speciation, including implications for primates and humans?	☐ ☐ ☐
Can you explain how the environment affects gene expression through DNA methylation and histone modification, using the Norrbotten studies, the Dutch Hunger Winter and twin studies?	☐ ☐ ☐

5.1.3 Gene technologies

5.1.3 Gene technologies

Can you explain post-transcriptional editing of mRNA, including introns, exons and how one gene can give several mature mRNAs?	☐ ☐ ☐
Can you describe how human proteins such as insulin are made in bacteria, including reverse transcriptase, restriction enzymes, palindromic recognition sequences, DNA ligase, plasmid vectors and reporter genes?	☐ ☐ ☐
Can you describe PCR, including primers and Taq polymerase, and use log scales to show copy number?	☐ ☐ ☐
Can you explain the principles and uses of agarose gel electrophoresis?	☐ ☐ ☐
Can you explain how haplotypes, SNPs and VNTRs are used in forensics, disease predisposition, ethnic migration, paternity testing and selecting people for clinical trials?	☐ ☐ ☐
Can you describe genetic engineering of eukaryotic cells, including knockout mice, human proteins produced by animals and GM crops?	☐ ☐ ☐
Can you compare somatic and germ line gene therapy and discuss the ethics, using cystic fibrosis and SCID as examples?	☐ ☐ ☐
Can you outline how siRNA and miRNA cause RNA interference and its potential use in treating disease?	☐ ☐ ☐

5.2.1

The nervous system and the identification and consequences of damage

Structure and function of the nervous system

Can you describe the organisation of the somatic and autonomic nervous systems?	☐ ☐ ☐
Can you identify nervous tissue using a light microscope?	☐ ☐ ☐
Can you describe the structure and functions of the cerebrum, cerebellum, medulla oblongata, hypothalamus and pituitary gland?	☐ ☐ ☐
Can you describe the structure of motor, sensory and relay neurones, including axons, dendrons, dendrites, cell body, myelin sheath and nodes of Ranvier?	☐ ☐ ☐
Can you explain resting and action potentials, interpret graphs of membrane potential and explain the roles of the myelin sheath and refractory period?	☐ ☐ ☐
Can you explain how synapses integrate responses, including excitatory and inhibitory postsynaptic potentials?	☐ ☐ ☐
Can you describe reflex arcs and compare reflexes with voluntary responses?	☐ ☐ ☐

Identifying and treating damage

Can you explain how the blink, iris and plantar reflexes are used to test for nervous system damage and level of consciousness?



Can you describe investigations into human reflexes and factors affecting reaction time, analysed using a Student's t-test?



Can you explain how CT, MRI, fMRI, PET and EEG are used to assess traumatic brain injury, stroke and spinal damage?



Can you describe the consequences of brain and spinal damage for memory, motor skills, speech and hormone balance, and discuss the ethics of establishing brain death?



Can you explain the therapeutic use of dopamine in Parkinson's disease and the effects of heroin, cannabis, methamphetamine and alcohol on synapses?



Can you explain the biological basis of psychological and physical drug dependency and its effects on individuals and society?



5.2.2 Monitoring visual function

5.2.2 Monitoring visual function

Can you describe the structure of the eye, including the sclera, conjunctiva, cornea, iris, pupil, lens, ciliary body, aqueous and vitreous humour, choroid and retina?



Can you describe the structure of the retina, including rods, cones, bipolar cells, ganglion cells, the fovea and the blind spot, and identify it in eye sections?



Can you explain how the retina acts as a receptor of light and as a transducer?



Can you describe eye tests for visual acuity and colour vision and the use of OCT scans?



5.2.3 The effect of ageing on the nervous system

5.2.3 The effect of ageing on the nervous system

Can you describe the symptoms, histological brain changes, cognitive and behavioural changes and genetic and environmental causes of Alzheimer's disease?



Can you describe age-related hearing impairment, visual impairment (cataracts, glaucoma, macular degeneration) and memory loss, and analyse hearing and sight test data?



Can you describe investigations into how reaction time and memory change with age?



5.3.1**The principles and importance of homeostasis****5.3.1 The principles and importance of homeostasis**

Can you explain the principles of homeostasis, including receptors, effectors, negative feedback and normal ranges for body temperature, pH, blood glucose and blood pressure?



Can you explain positive feedback using oxytocin as an example?



Can you explain how the sympathetic and parasympathetic nervous systems and adrenaline control heart rate?



Can you explain temperature regulation, including peripheral receptors, the hypothalamus, sweating, shivering, vasoconstriction and vasodilation?



Can you explain how thyroxine release is regulated and how thyroxine affects metabolic rate?



Can you compare oral, tympanic, axillary and rectal methods of measuring core temperature and explain the significance of abnormal readings in adults and children?



Can you describe the causes, symptoms and treatment of hypothermia and hyperthermia, including links to fuel poverty and climate data?

**5.3.2****The hormonal control of blood glucose and the management of diabetes****5.3.2 The hormonal control of blood glucose and the management of diabetes**

Can you describe the pancreas as an endocrine gland and identify the Islets of Langerhans in prepared slides?



Can you explain how insulin and glucagon regulate blood glucose by negative feedback, including their action at the cellular level?



Can you describe the causes, risk factors and diagnosis of Type 1 and Type 2 diabetes?



Can you describe fasting blood glucose tests, glucose tolerance tests and biosensors, and analyse glucose test data?



Can you describe the treatment of diabetes with insulin, lifestyle changes and drugs, and monitoring using HbA1c?



Can you describe the roles of the diabetes healthcare team (diabetes nurses, dietitians, retinal screeners, podiatrists) and evidence-based practice?



Can you discuss the future impact of diabetes on the human population?



Kidney structure and function

Can you describe deamination of amino acids and the production of urea in the liver?



Can you describe the gross structure of the kidney and urinary system, including the cortex, medulla, renal pyramids, renal pelvis, ureter, renal artery and vein, bladder and urethra?



Can you explain how the nephron forms urine by ultrafiltration and selective reabsorption?



Can you describe a biochemical investigation of mock urine, plasma and filtrate?



Can you explain osmoregulation, including osmoreceptors, ADH from the posterior pituitary, cyclic AMP and the insertion and removal of aquaporins in the collecting duct?



Can you explain the endocrine role of the kidney in producing EPO and renin?

**Kidney failure and treatment**

Can you describe the causes of kidney failure (uncontrolled diabetes, kidney stones, high blood pressure, bacterial infection), diagnose it from blood and urine data and explain its consequences?



Can you compare haemodialysis and peritoneal dialysis, including their advantages and disadvantages?



Can you discuss the practical issues involved in kidney transplants, including the supply of donor organs?



Can you discuss the future of transplant surgery, including therapeutic and reproductive cloning and stem cell technology?



Practical activity groups

PAG1 Can you use a light microscope to observe, draw and measure cells and tissues, for example blood smears, mitosis, stomata or eye sections?



PAG2 Can you safely dissect an animal or plant organ, such as a heart, kidney or plant stem, and record your observations?



PAG3 Can you use random and systematic sampling techniques in fieldwork to measure biodiversity?



PAG4 Can you investigate factors affecting the rate of an enzyme-controlled reaction?



PAG5 Can you use a colorimeter, for example to measure sugar, starch or protein concentration or membrane permeability?



PAG6 Can you separate biological compounds using chromatography or gel electrophoresis, for example amino acids, pigments or DNA?



PAG7 Can you use aseptic microbiological techniques, such as culturing bacteria and testing antibiotics?



PAG8 Can you investigate transport in and out of cells, for example diffusion in beetroot or osmosis in plant tissue?



PAG9 Can you use qualitative reagents to identify biological molecules, for example in mock urine, plasma and filtrate?



PAG10 Can you use a data logger or computer modelling to collect and process data, for example core body temperature or respiration rate?



PAG11 Can you investigate plant or animal responses or physiological functions, for example heart rate, reaction time or memory?



PAG12 Can you use research skills to plan an investigation and correctly cite sources?

