1.1 Unit description

Topic 1: Lifestyle, health and risk

This topic begins with a consideration of the structure and functions of a number of molecules, including water, carbohydrates and triglycerides. The structure and function of the cardiovascular system is also included as an introduction to the ways in which diet and lifestyle factors may affect the heart and circulatory system. Ideas about correlation, causation and the concept of risks to health are covered.

Topic 2: Genes and health

This topic begins with a consideration of the structure and functions of the cell membrane and gas exchange surfaces. The structure and properties of proteins, enzyme and nucleic acids lead to the genetic code and protein synthesis. Principles of inheritance, gene therapy and genetic screening are included, giving opportunities for discussion of the social and ethical issues surrounding genetic screening for genetic conditions.

1.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 80 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

1.3 Topic 1: Lifestyle, health and risk

Students will be assessed on their ability to:

1. Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

2. Explain the importance of water as a solvent in transport, including its dipole nature.

3. Distinguish between monosaccharides, disaccharides and polysaccharides (glycogen and starch – amylose and amylopectin) and relate their structures to their roles in providing and storing energy (β-glucose and cellulose are not required in this topic).

4. Describe how monosaccharides join to form disaccharides (sucrose, lactose and maltose) and polysaccharides (glycogen and amylose) through condensation reactions forming glycosidic bonds, and how these can be split through hydrolysis reactions.

5. Describe the synthesis of a triglyceride by the formation of ester bonds during condensation reactions between glycerol and three fatty acids and recognise differences between saturated and unsaturated lipids.

6. Explain why many animals have a heart and circulation (mass transport to overcome limitations of diffusion in meeting the requirements of organisms).

7. Describe the cardiac cycle (atrial systole, ventricular systole and diastole) and relate the structure and operation of the mammalian heart to its function, including the major blood vessels.

8. Explain how the structures of blood vessels (capillaries, arteries and veins) relate to their functions.

9. **Describe how the effect of caffeine on heart rate in *Daphnia* can be investigated practically, and discuss whether there are ethical issues in the use of invertebrates.**

10. Describe the blood clotting process (thromboplastin release, conversion of prothrombin to thrombin and fibrinogen to fibrin) and its role in cardiovascular disease (CVD).

11 Explain the course of events that leads to atherosclerosis (endothelial damage, inflammatory response, plaque formation, raised blood pressure).

12 Describe the factors that increase the risk of CVD (genetic, diet, age, gender, high blood pressure, smoking and inactivity).

13 Describe the benefits and risks of treatments for CVD (antihypertensives, plant statins, anticoagulants and platelet inhibitory drugs).

14 Analyse and interpret data on the possible significance for health of blood cholesterol levels and levels of high-density lipoproteins (HDLs) and low-density lipoproteins (LDLs). Describe the evidence for a causal relationship between blood cholesterol levels (total cholesterol and LDL cholesterol) and CVD.

15 Discuss how people use scientific knowledge about the effects of diet (including obesity indicators), exercise and smoking to reduce their risk of coronary heart disease.

16 **Describe how to investigate the vitamin C content of food and drink.**

17 Analyse data on energy budgets and diet so as to be able to discuss the consequences of energy imbalance, including weight loss, weight gain, and development of obesity.

18 Analyse and interpret quantitative data on illness and mortality rates to determine health risks (including distinguishing between correlation and causation and recognising conflicting evidence).

19 Evaluate design of studies used to determine health risk factors (including sample selection and sample size used to collect data that is both valid and reliable).

20 Explain why people's perceptions of risks are often different from the actual risks (including underestimating and overestimating the risks due to diet and other lifestyle factors in the development of heart disease).

1.4 Topic 2: Genes and health

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

2 Explain how models such as the fluid mosaic model of cell membranes are interpretations of data used to develop scientific explanations of the structure and properties of cell membranes.

3 Explain what is meant by osmosis in terms of the movement of free water molecules through a partially permeable membrane (consideration of water potential is not required).

4 Explain what is meant by passive transport (diffusion, facilitated diffusion), active transport (including the role of ATP), endocytosis and exocytosis and describe the involvement of carrier and channel proteins in membrane transport.

5 **Describe how membrane structure can be investigated practically, e.g. by the effect of alcohol concentration or temperature on membrane permeability.**

6 Describe the properties of gas exchange surfaces in living organisms (large surface area to volume ratio, thickness of surface, difference in concentration) and explain how the structure of the mammalian lung is adapted for rapid gaseous exchange.

7 Describe the basic structure of an amino acid (structures of specific amino acids are not required) and the formation of polypeptides and proteins (as amino acid monomers linked by peptide bonds in condensation reactions) and explain the significance of a protein's primary structure in determining its three-dimensional structure and properties (globular and fibrous proteins and types of bonds involved in three-dimensional structure).

8 Explain the mechanism of action and specificity of enzymes in terms of their three-dimensional structure and explain that enzymes are biological catalysts that reduce activation energy, catalysing a wide range of intracellular and extracellular reactions.

9 **Describe how enzyme concentrations can affect the rates of reactions and how this can be investigated practically by measuring the initial rate of reaction.**

10 Describe the basic structure of mononucleotides (as a deoxyribose or ribose linked to a phosphate and a base, i.e. thymine, uracil, cytosine, adenine or guanine) and the structures of DNA and RNA (as polynucleotides composed of mononucleotides linked through condensation reactions) and describe how complementary base pairing and the hydrogen bonding between two complementary strands are involved in the formation of the DNA double helix.

11 Describe DNA replication (including the role of DNA polymerase), and explain how Meselson and Stahl's classic experiment provided new data that supported the accepted theory of replication of DNA and refuted competing theories.

12 Explain the nature of the genetic code (triplet code only; non-overlapping and degenerate not required at IAS).

13 Describe a gene as being a sequence of bases on a DNA molecule coding for a sequence of amino acids in a polypeptide chain.

14 Outline the process of protein synthesis, including the role of transcription, translation, messenger RNA, transfer RNA and the template (antisense) DNA strand (details of the mechanism of protein synthesis on ribosomes are not required at IAS).

15 Explain how errors in DNA replication can give rise to mutations and explain how cystic fibrosis results from one of a number of possible gene mutations.

16 Explain the terms gene, allele, genotype, phenotype, recessive, dominant, homozygote and heterozygote, and explain monohybrid inheritance, including the interpretation of genetic pedigree diagrams, in the context of traits such as cystic fibrosis, albinism, thalassaemia, garden pea height and seed morphology.

17 Explain how the expression of a gene mutation in people with cystic fibrosis impairs the functioning of the gaseous exchange, digestive and reproductive systems.

18 Describe the principles of gene therapy and distinguish between somatic and germ line therapy.

19 Explain the uses of genetic screening: identification of carriers, preimplantation genetic diagnosis and prenatal testing (amniocentesis and chorionic villus sampling) and discuss the implications of prenatal genetic screening.

20 Identify and discuss the social and ethical issues related to genetic screening from a range of ethical viewpoints.

2.1 Unit description

Topic 3: The voice of the genome

This topic begins with an overview of cell structure and considers how cell ultrastructure is related to function. Cell division and cell aggregation to form tissues and organs are also included. The topic then considers meiosis, the formation of gametes, fertilisation, stem cells, gene expression and cell differentiation. The role of the genotype and effect of the environment on phenotype is also stressed.

Topic 4: Biodiversity and natural resources

This topic begins with a comparison of the structure of a typical plant cell with that of an animal cell, and the structure and roles of cellulose and starch. The relationship between plant tissues, xylem and sclerenchyma, is also included. The topic continues with a consideration of the importance of plant products to humans, species diversity, and how diversity arises through natural selection and evolutionary change. The role of zoos in the conservation of endangered species is also described.

2.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 80 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

2.3 Topic 3: The voice of the genome

Students will be assessed on their ability to:

1. Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

2. Distinguish between eukaryotic and prokaryotic cells in terms of their structure and ultrastructure.

3. Describe the ultrastructure of an animal (eukaryotic) cell (nucleus, nucleolus, ribosomes, rough and smooth endoplasmic reticulum, mitochondria, centrioles, lysosomes, and Golgi apparatus) and recognise these organelles from EM images.

4. Explain the role of the rough endoplasmic reticulum (rER) and the Golgi apparatus in protein transport within cells and including its role in formation of extracellular enzymes.

5. Describe how the cells of multicellular organisms can be organised into tissues, tissues into organs and organs into systems.

6. Explain the role of mitosis and the cell cycle for growth and asexual reproduction.

7. **Describe the stages of mitosis and how to prepare and stain a root tip squash in order to observe them practically.**

8. Explain the role of meiosis in the production of gametes and genetic variation through recombination of alleles and genes including independent assortment and crossing over (details of the stages of meiosis are not required).

9. Explain how mammalian gametes are specialised for their functions.

10. Describe the process of fertilisation in mammals and flowering plants (starting with the acrosome reaction in mammals and pollen tube growth in plants and ending with the fusion of the nuclei) and explain the importance of fertilisation in sexual reproduction.

11 Explain what is meant by the terms stem cell, pluripotency and totipotency and discuss the way society uses scientific knowledge to make decisions about the use of stem cells in medical therapies (e.g. regulatory authorities relating to human embryo research, ability of stem cells to develop into specialised tissues, potential sources of stem cells, who could benefit from the therapies, procedures to obtain stem cells and their risks).

12 **Describe how totipotency can be demonstrated practically using plant tissue culture techniques.**

13 Explain how cells become specialised through differential gene expression, producing active mRNA leading to synthesis of proteins, which in turn control cell processes or determine cell structure in animals and plants (details of transcription factors are not required at IAS).

14 Explain how a phenotype is the result of an interaction between genotype and the environment (e.g. animal hair colour, human height, monoamine oxidase A (MAOA) and cancers), but the data on the relative contributions of genes and environment is often difficult to interpret.

15 Explain how some phenotypes are affected by alleles at many loci (polygenic inheritance) as well as the environment (e.g. height) and how this can give rise to phenotypes that show continuous variation.

2.4 Topic 4: Biodiversity and natural resources

Students will be assessed on their ability to:

1. Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

2. Compare the ultrastructure of plant cells (cell wall, chloroplasts, amyloplasts, vacuole, tonoplast, plasmodesmata, pits and middle lamella) with that of animal cells.

3. Compare the structure and function of the polysaccharides starch and cellulose including the role of hydrogen bonds between β-glucose molecules in the formation of cellulose microfibrils.

4. Explain how the arrangement of cellulose microfibrils in plant cell walls and secondary thickening contribute to the physical properties of plant fibres, which can be exploited by humans.

5. Compare the structures, position in the stem and function of sclerenchyma fibres (support) and xylem vessels (support and transport of water and mineral ions).

6. Describe how the uses of plant fibres and starch may contribute to sustainability, e.g. plant-based products to replace oil-based plastics.

7. Identify sclerenchyma fibres and xylem vessels as seen through a light microscope.

8. **Describe how to determine the tensile strength of plant fibres practically.**

9. Explain the importance of water and inorganic ions (nitrate, calcium ions and magnesium ions) to plants.

10. **Describe how to investigate plant mineral deficiencies practically.**

11. **Describe how to investigate the antimicrobial properties of plants.**

12. Compare historic drug testing with contemporary drug testing protocols, e.g. William Withering's digitalis soup; double blind trials; placebo; three-phased testing.

13 Explain the terms biodiversity and endemism and describe how biodiversity can be measured within a habitat using species richness and within a species using genetic diversity, e.g. variety of alleles in a gene pool.

14 Describe the concept of niche and discuss examples of adaptation of organisms to their environment (behavioural, physiological and anatomical).

15 Describe how natural selection can lead to adaptation and evolution.

16 Discuss the process and importance of critical evaluation of new data by the scientific community, which leads to new taxonomic groupings (i.e. three domains based on molecular phylogeny).

17 Discuss and evaluate the methods used by zoos and seedbanks in the conservation of endangered species and their genetic diversity (e.g. scientific research, captive breeding programmes, reintroduction programmes and education).

3.1 Unit description

Topic 5: On the wild side

This topic builds an appreciation that photosynthesis is the primary process that underpins the majority of ecosystems, and provides students with an understanding of how ecosystems work. The topic continues by looking at whether climate change will lead to extinction of species or evolution by natural selection, and looks at the evidence for global warming and its effects on plants and animals. By the end of the topic students should appreciate how scientific understanding can make us aware of our responsibilities as stewards of the environment.

Topic 6: Infection, immunity and forensics

This topic starts by looking at how forensic pathologists use a wide variety of analytical techniques to determine the identity of a person or other animal, and to establish the time and cause of death of an organism, including humans. It then considers how bacteria and viruses use a variety of routes into their hosts and how hosts have evolved barriers and internal mechanisms to combat infections. These protections are not always successful and many people in the world still die from infectious diseases. This topic also investigates the evolutionary battles that take place between invading pathogens and their hosts.

3.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 90 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

3.3 Topic 5: On the wild side

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

2 Describe the structure of chloroplasts in relation to their role in photosynthesis.

3 Describe the overall reaction of photosynthesis as requiring energy from light to split apart the strong bonds in water molecules, storing the hydrogen in a fuel (glucose) by combining it with carbon dioxide and releasing oxygen into the atmosphere.

4 Describe the light-dependent reactions of photosynthesis including how light energy is trapped by exciting electrons in chlorophyll and the role of these electrons in generating ATP, and reducing NADP in photophosphorylation and producing oxygen through photolysis of water.

5 Describe how phosphorylation of ADP requires energy and how hydrolysis of ATP provides an immediate supply of energy for biological processes.

6 Describe the light-independent reactions as reduction of carbon dioxide using the products of the light-dependent reactions (carbon fixation in the Calvin cycle, the role of GP, GALP, RuBP and RUBISCO) and describe the products as simple sugars that are used by plants, animals and other organisms in respiration and the synthesis of new biological molecules (including polysaccharides, amino acids, lipids and nucleic acids).

7 Carry out calculations of net primary productivity and explain the relationship between gross primary productivity, net primary productivity and plant respiration.

8 Calculate the efficiency of energy transfers between trophic levels.

9 Discuss how understanding the carbon cycle can lead to methods to reduce atmospheric levels of carbon dioxide (including the use of biofuels and reforestation).

10 Explain that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors.

11 **Describe how to carry out a study on the ecology of a habitat to produce valid and reliable data (including the use of quadrats and transects to assess abundance and distribution of organisms and the measurement of abiotic factors, e.g. solar energy input, climate, topography, oxygen availability and edaphic factors).**

12 Explain how the concept of niche accounts for distribution and abundance of organisms in a habitat.

13 Describe the concept of succession to a climax community.

14 Outline the causes of global warming – including the role of greenhouse gases (carbon dioxide and methane, CH_4) in the greenhouse effect.

15 Describe the effects of global warming (rising temperature, changing rainfall patterns and seasonal cycles) on plants and animals (distribution of species, development and life cycles).

16 Explain the effect of increasing temperature on the rate of enzyme activity in plants, animals and micro-organisms.

17 **Describe how to investigate the effects of temperature on the development of organisms (e.g. seedling growth rate, brine shrimp hatch rates).**

18 Analyse and interpret different types of evidence for global warming and its causes (including records of carbon dioxide levels, temperature records, pollen in peat bogs and dendrochronology) recognising correlations and causal relationships.

19 Describe that data can be extrapolated to make predictions, that these are used in models of future global warming, and that these models have limitations.

20 Discuss the way in which scientific conclusions about controversial issues, such as what actions should be taken to reduce global warming or the degree to which humans are affecting global warming, can sometimes depend on who is reaching the conclusions.

21 Describe how evolution (a change in the allele frequency) can come about through gene mutation and natural selection.

22 Explain how reproductive isolation can lead to speciation.

23 Describe the role of the scientific community in validating new evidence (including molecular biology, e.g. DNA, proteomics) supporting the accepted scientific theory of evolution (scientific journals, the peer review process, scientific conferences).

3.4 Topic 6: Infection, immunity and forensics

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

2 Explain the nature of the genetic code (triplet code, non-overlapping and degenerate).

3 Explain the process of protein synthesis (transcription, translation messenger RNA, transfer RNA, ribosomes and the role of start and stop codons) and explain the roles of the template (antisense) DNA strand in transcription, codons on messenger RNA, anticodons on transfer RNA.

4 Explain how one gene can give rise to more than one protein through post-transcriptional changes to messenger RNA.

5 Describe how DNA profiling is used for identification and determining genetic relationships between organisms (plants and animals).

6 **Describe how DNA can be amplified using the polymerase chain reaction (PCR).**

7 **Describe how gel electrophoresis can be used to separate DNA fragments of different length.**

8 Distinguish between the structure of bacteria and viruses.

9 Describe the role of micro-organisms in the decomposition of organic matter and the recycling of carbon.

10 Describe the major routes pathogens may take when entering the body and explain the role of barriers in protecting the body from infection, including the roles of skin, stomach acid, gut and skin flora.

11 Explain how bacterial and viral infectious diseases have a sequence of symptoms that may result in death, including the diseases caused by *Mycobacterium tuberculosis* (TB) and Human Immunodeficiency Virus (HIV).

12 Describe the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon and phagocytosis.

13 Explain the roles of antigens and antibodies in the body's immune response including the involvement of plasma cells, macrophages and antigen-presenting cells.

14 Distinguish between the roles of B cells (including B memory and B effector cells) and T cells (T helper, T killer and T memory cells) in the body's immune response.

15 Explain how individuals may develop immunity (natural, artificial, active, passive).

16 Discuss how the theory of an 'evolutionary race' between pathogens and their hosts is supported by the evasion mechanisms as shown by Human Immunodeficiency Virus (HIV) and *Mycobacterium tuberculosis* (TB).

17 Distinguish between bacteriostatic and bactericidal antibiotics.

18 **Describe how to investigate the effect of different antibiotics on bacteria.**

19 Describe how an understanding of the contributory causes of hospital acquired infections have led to codes of practice relating to antibiotic prescription and hospital practice relating to infection prevention and control.

20 Describe how to determine the time of death of a mammal by examining the extent of decomposition, stage of succession, forensic entomology, body temperature and degree of muscle contraction.

4.1 Unit description

Topic 7: Run for your life

This topic begins with a study of muscle structure and function, and the ways in which energy is provided by means of aerobic and anaerobic respiration. The responses of the heart and respiratory system to exercise are included, with the concept of homeostasis and its importance in both the regulation of body temperature and at the molecular level with a reference to gene switching. The topic ends by considering the effects of both too much and too little exercise on the body, how medical technology is used in relation to sports, and the ethical positions with respect to the use of performance-enhancing substances by athletes.

Topic 8: Grey matter

This topic begins by considering how plants detect and respond to changes in their environment. This is followed by details of the structure and function of the mammalian nervous system, including imaging techniques to investigate the brain. This is developed into an enquiry into how imbalances in brain chemicals may result in conditions such as Parkinson's disease and its treatment with drugs. The topic requires students to discuss the ethics of the Human Genome Project and to consider the risks and benefits associated with the use of genetically modified organisms.

4.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 90 marks, lasts 1 hour 45 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

One question will relate to a previously released scientific article that students will have studied during the course. Students may be asked to summarise the information in the article, and explain or comment upon the biology and other issues within the context of the article. The article may draw on knowledge and understanding from any of the four units 1, 2, 4, and 5. A different article will be provided each year and the examination questions will change to reflect this. This question carries a third of the marks of this unit.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

4.3 Topic 7: Run for your life

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

2 Describe the structure of a muscle fibre and explain the structural and physiological differences between fast and slow twitch muscle fibres.

3 Explain the contraction of skeletal muscle in terms of the sliding filament theory, including the role of actin, myosin, troponin, tropomyosin, calcium ions (Ca^{2+}), ATP and ATPase.

4 Recall the way in which muscles, tendons, the skeleton and ligaments interact to enable movement, including antagonistic muscle pairs, extensors and flexors.

5 Describe the overall reaction of aerobic respiration as splitting of the respiratory substrate (e.g. glucose) to release carbon dioxide as a waste product and reuniting of hydrogen with atmospheric oxygen with the release of a large amount of energy.

6 **Describe how to investigate rate of respiration practically.**

7 Recall how phosphorylation of ADP requires energy and how hydrolysis of ATP provides an accessible supply of energy for biological processes.

8 Describe the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP, reduced coenzyme and pyruvate acid (details of intermediate stages and compounds are not required).

9 Describe the role of the Krebs cycle in the complete oxidation of glucose and formation of carbon dioxide (CO_2), ATP, reduced NAD and reduced FAD (names of other compounds are not required) and that respiration is a many-stepped process with each step controlled and catalysed by a specific intracellular enzyme.

10 Describe the synthesis of ATP by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATPase.

11 Explain the fate of lactate after a period of anaerobic respiration in animals.

12 Understand that cardiac muscle is myogenic and describe the normal electrical activity of the heart, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN) and the bundle of His, and how the use of electrocardiograms (ECGs) can aid the diagnosis of cardiovascular disease (CVD) and other heart conditions.

13 Explain how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre.

14 **Describe how to investigate the effects of exercise on tidal volume and breathing rate using data from spirometer traces.**

15 Explain the principle of negative feedback in maintaining systems within narrow limits.

16 Discuss the concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium during exercise, including the role of the hypothalamus and the mechanisms of thermoregulation.

17 Explain how genes can be switched on and off by DNA transcription factors including hormones.

18 Analyse and interpret data on possible disadvantages of exercising too much (wear and tear on joints, suppression of the immune system) and exercising too little (increased risk of obesity, coronary heart disease (CHD) and diabetes), recognising correlation and causal relationships.

19 Explain how medical technology, including the use of keyhole surgery and prostheses, is enabling those with injuries and disabilities to participate in sports, e.g. cruciate ligaments repair using keyhole surgery and knee joint replacement using prosthetics.

20 Outline two ethical positions relating to whether the use of performance-enhancing substances by athletes is acceptable.

4.4 Topic 8: Grey matter

Students will be assessed on their ability to:

1. Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

2. Describe how plants detect light using photoreceptors and how they respond to environmental cues.

3. Describe the structure and function of sensory, relay and motor neurones including the role of Schwann cells and myelination.

4. Describe how a nerve impulse (action potential) is conducted along an axon including changes in membrane permeability to sodium and potassium ions and the role of the nodes of Ranvier.

5. Describe the structure and function of synapses, including the role of neurotransmitters, such as acetylcholine.

6. Describe how the nervous systems of organisms can detect stimuli with reference to rods in the retina of mammals, the roles of rhodopsin, opsin, retinal, sodium ions, cation channels and hyperpolarisation of rod cells in forming action potentials in the optic neurones.

7. Explain how the nervous systems of organisms can cause effectors to respond as exemplified by pupil dilation and contraction.

8. Compare mechanisms of coordination in plants and animals, i.e. nervous and hormonal, including the role of IAA in phototropism (details of individual mammalian hormones are not required).

9. Locate and state the functions of the regions of the human brain's cerebral hemispheres (ability to see, think, learn and feel emotions), hypothalamus (thermoregulate), cerebellum (coordinate movement) and medulla oblongata (control the heartbeat).

10. Describe the use of magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI) and computed tomography (CT) scans in medical diagnosis and investigating brain structure and function.

11 Discuss whether there exists a critical 'window' within which humans must be exposed to particular stimuli if they are to develop their visual capacities to the full.

12 Describe the role animal models have played in developing explanations of human brain development and function, including Hubel and Wiesel's experiments with monkeys and kittens.

13 Consider the methods used to compare the contributions of nature and nurture to brain development, including evidence from the abilities of newborn babies, animal experiments, studies of individuals with damaged brain areas, twin studies and cross-cultural studies.

14 Describe how animals, including humans, can learn by habituation.

15 **Describe how to investigate habituation to a stimulus.**

16 Discuss the moral and ethical issues relating to the use of animals in medical research from two ethical standpoints.

17 Explain how imbalances in certain, naturally occurring, brain chemicals can contribute to ill health (e.g. dopamine in Parkinson's disease and serotonin in depression) and to the development of new drugs.

18 Explain the effects of drugs on synaptic transmissions, including the use of L-Dopa in the treatment of Parkinson's disease and the action of MDMA in ecstasy.

19 Discuss how the outcomes of the Human Genome Project are being used in the development of new drugs and the social, moral and ethical issues this raises.

20 Describe how drugs can be produced using genetically modified organisms (plants and animals and micro organisms).

21 Discuss the risks and benefits associated with the use of genetically modified organisms.

Context-led approach (based on the Salters-Nuffield Advanced Biology project)

The following section shows how the specification may be taught using a context-led approach. The content in this section is presented in a different order to the concept-led approach and therefore do not appear in numerical order.

5.1 Unit description

Topic 1: Lifestyle, health and risk

This topic builds on students' knowledge and understanding of the functioning of the circulatory system and the importance of lifestyle choices to health. The role of diet and other lifestyle factors in maintenance of good health is considered with particular reference to the heart and circulation and to cardiovascular disease (CVD). The structures and functions of some carbohydrates and lipids are also detailed within this context. Ideas about correlation, causation and the concept of risks to health are covered.

Topic 2: Genes and health

This topic considers the following biological principles: the properties of and transport of materials, across cell membranes and gas exchange surfaces, DNA structure and replication, protein synthesis, enzymes and monohybrid inheritance through the context of the genetic disease cystic fibrosis. The potential that gene therapy offers as treatment for cystic fibrosis is examined. The topic also allows for discussion of the social and ethical issues surrounding the genetic screening for genetic conditions.

5.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 80 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

5.3 Topic 1: Lifestyle, health and risk

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

6 Explain why many animals have a heart and circulation (mass transport to overcome limitations of diffusion in meeting the requirements of organisms).

2 Explain the importance of water as a solvent in transport, including its dipole nature.

8 Explain how the structures of blood vessels (capillaries, arteries and veins) relate to their functions.

7 Describe the cardiac cycle (atrial systole, ventricular systole and diastole) and relate the structure and operation of the mammalian heart to its function, including the major blood vessels.

11 Explain the course of events that leads to atherosclerosis (endothelial damage, inflammatory response, plaque formation, raised blood pressure).

10 Describe the blood clotting process (thromboplastin release, conversion of prothrombin to thrombin and fibrinogen to fibrin) and its role in cardiovascular disease (CVD).

12 Describe the factors that increase the risk of CVD (genetic, diet, age, gender, high blood pressure, smoking and inactivity).

18 Analyse and interpret quantitative data on illness and mortality rates to determine health risks (including distinguishing between correlation and causation and recognising conflicting evidence).

19 Evaluate design of studies used to determine health risk factors (including sample selection and sample size used to collect data that is both valid and reliable).

20 Explain why people's perceptions of risks are often different from the actual risks (including underestimating and overestimating the risks due to diet and other lifestyle factors in the development of heart disease).

17 Analyse data on energy budgets and diet so as to be able to discuss the consequences of energy imbalance, including weight loss, weight gain, and development of obesity.

3 Distinguish between monosaccharides, disaccharides and polysaccharides (glycogen and starch – amylose and amylopectin) and relate their structures to their roles in providing and storing energy (β-glucose and cellulose are not required in this topic).

4 Describe how monosaccharides join to form disaccharides (sucrose, lactose and maltose) and polysaccharides (glycogen and amylose) through condensation reactions forming glycosidic bonds, and how these can be split through hydrolysis reactions.

5 Describe the synthesis of a triglyceride by the formation of ester bonds during condensation reactions between glycerol and three fatty acids and recognise differences between saturated and unsaturated lipids.

14 Analyse and interpret data on the possible significance for health of blood cholesterol levels and levels of high-density lipoproteins (HDLs) and low-density lipoproteins (LDLs). Describe the evidence for a causal relationship between blood cholesterol levels (total cholesterol and LDL cholesterol) and CVD.

9 **Describe how the effect of caffeine on heart rate in *Daphnia* can be investigated practically, and discuss whether there are ethical issues in the use of invertebrates.**

16 **Describe how to investigate the vitamin C content of food and drink.**

15 Discuss how people use scientific knowledge about the effects of diet (including obesity indicators), exercise and smoking to reduce their risk of coronary heart disease.

13 Describe the benefits and risks of treatments for CVD (antihypertensives, plant statins, anticoagulants and platelet inhibitory drugs).

5.4 Topic 2: Genes and health

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

6 Describe the properties of gas exchange surfaces in living organisms (large surface area to volume ratio, thickness of surface, difference in concentration) and explain how the structure of the mammalian lung is adapted for rapid gaseous exchange.

2 Explain how models such as the fluid mosaic model of cell membranes are interpretations of data used to develop scientific explanations of the structure and properties of cell membranes.

5 **Describe how membrane structure can be investigated practically, e.g. by the effect of alcohol concentration or temperature on membrane permeability.**

3 Explain what is meant by osmosis in terms of the movement of free water molecules through a partially permeable membrane (consideration of water potential is not required).

4 Explain what is meant by passive transport (diffusion, facilitated diffusion), active transport (including the role of ATP), endocytosis and exocytosis and describe the involvement of carrier and channel proteins in membrane transport.

10 Describe the basic structure of mononucleotides (as a deoxyribose or ribose linked to a phosphate and a base, i.e. thymine, uracil, cytosine, adenine or guanine) and the structures of DNA and RNA (as polynucleotides composed of mononucleotides linked through condensation reactions) and describe how complementary base pairing and the hydrogen bonding between two complementary strands are involved in the formation of the DNA double helix.

14 Outline the process of protein synthesis, including the role of transcription, translation, messenger RNA, transfer RNA and the template (antisense) DNA strand (details of the mechanism of protein synthesis on ribosomes are not required at IAS).

12 Explain the nature of the genetic code (triplet code only; non-overlapping and degenerate not required at IAS).

13 Describe a gene as being a sequence of bases on a DNA molecule coding for a sequence of amino acids in a polypeptide chain.

7 Describe the basic structure of an amino acid (structures of specific amino acids are not required) and the formation of polypeptides and proteins (as amino acid monomers linked by peptide bonds in condensation reactions) and explain the significance of a protein's primary structure in determining its three-dimensional structure and properties (globular and fibrous proteins and types of bonds involved in three-dimensional structure).

8 Explain the mechanism of action and specificity of enzymes in terms of their three-dimensional structure and explain that enzymes are biological catalysts that reduce activation energy, catalysing a wide range of intracellular and extracellular reactions.

9 **Describe how enzyme concentrations can affect the rates of reactions and how this can be investigated practically by measuring the initial rate of reaction.**

11 Describe DNA replication (including the role of DNA polymerase), and explain how Meselson and Stahl's classic experiment provided new data that supported the accepted theory of replication of DNA and refuted competing theories.

15 Explain how errors in DNA replication can give rise to mutations and explain how cystic fibrosis results from one of a number of possible gene mutations.

16 Explain the terms gene, allele, genotype, phenotype, recessive, dominant, homozygote and heterozygote, and explain monohybrid inheritance, including the interpretation of genetic pedigree diagrams, in the context of traits such as cystic fibrosis, albinism, thalassaemia, garden pea height and seed morphology.

17 Explain how the expression of a gene mutation in people with cystic fibrosis impairs the functioning of the gaseous exchange, digestive and reproductive systems.

18 Describe the principles of gene therapy and distinguish between somatic and germ line therapy.

19 Explain the uses of genetic screening: identification of carriers, preimplantation genetic diagnosis and prenatal testing (amniocentesis and chorionic villus sampling) and discuss the implications of prenatal genetic screening.

20 Identify and discuss the social and ethical issues related to genetic screening from a range of ethical viewpoints.

6.1 Unit description

Topic 3: The voice of the genome

This topic follows the development of multicellular organisms from single cells to complex individuals. Cell structure and ultrastructure, cell division, the importance of fertilisation, the roles of stem cells, gene expression, cell differentiation and tissue organisation are all considered within this topic, as is the role of the genotype and the effect of environment on phenotype.

Topic 4: Biodiversity and natural resources

The topic focuses on biodiversity and the wealth of natural resources used by humans. The meaning of biodiversity and how it can be measured is considered first and how all this diversity has come about through adaptation and natural selection. It has sections on both traditional and novel uses of plants and plant fibres and the use of chemical extracts from animals and plants. The concern for disappearing biodiversity and loss of potential natural resources is used to highlight the need for biologists to identify, name and classify species. The topic finishes by looking at the role of zoos in conservation of endangered species. General biological principles covered include the relationship of plant anatomy to function and the structure and role of cellulose and starch.

6.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 80 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

6.3 Topic 3: The voice of the genome

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

3 Describe the ultrastructure of an animal (eukaryotic) cell (nucleus, nucleolus, ribosomes, rough and smooth endoplasmic reticulum, mitochondria, centrioles, lysosomes, and Golgi apparatus) and recognise these organelles from EM images.

4 Explain the role of the rough endoplasmic reticulum (rER) and the Golgi apparatus in protein transport within cells and including its role in formation of extracellular enzymes.

2 Distinguish between eukaryotic and prokaryotic cells in terms of their structure and ultrastructure.

6 Explain the role of mitosis and the cell cycle for growth and asexual reproduction.

7 **Describe the stages of mitosis and how to prepare and stain a root tip squash in order to observe them practically.**

9 Explain how mammalian gametes are specialised for their functions.

10 Describe the process of fertilisation in mammals and flowering plants (starting with the acrosome reaction in mammals and pollen tube growth in plants and ending with the fusion of the nuclei) and explain the importance of fertilisation in sexual reproduction.

8 Explain the role of meiosis in the production of gametes and genetic variation through recombination of alleles and genes including independent assortment and crossing over (details of the stages of meiosis are not required).

11 Explain what is meant by the terms stem cell, pluripotency and totipotency and discuss the way society uses scientific knowledge to make decisions about the use of stem cells in medical therapies (e.g. regulatory authorities relating to human embryo research, ability of stem cells to develop into specialised tissues, potential sources of stem cells, who could benefit from the therapies, procedures to obtain stem cells and their risks).

13 Explain how cells become specialised through differential gene expression, producing active mRNA leading to synthesis of proteins, which in turn control cell processes or determine cell structure in animals and plants (details of transcription factors are not required at IAS).

5 Describe how the cells of multicellular organisms can be organised into tissues, tissues into organs and organs into systems.

14 Explain how a phenotype is the result of an interaction between genotype and the environment (e.g. animal hair colour, human height, monoamine oxidase A (MAOA) and cancers), but the data on the relative contributions of genes and environment is often difficult to interpret.

15 Explain how some phenotypes are affected by alleles at many loci (polygenic inheritance) as well as the environment (e.g. height) and how this can give rise to phenotypes that show continuous variation.

12 **Describe how totipotency can be demonstrated practically using plant tissue culture techniques.**

6.4 Topic 4: Biodiversity and natural resources

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the practical and investigative skills identified in numbers 4 and 5 in the table of *How Science Works* on page 12 of this specification.

13 Explain the terms biodiversity and endemism and describe how biodiversity can be measured within a habitat using species richness and within a species using genetic diversity, e.g. variety of alleles in a gene pool.

14 Describe the concept of niche and discuss examples of adaptation of organisms to their environment (behavioural, physiological and anatomical).

15 Describe how natural selection can lead to adaptation and evolution.

2 Compare the ultrastructure of plant cells (cell wall, chloroplasts, amyloplasts, vacuole, tonoplast, plasmodesmata, pits and middle lamella) with that of animal cells.

3 Compare the structure and function of the polysaccharides starch and cellulose including the role of hydrogen bonds between β-glucose molecules in the formation of cellulose microfibrils.

5 Compare the structures, position in the stem and function of sclerenchyma fibres (support) and xylem vessels (support and transport of water and mineral ions).

4 Explain how the arrangement of cellulose microfibrils in plant cell walls and secondary thickening contribute to the physical properties of plant fibres, which can be exploited by humans.

7 Identify sclerenchyma fibres and xylem vessels as seen through a light microscope.

8 **Describe how to determine the tensile strength of plant fibres practically.**

9 Explain the importance of water and inorganic ions (nitrate, calcium ions and magnesium ions) to plants.

10 **Describe how to investigate plant mineral deficiencies practically.**

6 Describe how the uses of plant fibres and starch may contribute to sustainability, e.g. plant-based products to replace oil-based plastics.

12 Compare historic drug testing with contemporary drug testing protocols, e.g. William Withering's digitalis soup; double blind trials; placebo; three-phased testing.

11 **Describe how to investigate the antimicrobial properties of plants.**

16 Discuss the process and importance of critical evaluation of new data by the scientific community, which leads to new taxonomic groupings (i.e. three domains based on molecular phylogeny).

17 Discuss and evaluate the methods used by zoos and seedbanks in the conservation of endangered species and their genetic diversity (e.g. scientific research, captive breeding programmes, reintroduction programmes and education).

7.1 Unit description

Topic 5: On the wild side

This topic looks at whether climate change will lead to an extinction of species or evolution by natural selection, and looks at the evidence for global warming and its effects on plants and animals. The topic continues by building an appreciation that photosynthesis is the primary process that underpins the majority of ecosystems, and provides students with an understanding of how ecosystems work. By the end of the topic students should appreciate how scientific understanding can make us aware of our responsibilities as stewards of the environment.

Topic 6: Infection, immunity and forensics

This topic starts by looking at how forensic pathologists use a wide variety of analytical techniques to determine the identity of a person or other animal, and to establish the time and cause of death of an organism, including humans. It then considers how bacteria and viruses use a variety of routes into their hosts and how hosts have evolved barriers and internal mechanisms to combat infections. These protections are not always successful and many people in the world still die from infectious diseases. This topic also investigates the evolutionary battles that take place between invading pathogens and their hosts.

7.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 90 marks, lasts 1 hour 30 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

7.3 Topic 5: On the wild side

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

11 **Describe how to carry out a study on the ecology of a habitat to produce valid and reliable data (including the use of quadrats and transects to assess abundance and distribution of organisms and the measurement of abiotic factors, e.g. solar energy input, climate, topography, oxygen availability and edaphic factors).**

10 Explain that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors.

12 Explain how the concept of niche accounts for distribution and abundance of organisms in a habitat.

13 Describe the concept of succession to a climax community.

14 Outline the causes of global warming – including the role of greenhouse gases (carbon dioxide and methane, CH_4) in the greenhouse effect.

18 Analyse and interpret different types of evidence for global warming and its causes (including records of carbon dioxide levels, temperature records, pollen in peat bogs and dendrochronology) recognising correlations and causal relationships.

19 Describe that data can be extrapolated to make predictions, that these are used in models of future global warming, and that these models have limitations.

20 Discuss the way in which scientific conclusions about controversial issues, such as what actions should be taken to reduce global warming or the degree to which humans are affecting global warming, can sometimes depend on who is reaching the conclusions.

15 Describe the effects of global warming (rising temperature, changing rainfall patterns and seasonal cycles) on plants and animals (distribution of species, development and life cycles).

16 Explain the effect of increasing temperature on the rate of enzyme activity in plants, animals and micro-organisms.

17 **Describe how to investigate the effects of temperature on the development of organisms (e.g. seedling growth rate, brine shrimp hatch rates).**

3 Describe the overall reaction of photosynthesis as requiring energy from light to split apart the strong bonds in water molecules, storing the hydrogen in a fuel (glucose) by combining it with carbon dioxide and releasing oxygen into the atmosphere.

5 Describe how phosphorylation of ADP requires energy and how hydrolysis of ATP provides an immediate supply of energy for biological processes.

4 Describe the light-dependent reactions of photosynthesis including how light energy is trapped by exciting electrons in chlorophyll and the role of these electrons in generating ATP, and reducing NADP in photophosphorylation and producing oxygen through photolysis of water.

6 Describe the light-independent reactions as reduction of carbon dioxide using the products of the light-dependent reactions (carbon fixation in the Calvin cycle, the role of GP, GALP, RuBP and RUBISCO) and describe the products as simple sugars that are used by plants, animals and other organisms in respiration and the synthesis of new biological molecules (including polysaccharides, amino acids, lipids and nucleic acids).

2 Describe the structure of chloroplasts in relation to their role in photosynthesis.

7 Carry out calculations of net primary productivity and explain the relationship between gross primary productivity, net primary productivity and plant respiration.

8 Calculate the efficiency of energy transfers between trophic levels.

9 Discuss how understanding the carbon cycle can lead to methods to reduce atmospheric levels of carbon dioxide (including the use of biofuels and reforestation).

21 Describe how evolution (a change in the allele frequency) can come about through gene mutation and natural selection.

23 Describe the role of the scientific community in validating new evidence (including molecular biology, e.g. DNA, proteomics) supporting the accepted scientific theory of evolution (scientific journals, the peer review process, scientific conferences).

22 Explain how reproductive isolation can lead to speciation.

7.4 Topic 6: Infection, immunity and forensics

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

20 Describe how to determine the time of death of a mammal by examining the extent of decomposition, stage of succession, forensic entomology, body temperature and degree of muscle contraction.

9 Describe the role of micro-organisms in the decomposition of organic matter and the recycling of carbon.

5 Describe how DNA profiling is used for identification and determining genetic relationships between organisms (plants and animals).

6 **Describe how DNA can be amplified using the polymerase chain reaction (PCR).**

7 **Describe how gel electrophoresis can be used to separate DNA fragments of different length.**

8 Distinguish between the structure of bacteria and viruses.

11 Explain how bacterial and viral infectious diseases have a sequence of symptoms that may result in death, including the diseases caused by *Mycobacterium tuberculosis* (TB) and Human Immunodeficiency Virus (HIV).

12 Describe the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon and phagocytosis.

13 Explain the roles of antigens and antibodies in the body's immune response including the involvement of plasma cells, macrophages and antigen-presenting cells.

14 Distinguish between the roles of B cells (including B memory and B effector cells) and T cells (T helper, T killer and T memory cells) in the body's immune response.

3 Explain the process of protein synthesis (transcription, translation messenger RNA, transfer RNA, ribosomes and the role of start and stop codons) and explain the roles of the template (antisense) DNA strand in transcription, codons on messenger RNA, anticodons on transfer RNA.

2 Explain the nature of the genetic code (triplet code, non-overlapping and degenerate).

4 Explain how one gene can give rise to more than one protein through post-transcriptional changes to messenger RNA.

10 Describe the major routes pathogens may take when entering the body and explain the role of barriers in protecting the body from infection, including the roles of skin, stomach acid, gut and skin flora.

15 Explain how individuals may develop immunity (natural, artificial, active, passive).

16 Discuss how the theory of an 'evolutionary race' between pathogens and their hosts is supported by the evasion mechanisms as shown by Human Immunodeficiency Virus (HIV) and *Mycobacterium tuberculosis* (TB).

17 Distinguish between bacteriostatic and bactericidal antibiotics.

18 **Describe how to investigate the effect of different antibiotics on bacteria.**

19 Describe how an understanding of the contributory causes of hospital acquired infections have led to codes of practice relating to antibiotic prescription and hospital practice relating to infection prevention and control.

8.1 Unit description

Topic 7: Run for your life

This topic is centred on the physiological adaptations that enable animals and humans, particularly sports people, to undertake strenuous exercise. It explores the links between an animal's physiology and its performance. The topic summarises the biochemical requirements for respiration and looks at the links between homeostasis, muscle physiology and performance. It ends by looking at how medical technology is enabling more people to participate in sport, and by raising the issue as to whether the use of performance-enhancing substances by athletes can be justified.

Topic 8: Grey matter

The scene is set by considering how the working of the nervous system enables us to see. Brain imaging and the regions of the brain are considered. The topic also demonstrates how an understanding of brain structure and functioning is relevant to such issues as the response to stimuli, the development of vision and learning. It investigates how imbalances in brain chemicals may result in conditions such as Parkinson's disease and its treatment with drugs are investigated. Students discuss the ethical issues raised by the Human Genome Project and the risks and benefits of using genetically modified organisms.

8.2 Assessment information

This unit is assessed by means of a written examination paper, which carries 90 marks, lasts 1 hour 45 minutes and will include:

- objective questions
- structured questions
- short-answer questions

and will also cover:

- *How Science Works*
- practical–related questions.

Students may use a calculator.

One question will relate to a previously released scientific article that students will have studied during the course. Students may be asked to summarise the information in the article, and explain or comment upon the biology and other issues within the context of the article. The article may draw on knowledge and understanding from any of the four units 1, 2, 4, and 5. A different article will be provided each year and the examination questions will change to reflect this. This question carries a third of the marks of this unit.

The quality of written communication will be assessed in the context of this unit through questions which are labelled with an asterisk (*). Students should take particular care with spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

8.3 Topic 7: Run for your life

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

4 Recall the way in which muscles, tendons, the skeleton and ligaments interact to enable movement, including antagonistic muscle pairs, extensors and flexors.

3 Explain the contraction of skeletal muscle in terms of the sliding filament theory, including the role of actin, myosin, troponin, tropomyosin, calcium ions (Ca^{2+}), ATP and ATPase.

5 Describe the overall reaction of aerobic respiration as splitting of the respiratory substrate (e.g. glucose) to release carbon dioxide as a waste product and reuniting of hydrogen with atmospheric oxygen with the release of a large amount of energy.

7 Recall how phosphorylation of ADP requires energy and how hydrolysis of ATP provides an accessible supply of energy for biological processes.

8 Describe the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP, reduced coenzyme and pyruvate acid (details of intermediate stages and compounds are not required).

9 Describe the role of the Krebs cycle in the complete oxidation of glucose and formation of carbon dioxide (CO_2), ATP, reduced NAD and reduced FAD (names of other compounds are not required) and that respiration is a many-stepped process with each step controlled and catalysed by a specific intracellular enzyme.

10 Describe the synthesis of ATP by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATPase.

11 Explain the fate of lactate after a period of anaerobic respiration in animals.

12 Understand that cardiac muscle is myogenic and describe the normal electrical activity of the heart, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN) and the bundle of His, and how the use of electrocardiograms (ECGs) can aid the diagnosis of cardiovascular disease (CVD) and other heart conditions.

13 Explain how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre.

14 **Describe how to investigate the effects of exercise on tidal volume and breathing rate using data from spirometer traces.**

2 Describe the structure of a muscle fibre and explain the structural and physiological differences between fast and slow twitch muscle fibres.

15 Explain the principle of negative feedback in maintaining systems within narrow limits.

16 Discuss the concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium during exercise, including the role of the hypothalamus and the mechanisms of thermoregulation.

18 Analyse and interpret data on possible disadvantages of exercising too much (wear and tear on joints, suppression of the immune system) and exercising too little (increased risk of obesity, coronary heart disease (CHD) and diabetes), recognising correlation and causal relationships.

19 Explain how medical technology, including the use of keyhole surgery and prostheses, is enabling those with injuries and disabilities to participate in sports, e.g. cruciate ligaments repair using keyhole surgery and knee joint replacement using prosthetics.

20 Outline two ethical positions relating to whether the use of performance-enhancing substances by athletes is acceptable.

17 Explain how genes can be switched on and off by DNA transcription factors including hormones.

6 **Describe how to investigate rate of respiration practically.**

8.4 Topic 8: Grey matter

Students will be assessed on their ability to:

1 Demonstrate knowledge and understanding of the *How Science Works* areas listed in the table on page 12 of this specification.

3 Describe the structure and function of sensory, relay and motor neurones including the role of Schwann cells and myelination.

7 Explain how the nervous systems of organisms can cause effectors to respond as exemplified by pupil dilation and contraction.

4 Describe how a nerve impulse (action potential) is conducted along an axon including changes in membrane permeability to sodium and potassium ions and the role of the nodes of Ranvier.

2 Describe how plants detect light using photoreceptors and how they respond to environmental cues.

5 Describe the structure and function of synapses, including the role of neurotransmitters, such as acetylcholine.

6 Describe how the nervous systems of organisms can detect stimuli with reference to rods in the retina of mammals, the roles of rhodopsin, opsin, retinal, sodium ions, cation channels and hyperpolarisation of rod cells in forming action potentials in the optic neurones.

8 Compare mechanisms of coordination in plants and animals, i.e. nervous and hormonal, including the role of IAA in phototropism (details of individual mammalian hormones are not required).

9 Locate and state the functions of the regions of the human brain's cerebral hemispheres (ability to see, think, learn and feel emotions), hypothalamus (thermoregulate), cerebellum (coordinate movement) and medulla oblongata (control the heartbeat).

10 Describe the use of magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI) and computed tomography (CT) scans in medical diagnosis and investigating brain structure and function.

11 Discuss whether there exists a critical 'window' within which humans must be exposed to particular stimuli if they are to develop their visual capacities to the full.

14 Describe how animals, including humans, can learn by habituation.

12 Describe the role animal models have played in developing explanations of human brain development and function, including Hubel and Wiesel's experiments with monkeys and kittens.

16 Discuss the moral and ethical issues relating to the use of animals in medical research from two ethical standpoints.

17 Explain how imbalances in certain, naturally occurring, brain chemicals can contribute to ill health (e.g. dopamine in Parkinson's disease and serotonin in depression) and to the development of new drugs.

18 Explain the effects of drugs on synaptic transmissions, including the use of L-Dopa in the treatment of Parkinson's disease and the action of MDMA in ecstasy.

19 Discuss how the outcomes of the Human Genome Project are being used in the development of new drugs and the social, moral and ethical issues this raises.

20 Describe how drugs can be produced using genetically modified organisms (plants and animals and micro organisms).

21 Discuss the risks and benefits associated with the use of genetically modified organisms.

13 Consider the methods used to compare the contributions of nature and nurture to brain development, including evidence from the abilities of newborn babies, animal experiments, studies of individuals with damaged brain areas, twin studies and cross-cultural studies.

15 **Describe how to investigate habituation to a stimulus**