	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(ii) A.1 - handling data		
A.1.1	Use an appropriate number of significant figures	Candidates may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures • understand that calculated results can be reported only to the limits of the least accurate measurement
A.1.2	Find arithmetic means	Candidates may be tested on their ability to: • find the mean of a range of data, e.g. the mean number of stomata in the leaves of a plant
A.1.3	Construct and interpret frequency tables and diagrams, bar charts and histograms	Candidates may be tested on their ability to: • represent a range of data in a table with clear headings, units and consistent decimal places • interpret data from a variety of tables, e.g. data relating to organ function • plot a range of data in an appropriate format, e.g. enzyme activity over time represented on a graph • interpret data for a variety of graphs, e.g. explain electrocardiogram traces
A.1.4	Understand simple probability	Candidates may be tested on their ability to: • use the terms probability and chance appropriately • understand the probability associated with genetic inheritance
A.1.5	Understand the principles of sampling as applied to scientific data	Candidates may be tested on their ability to: • analyse random data collected by an appropriate means, e.g. use Simpson's index of diversity to calculate the biodiversity of a habitat
A.1.6	Understand the terms mean, median and mode	Candidates may be tested on their ability to: • calculate or compare the mean, median and mode of a set of data, e.g. height/mass/size of a group of organisms

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(i) A.1 - handling data		
A.1.7	Use a scatter diagram to identify a correlation between two variables	Candidates may be tested on their ability to: • interpret a scattergram, e.g. the effect of life style factors on health
A.1.8	Make order of magnitude calculations	Candidates may be tested on their ability to: • use and manipulate the magnification formula magnification = size of image / size of real object
A.1.9	Select and use a statistical test	Candidates may be tested on their ability to select and use: • the Chi squared test to test the significance of the difference between observed and expected results • the Student's t-test • the correlation coefficient
A.1.10	Understand measures of dispersion, including standard deviation and range	Candidates may be tested on their ability to: • calculate the standard deviation • understand why standard deviation might be a more useful measure of dispersion for a given set of data, e.g. where there is an outlying result
A.1.11	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Candidates may be tested on their ability to: • calculate percentage error where there are uncertainties in measurement
(ii) A.2 – algebra		
A.2.1	Understand and use the symbols: =, <, <<, >>, >, ∝, ~.	No exemplification required.
A.2.2	Change the subject of an equation	Candidates may be tested on their ability to: • use and manipulate equations, e.g. magnification
A.2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Candidates may be tested on their ability to: use a given equation e.g. Simpson's-index of diversity $D = \frac{N(N-1)}{\Sigma n(n-1)}$

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
A.2.4	Solve algebraic equations	Candidates may be tested on their ability to: • solve equations in a biological context, e.g. cardiac output = stroke volume x heart rate
A.2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	**Candidates may be tested on their ability to:** • **use a logarithmic scale in the context of microbiology, e.g. growth rate of a microorganism such as yeast**
(iii) A.3 – graphs		
A.3.1	Translate information between graphical, numerical and algebraic forms	Candidates may be tested on their ability to: • understand that data may be presented in a number of formats and be able to use these data, e.g. dissociation curves
A.3.2	Plot two variables from experimental or other data	Candidates may be tested on their ability to: • select an appropriate format for presenting data, bar charts, histograms, graphs and scattergrams
A.3.3	Understand that $y = mx + c$ represents a linear relationship	Candidates may be tested on their ability to: • predict/sketch the shape of a graph with a linear relationship, e.g. the effect of substrate concentration on the rate of an enzyme-controlled reaction with excess enzyme
A.3.4	**Determine the intercept of a graph**	**Candidates may be tested on their ability to:** • **read off an intercept point from a graph, e.g. compensation point in plants**
A.3.5	Calculate rate of change from a graph showing a linear relationship	Candidates may be tested on their ability to: • calculate a rate from a graph, e.g. rate of transpiration
A.3.6	Draw and use the slope of a tangent to a curve as a measure of rate of change	Candidates may be tested on their ability to: • use this method to measure the gradient of a point on a curve, e.g. amount of product formed plotted against time when the concentration of enzyme is fixed

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(iv) A.4 - geometry and trigonometry		
A.4.1	Calculate the circumferences, surface areas and volumes of regular shapes	Candidates may be tested on their ability to: • calculate the circumference and area of a circle • calculate the surface area and volume of rectangular prisms, of cylindrical prisms and of spheres • e.g. calculate the surface area or volume of a cell

Appendix 7: Command words used in examination papers

The following table lists the command words used in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to a stimulus material given in the question, for example labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included.
Comment on	Requires the synthesis of a number of variables from data/information to form a judgement.
Compare and contrast	Looking for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete	Requires the completion of a table/diagram.
Criticise	Inspect a set of data, an experimental plan or a scientific statement and consider the elements. Look at the merits and faults of the information presented and support judgements made by giving evidence.
Deduce	Draw/reach conclusion(s) from the information provided.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.
Devise	Plan or invent a procedure from existing principles/ideas.
Discuss	• Identify the issue/situation/problem/argument that is being assessed within the question • Explore all aspects of an issue/situation/problem/argument • Investigate the issue/situation etc by reasoning or argument
Draw	Produce a diagram either using a ruler or using freehand.
Evaluate	Review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a	When a statement has been made and the requirement is only to

Command word	Definition
reason/reasons	give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer)
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axis with important features indicated, the axis are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Write	When the questions ask for an equation.

Appendix 8: Presentation by themes

Content overview

The learning outcomes for the Advanced GCE qualification are organised below according to biological themes. This enables teachers to identify how the learning outcomes in the topics link together as themes, should this approach be helpful.

Each learning outcome retains the same identifying topic sub references.

Students will be expected to demonstrate and apply the knowledge, understanding and skills described in the content below. In addition, they will be expected to analyse, interpret and evaluate a range of scientific information, ideas and evidence using their knowledge, understanding and skills.

To demonstrate knowledge, learners should be able to undertake a range of activities including the ability to recall, describe and define, as appropriate. To demonstrate understanding, students should be able to explain ideas and to use their knowledge to apply, analyse, interpret and evaluate, as appropriate.

There are opportunities for students to develop mathematical skills throughout the content. They are required to apply the skills to relevant biology contexts. Please see *Appendix 6: Mathematical skills and exemplifications*, for further information.

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.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
1.2	Understand the importance of water as a solvent in transport, including its dipole nature.
1.12	i) Know the difference between monosaccharides, disaccharides and polysaccharides, including glycogen and starch (amylose and amylopectin). ii) Be able to relate the structures of monosaccharides, disaccharides and polysaccharides to their roles in providing and storing energy (β-glucose and cellulose are not required in this topic).
1.13	Know 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.
1.14	i) Know how a triglyceride is synthesised by the formation of ester bonds during condensation reactions between glycerol and three fatty acids.

Students should:	
	ii) Know the differences between saturated and unsaturated lipids.
1.1	Understand why many animals have a heart and circulation (mass transport to overcome limitations of diffusion in meeting the requirements of organisms).
1.4	i) Know the cardiac cycle (atrial systole, ventricular systole and cardiac diastole) and relate the structure and operation of the mammalian heart, including the major blood vessels, to its function. ii) Know how the relationship between heart structure and function can be investigated practically.
1.3	Understand how the structures of blood vessels (capillaries, arteries and veins) relate to their functions.
CORE PRACTICAL 1: investigate the effect of caffeine on heart rate in daphnia.	
1.17	Discuss the potential ethical issues regarding the use of invertebrates in research.
1.6	Understand the blood-clotting process (thromboplastin release, conversion of prothrombin to thrombin and fibrinogen to fibrin) and its role in cardiovascular disease (CVD).
1.5	Understand the course of events that leads to atherosclerosis (endothelial dysfunction, inflammatory response, plaque formation, raised blood pressure).
1.7	Know how factors such as genetic, diet, age, gender, high blood pressure, smoking and inactivity increase the risk of cardiovascular disease (CVD).
1.18	Know the benefits and risks of treatments for cardiovascular disease (CVD) (antihypertensives, statins, anticoagulants and platelet inhibitors).
1.15	i) Be able to 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). ii) Know the evidence for a causal relationship between blood cholesterol levels (total cholesterol and LDL cholesterol) and cardiovascular disease (CVD).
1.16	Understand how people use scientific knowledge about the effects of diet including obesity indicators body mass index and waist-to-hip ratio, exercise and smoking to reduce their risk of coronary heart disease.
CORE PRACTICAL 2: Investigate the vitamin C content of food and drink.	
1.11	i) Be able to analyse data on energy budgets and diet. ii) Understand the consequences of energy imbalance, including weight loss, weight gain, and development of obesity.
1.8	Be able to analyse and interpret quantitative data on illness and mortality rates to determine health risks (including distinguishing between correlation and causation and recognising conflicting evidence).
1.9	Be able to evaluate the 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.

Students should:	
1.10	Understand 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.

Topic 2: Genes and Health

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

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
2.1	i) Know the properties of gas exchange surfaces in living organisms (large surface area to volume ratio, thickness of surface, difference in concentration). ii) Understand how the rate of diffusion is dependent on these properties and can be calculated using Fick's Law of Diffusion. iii) Understand how the structure of the mammalian lung is adapted for rapid gaseous exchange.
2.2	i) Know the structure and properties of cell membranes. ii) Understand 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.
CORE PRACTICAL 3:	Investigate membrane structure, including the effect of alcohol concentration or temperature on membrane permeability.
2.3	Understand 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).
2.4	i) Understand what is meant by passive transport (diffusion, facilitated diffusion), active transport (including the role of ATP as an immediate source of energy), endocytosis and exocytosis. ii) Understand the involvement of carrier and channel proteins in membrane transport.
2.5	i) Know the basic structure of mononucleotides (deoxyribose or ribose linked to a phosphate and a base, including thymine, uracil, cytosine, adenine or guanine) and the structures of DNA and RNA (polynucleotides composed of mononucleotides linked through condensation reactions). ii) Know how complementary base pairing and the hydrogen bonding between two complementary strands are involved in the formation of the DNA double helix.

Students should:	
2.6	i) Understand the process of protein synthesis (transcription) including the role of RNA polymerase, translation, messenger RNA, transfer RNA, ribosomes and the role of start and stop codons. ii) Understand the roles of the DNA template (antisense) strand in transcription, codons on messenger RNA and anticodons on transfer RNA.
2.7	Understand the nature of the genetic code (triplet code, non-overlapping and degenerate).
2.8	Know that a gene is a sequence of bases on a DNA molecule that codes for a sequence of amino acids in a polypeptide chain.
2.9	i) Know the basic structure of an amino acid (structures of specific amino acids are not required). ii) Understand the formation of polypeptides and proteins (amino acid monomers linked by peptide bonds in condensation reactions). iii) Understand the significance of a protein's primary structure in determining its three-dimensional structure and properties (globular and fibrous proteins and the types of bonds involved in its three-dimensional structure). iv) Know the molecular structure of a globular protein and a fibrous protein and understand how their structures relate to their functions (including haemoglobin and collagen).
2.10	i) Understand the mechanism of action and the specificity of enzymes in terms of their three-dimensional structure. ii) Understand that enzymes are biological catalysts that reduce activation energy. iii) Know that there are intracellular enzymes catalysing reactions inside cells and extracellular enzymes produced by cells catalysing reactions outside of cells.
CORE PRACTICAL 4: Investigate the effect of enzyme and substrate concentrations on the initial rates of reactions.	
2.11	i) Understand the process of DNA replication, including the role of DNA polymerase. ii) Understand how Meselson and Stahl's classic experiment provided new data that supported the accepted theory of replication of DNA and refuted competing theories.
2.12	i) Understand how errors in DNA replication can give rise to mutations. ii) Understand how cystic fibrosis results from one of a number of possible gene mutations.

Students should:	
2.13	i) Know the meaning of the terms: gene, allele, genotype, phenotype, recessive, dominant, incomplete dominance, homozygote and heterozygote. ii) Understand patterns of inheritance, including the interpretation of genetic pedigree diagrams, in the context of monohybrid inheritance.
2.14	Understand how the expression of a gene mutation in people with cystic fibrosis impairs the functioning of the gaseous exchange, digestive and reproductive systems.
2.15	i) Understand the uses of genetic screening, including the identification of carriers, pre-implantation genetic diagnosis (PGD) and prenatal testing, including amniocentesis and chorionic villus sampling. ii) Understand the implications of prenatal genetic screening.
2.16	Be able to identify and discuss the social and ethical issues related to genetic screening from a range of ethical viewpoints.

Topic 3: 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, epigenetics and the effect of environment on phenotype.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
3.1	Know that all living organisms are made of cells, sharing some common features.
3.4	Know the ultrastructure of prokaryotic cells, including cell wall, capsule, plasmid, flagellum, pili, ribosomes, mesosomes and circular DNA.
3.2	Know the ultrastructure of eukaryotic cells, including nucleus, nucleolus, ribosomes, rough and smooth endoplasmic reticulum, mitochondria, centrioles, lysosomes, and Golgi apparatus.
3.5	Be able to recognise the organelles in 3.2 from electron microscope (EM) images.
3.3	Understand the role of the rough endoplasmic reticulum (rER) and the Golgi apparatus in protein transport within cells, including their role in the formation of extracellular enzymes.
3.13	Understand why the cells of multicellular organisms are organised into tissues, tissues into organs and organs into systems.
3.10	Understand the role of mitosis and the cell cycle in producing identical daughter cells for growth and asexual reproduction.
CORE PRACTICAL 5:	Understand how to prepare and stain a root tip squash to observe the stages of mitosis.
3.9	Understand the role of meiosis in ensuring genetic variation through the production of non-identical gametes as a consequence of independent assortment of chromosomes and crossing over of alleles between chromatids (details of the stages of meiosis are not required).
3.8	i) Know that a locus (loci) is the location of genes on a chromosome. ii) Understand the linkage of genes on a chromosome and sex linkage.
3.6	Understand how mammalian gametes are specialised for their functions (including the acrosome in sperm and the zona pellucida in the egg).
3.7	Know the process of fertilisation in mammals, including the acrosome reaction, the cortical reaction and the fusion of nuclei.
3.11	i) Understand what is meant by the terms 'stem cell, pluripotency and totipotency'. ii) Be able to discuss the way society uses scientific knowledge to make decisions about the use of stem cells in medical therapies.
3.12	Understand 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 including lac operon

Students should:	
3.14	i) Understand how phenotype is the result of an interaction between genotype and the environment. ii) Know how epigenetic changes (including DNA methylation and histone modification) can modify the activation of certain genes. iii) Understand how epigenetic changes can be passed on following cell division.
3.15	Understand how some phenotypes are affected by multiple alleles for the same gene at many loci (polygenic inheritance) as well as the environment and how this can give rise to phenotypes that show continuous variation.

Topic 4: Biodiversity and Natural Resources

The topic focuses on biodiversity and the wealth of natural resources used by humans. Why there are so many different species is considered first, with the concept of niche and adaptation explored. The topic looks at how all this diversity has come about through adaptation and natural selection and how this leads to evolution. The concerns for disappearing biodiversity and loss of potential natural resources are used to highlight the need for biologists to identify, name and classify species. The topic has sections on both traditional and novel uses of plants and plant fibres and the use of chemical extracts from animals and plants. The relationship of plant anatomy to function and the structure and roles of cellulose and starch are studied. The topic ends with the issue of sustainability and the role of zoos and seed banks in conservation of endangered species.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
4.1	Know that over time the variety of life has become extensive but is now being threatened by human activity
4.2	i) Understand the terms biodiversity and endemism. ii) Know how biodiversity can be measured within a habitat using species richness and within a species using genetic diversity by calculating the heterozygosity index (H): $H = \frac{\text{number of heterozygotes}}{\text{number of individuals in the population}}$ iii) how biodiversity can be compared in different habitats using Simpson's diversity index (D): $D = \frac{N(N-1)}{\Sigma n(n-1)}$
4.3	Understand the concept of niche and be able to discuss examples of adaptation of organisms to their environment (behavioural, physiological and anatomical).
4.4	Understand how natural selection can lead to adaptation and evolution.
4.5	i) Understand how the Hardy-Weinberg equation can be used to see whether a change in allele frequency is occurring in a population over time. ii) Understand that reproductive isolation can lead to accumulation of different genetic information in populations potentially leading to the formation of new species.

Students should:	
4.6	i) Understand that classification is a means of organising the variety of life based on relationships between organisms using differences and similarities in phenotypes and in genotypes, and is built around the species concept. ii) Understand the process and importance of critical evaluation of new data by the scientific community, which leads to new taxonomic groupings, including the three domains of life based on molecular phylogeny, which are Bacteria, Archaea, Eukaryota
4.7	Know the ultrastructure of plant cells (cell walls, chloroplasts, amyloplasts, vacuole, tonoplast, plasmodesmata, pits and middle lamella) and be able to compare it with animal cells.
4.8	Be able to recognise the organelles in 4.7 from electron microscope (EM) images.
4.9	Understand 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.
4.10	Understand how the arrangement of cellulose microfibrils and secondary thickening in plant cell walls contributes to the physical properties of xylem vessels and sclerenchyma fibres in plant fibres that can be exploited by humans.
CORE PRACTICAL 6:	Identify sclerenchyma fibres, phloem sieve tubes and xylem vessels and their location within stems through a light microscope.
4.11	Know the similarities and differences between the structures, position in the stem and function of sclerenchyma fibres (support), xylem vessels (support and transport of water and mineral ions) and phloem (translocation of organic solutes).
4.12	Understand the importance of water and inorganic ions (nitrate, calcium ions and magnesium ions) to plants.
CORE PRACTICAL 7:	Understand how to investigate plant mineral deficiencies practically.
CORE PRACTICAL 8:	Determine the tensile strength of plant fibres practically.
4.13	Understand the development of drug testing from historic to contemporary protocols, including William Withering's digitalis soup, double blind trials, placebo, three-phased testing.
4.14	Understand the conditions required for bacterial growth.
CORE PRACTICAL 9:	Investigate the antimicrobial properties of plants, including aseptic techniques for the safe handling of bacteria.
4.15	Understand how the uses of plant fibres and starch may contribute to sustainability, including plant-based products to replace oil-based plastics.

Students should:	
4.16	Be able to evaluate the methods used by zoos and seed banks in the conservation of endangered species and their genetic diversity, including scientific research, captive breeding programmes, reintroduction programmes and education.

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 climate change 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.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
5.9	Understand the structure of chloroplasts in relation to their role in photosynthesis.
CORE PRACTICAL 11:	Investigate photosynthesis using isolated chloroplasts (the Hill reaction).
5.5	Understand 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.
5.7	Understand 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, reducing NADP in photophosphorylation and producing oxygen through photolysis of water.
5.6	Understand how phosphorylation of ADP requires energy and that hydrolysis of ATP provides an immediate supply of energy for biological processes.
5.8	i) Understand 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). ii) Know that the products are 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).
5.10	i) Be able to calculate net primary productivity. ii) Understand the relationship between gross primary productivity, net primary productivity and plant respiration.
5.11	Know how to calculate the efficiency of biomass and energy transfers between trophic levels.
5.21	Understand how knowledge of the carbon cycle can be applied to methods to reduce atmospheric levels of carbon dioxide.
5.1	Understand the terms ecosystem, community, population and habitat.
5.2	Understand that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors.
CORE PRACTICAL 10:	Be able to carry out a study on the ecology of a habitat, including using quadrats and transects to determine distribution and abundance of organisms,

Students should:	
	and measuring abiotic factors appropriate to the habitat.
5.3	Understand how the concept of niche accounts for distribution and abundance of organisms in a habitat.
5.4	Understand the stages of succession which result in a climax community.
5.13	Understand the causes of anthropogenic climate change – including the role of greenhouse gases (carbon dioxide and methane) in the greenhouse effect.

Students should:	
5.15	Understand the effects of climate change (changing rainfall patterns and changes in seasonal cycles) on plants and animals (distribution of species, development and life cycles).
5.16	Understand the effect of temperature on the rate of enzyme activity and its impact on plants, animals and microorganisms.
CORE PRACTICAL 12:	Be able to investigate the effect of temperature on the rate of an enzyme-catalysed reaction, to include Q10.
CORE PRACTICAL 13:	Be able to investigate the effects of temperature on the development of organisms (such as seedling growth rate, brine shrimp hatch rates).
5.12	Understand the different types of evidence for climate change and its causes (including records of carbon dioxide levels, temperature records, pollen in peat bogs and dendrochronology) recognising correlations and causal relationships.
5.14	i) Understand that data can be extrapolated to make predictions and that these are used in models of future climate change. ii) Understand that models for climate change have limitations.
5.20	Understand the way in which scientific conclusions about controversial issues, such as what actions should be taken to reduce climate change or the degree to which humans are affecting climate change, can sometimes depend on who is reaching the conclusions.
5.22	Understand how reforestation and the use of sustainable resources including biofuels are examples of the effective management of the conflict between human needs and conservation.
5.17	Understand how evolution (a change in the allele frequency) can come about through gene mutation and natural selection.
5.19	Understand how isolation reduces gene flow between populations leading to allopatric or sympatric speciation.
5.18	Understand the role of the scientific community (scientific journals, the peer review process, scientific conferences) in validating new evidence, including proteomics and genomics, that supports the accepted scientific theory of evolution.

Topic 6: Immunity, Infection and Forensics

This topic starts by looking at how forensic pathologists use a wide variety of analytical techniques to determine identity and 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. The topic ends by looking at hospital acquired infections, their prevention and control.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
6.10	Understand how one gene can give rise to more than one protein through post-transcriptional changes to messenger RNA (mRNA).
6.3	Know how DNA profiling is used for identification and determining genetic relationships between organisms (plants and animals).
6.4	Know how DNA can be amplified using the polymerase chain reaction (PCR).
CORE PRACTICAL 14:	Understand how to use gel electrophoresis to separate DNA fragments of different length.
6.5	Be able to compare the structure of bacteria and viruses.
6.2	Know the role of micro-organisms in the decomposition of organic matter and the recycling of carbon.
6.11	i) Know the major routes pathogens may take when entering the body. ii) Understand the role of barriers in protecting the body from infection, including the roles of skin, stomach acid, and gut and skin flora.
6.6	Understand how *Mycobacterium tuberculosis* (TB) and Human Immunodeficiency Virus (HIV) infect human cells, causing a sequence of symptoms that may result in death.
6.7	Understand the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon, and phagocytosis.
6.8	Understand the roles of antigens and antibodies in the body's immune response including the involvement of plasma cells, macrophages and antigen-presenting cells.
6.9	Understand the differences 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.
6.12	Understand how individuals may develop immunity (natural, artificial, active, passive).
6.13	Understand how the theory of an 'evolutionary race' between pathogens and their hosts is supported by the evasion mechanisms shown by pathogens.

6.14 Understand the difference between bacteriostatic and bactericidal antibiotics.
CORE PRACTICAL 15: Investigate the effect of different antibiotics on bacteria.

Students should:	
6.15	Know how an understanding of the contributory causes of hospital acquired infections have led to codes of practice regarding antibiotic prescription and hospital practice that relate to infection prevention and control.
6.1	Understand 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.

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 raises the issue of whether the use of performance-enhancing substances by athletes can be justified.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
7.10	i) Know the structure of a muscle fibre. ii) Understand the structural and physiological differences between fast and slow twitch muscle fibres.
7.2	Understand the process of 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.
7.1	Know the way in which muscles, tendons, the skeleton and ligaments interact to enable movement, including antagonistic muscle pairs, extensors and flexors.
7.3	i) Understand the overall reaction of aerobic respiration as splitting of the respiratory substrate, including 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. ii) Understand that respiration is a many-stepped process with each step controlled and catalysed by a specific intracellular enzyme.
CORE PRACTICAL 16:	Investigate rate of respiration practically.
7.4	Understand the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP, reduced coenzyme, pyruvate and lactate (details of intermediate stages and compounds are not required).
7.5	Understand the role of the link reaction and 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 why these steps take place in the mitochondria, unlike glycolysis which occurs in the cytoplasm.
7.6	Understand how ATP is synthesised by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATP synthase.
7.7	Understand what happens to lactate after a period of anaerobic respiration in animals.
7.8	i) Know the myogenic nature of cardiac muscle

Students should:
ii) Understand how the normal electrical activity of the heart coordinates the heart beat, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN), the bundle of His and the Purkyne fibres. iii) Understand how the use of electrocardiograms (ECGs) can aid the diagnosis of cardiovascular disease (CVD) and other heart conditions.

Students should:	
7.9	i) Know how to calculate cardiac output. ii) Understand 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 in the medulla oblongata.
CORE PRACTICAL 17:	Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation and oxygen consumption using data from spirometer traces.
7.11	Understand the principle of negative feedback in maintaining systems within narrow limits.
7.12	Understand 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.
7.16	Understand how genes can be switched on and off by DNA transcription factors including hormones.
7.13	Understand the analysis and interpretation of data relating to possible disadvantages of exercising too much (wear and tear on joints, suppression of the immune system) and exercising too little (increased risk of obesity, cardiovascular disease (CVD) and diabetes), recognising correlation and causal relationships.
7.14	Understand how medical technology, including the use of keyhole surgery and prostheses, is enabling those with injuries and disabilities to participate in sports.
7.15	Be able to discuss different ethical positions relating to whether the use of performance-enhancing substances by athletes is acceptable.

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 issues such 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, which can be treated with suitable drugs. Students discuss the ethical issues raised by the Human Genome Project and the risks and benefits of using genetically-modified organisms.

Students should be encouraged to carry out a range of practical experiments related to this topic in order to develop their practical skills.

Students should:	
8.6	Understand how phytochrome and IAA bring about responses in plants to environmental cues, including their effects on transcription.
8.1	Know the structure and function of sensory, relay and motor neurones including the role of Schwann cells and myelination.
8.3	Understand 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 myelination.
8.4	Know the structure and function of synapses in nerve impulse transmission, including the role of neurotransmitters, including acetylcholine.
8.5	Understand 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.
8.2	i) Understand how the nervous systems of organisms can cause effectors to respond to a stimulus. ii) Understand how the pupil dilates and contracts.
8.7	Understand how co-ordination is brought about through nervous and hormonal control in animals.
8.8	Know the location and functions of the cerebral hemispheres, hypothalamus, cerebellum and medulla oblongata in the human brain.
8.9	Understand how magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and computed tomography (CT) scans are used in medical diagnosis and the investigation of brain structure and function.
8.10	Understand what happens during the critical period so that mammals can develop their visual capacities to the full.
8.11	Understand the role animal models have played in the research into human brain development and function, including Hubel and Wiesel's experiments with monkeys and kittens.

Students should:
8.19 Understand the methods used to investigate the contributions of nature and nurture to brain development, including evidence from the abilities of new-born babies, animal experiments, studies of individuals with damaged brain areas, twin studies and cross-cultural studies.
8.13 Understand how animals, including humans, can learn by habituation.
CORE PRACTICAL 18: Investigate habituation to a stimulus.
8.12 Be able to discuss the moral and ethical issues relating to the use of animals in medical research from two ethical standpoints.

Students should:	
8.14	Understand how imbalances in certain, naturally occurring, brain chemicals can contribute to ill health, including dopamine in Parkinson's disease and serotonin in depression, and to the development of new drugs.
8.15	Understand 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.
8.16	Understand how the outcomes of genome sequencing projects are being used in the development of personalised medicine and the social, moral and ethical issues this raises.
8.17	Know how drugs can be produced using genetically modified organisms (plants, animals and microorganisms).
8.18	Understand the risks and benefits associated with the use of genetically modified organisms.

Appendix 9: Support from the University of York

The Salters-Nuffield Advanced Biology (SNAB) project team in the University of York Science Education Group runs in-service courses for teachers from centres that are following, or preparing to follow, this qualification.

The project team also runs an advice service to help with questions concerning the teaching of the course. Teachers and technicians can join an email group for those following the course.

Centres following this qualification may be eligible for additional financial support (for example book grants) from the Salters Companies.

For further information about the SNAB course and about the support available to centres, please visit the SNAB project website:
www.york.ac.uk/education/projects/SNAB

or contact the project administrator:

Salters-Nuffield Advanced Biology Project
Science Education Group
Alcuin College D Block
University of York
Heslington
York
YO10 5DD

Telephone: 01904 322601
Fax: 01904 322605
Email: uyseg-snab@york.ac.uk

Enquiries concerning assessment and administration should be addressed to the Qualifications and Delivery and Awards Manager for Biology at Pearson.

October 2014

For more information on Edexcel and BTEC qualifications please visit our websites: www.edexcel.com and www.btec.co.uk