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INTERNATIONAL ADVANCED LEVEL

Biology

SPECIFICATION

Pearson Edexcel International Advanced Subsidiary in Biology (XBI01)

Pearson Edexcel International Advanced Level in Biology (YBI01)

For first teaching in September 2013
First examination January 2014
Issue 2

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Acknowledgements
This specification has been produced by Pearson on the basis of consultation with teachers, examiners, consultants and other interested parties. Pearson would like to thank all those who contributed their time and expertise to the specification's development.

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About this specification

Pearson Edexcel International Advanced Level in Biology is designed for use in schools and colleges outside the United Kingdom. It is part of a suite of International Advanced Level qualifications offered by Pearson.

This qualification has been approved by Pearson Education Limited as meeting the criteria for Pearson's Self-regulated Framework.

Pearson's Self-regulated Framework is designed for qualifications that have been customised to meet the needs of a particular range of learners and stakeholders. These qualifications are not accredited or regulated by any UK regulatory body.

Structure: flexible, modular structure comprising six units.

Content: engaging and relevant to international customers.

Assessment: 100% external assessment, with January and June assessment opportunities.

Approach: use of contemporary contexts and a choice of two teaching and learning styles within one common assessment structure.

Specification updates

This specification is Issue 2 and is valid for the Pearson Edexcel International Advanced Subsidiary and International Advanced Level examination from 2014. If there are any significant changes to the specification Pearson will write to centres to let them know. Changes will also be posted on our website.

For more information please visit: www.edexcel.com/ial

Using this specification

The specification content has been designed to give guidance to teachers and encourage effective delivery of the qualification. The following information will help you get the most out of the content and guidance.

The specification content has been produced to engage and inspire students by showing how an understanding of many contemporary issues requires a grasp of fundamental biological ideas.

The two approaches to the content of the specification are:

- a concept-led approach. This approach begins with a study of the laws, theories and models of biology and finishes with an exploration of their practical applications
- a context-led approach. This approach begins with the consideration of an application that draws on many different areas of biology, and then moves on to the biological concepts underlying this application.

Both approaches enable the use of motivating, contemporary contexts. Centres may offer courses based completely on either or both approaches, or 'mix and match' the approaches to different topics within one course. This aims both to attract and retain more students by matching their own learning needs and to make teaching more enjoyable for teachers.

The specification content has been developed in collaboration with the Salters-Nuffield Advanced Biology project, which leads the field in innovative approaches to teaching and learning in biology at the International Advanced Level.

Salters-Nuffield Advanced Biology is a collaboration between two major forces for innovation in science education: the University of York Science Education Group and the Nuffield Foundation. Both have a long and distinguished history of seminal curriculum projects in science and have combined their experience to develop a biology course which meets the needs of today's students.

Depth and breadth of content: teachers should prepare students to respond to assessment questions. Teachers should use the full range of content and all the assessment objectives given in *Section B: Specification Overview*.

Qualification abbreviations

International Advanced Level – IAL

International Advanced Subsidiary – IAS

International Advanced Level 2 (the additional content required for an IAL) – IA2

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A Specification at a glance

Unit overview

IAS Unit 1: Lifestyle, Transport, Genes and Health	*Unit code WBI01	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	40% of the total IAS raw marks	20% of the total IAL raw marks
Content summary: ■ structure and function of carbohydrates, lipids and proteins; enzyme action ■ structure and properties of cell membranes; passive and active transport ■ structure and role of DNA and RNA ■ replication; protein synthesis ■ monohybrid inheritance ■ gene mutations ■ principles of gene therapy; social and ethical issues.		
Assessment: Written examination of 1 hour and 30 minutes, consisting of objective, structured and short-answer questions.		

IAS Unit 2: Development, Plants and the Environment	*Unit code WBI02	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	40% of the total IAS raw marks	20% of the total IAL raw marks
Content summary: ■ cell structure and ultrastructure of eukaryote and prokaryote cells; cell specialisation ■ the role of meiosis ■ genotype and environmental influence ■ stem cell research and its implications ■ biodiversity, adaptations and natural selection ■ principles of taxonomy ■ plant cell structure ■ transport of water in plants ■ uses of plant products.		
Assessment: Written examination of 1 hour and 30 minutes, consisting of objective, structured and short-answer questions.		

* See *Appendix 2* for description of this code and all other codes relevant to this qualification.

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IAS Unit 3: Practical Biology and Research Skills	*Unit code WBI03	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	20% of the total IAS raw marks	10% of the total IAL raw marks
Content summary: Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out a range of practical experiments and investigations while they study Units 1 and 2. This unit will assess students' knowledge and understanding of experimental procedures and techniques that were developed throughout Units 1 and 2.		
Assessment: Written examination of 1 hour and 30 minutes, consisting of objective, structured and short-answer questions.		

IA2 Unit 4: The Natural Environment and Species Survival	*Unit code WBI04	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	40% of the total IA2 raw marks	20% of the total IAL raw marks
Content summary: ■ photosynthesis; energy transfer within ecosystems ■ evidence for global warming ■ evolution through natural selection and speciation ■ nutrient recycling ■ DNA profiling and PCR ■ structure of bacteria and viruses ■ infectious diseases (e.g. AIDS and TB) and immunology.		
Assessment: Written examination of 1 hour and 30 minutes, consisting of objective, structured and short-answer questions.		

* See *Appendix 2* for description of this code and all other codes relevant to this qualification.

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A Specification at a glance

IA2 Unit 5: Energy, Exercise and Coordination	*Unit code WBI05	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	40% of the total IA2 raw marks	20% of the total IAL raw marks
Content summary: ■ ATP, glycolysis, anaerobic/aerobic respiration ■ control and functioning of heart; ventilation and cardiac output ■ homeostasis ■ the nervous system ■ impact of exercise on body, and improving performance ■ hormonal coordination ■ brain structure and development ■ imbalances in brain chemicals ■ Human Genome Project.		
Assessment: Written examination of 1 hour and 45 minutes, consisting of objective, structured and short-answer questions. Pre-released reading will be provided for this assessment.		

IA2 Unit 6: Practical Biology and Investigative Skills	*Unit code WBI06	
■ Externally assessed ■ Availability: January and June ■ First assessment: January 2014	20% of the total IA2 raw marks	10% of the total IAL raw marks
Content summary: Students are expected to develop a wide knowledge and understanding of experimental procedures and techniques throughout the whole of their International Advanced Level course. They are expected to become aware of how these techniques might be used to investigate interesting biological questions. This unit will assess students' knowledge and understanding of experimental procedures and techniques and their ability to plan whole investigations, analyse data and to evaluate their results and experimental methodology.		
Assessment: Written examination of 1 hour and 30 minutes, consisting of objective, structured and short-answer questions.		

* See *Appendix 2* for description of this code and all other codes relevant to this qualification.

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B Specification overview

Summary of assessment requirements

Unit number and unit title	Level	Assessment information	Number of raw marks allocated in the unit
Unit 1: Lifestyle, Transport, Genes and Health	IAS	Examination length: 1 hour 30 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions and will also cover: ■ *How Science Works* ■ practical-related questions.	80
Unit 2: Development, Plants and the Environment	IAS	Examination length: 1 hour 30 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions and will also cover: ■ *How Science Works* ■ practical-related questions.	80
Unit 3: Practical Biology and Research Skills	IAS	Examination length: 1 hour 30 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions The paper will contain two questions. The first question will be based on an area of one (or more) of the specified core practicals, but will generally be set in a novel situation. Students will be expected to apply familiar core practical techniques to answer this question successfully. The second question will be based on a partially complete visit/issue report that will be provided. Students will be required to comment on material already in the report and to suggest improvements or/and additions. Ten minutes reading time is built in. The examination paper will assess a student's ability to understand how to produce a report as described in the criteria on page 76 of the specification.	40

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B Specification overview

Unit number and unit title	Level	Assessment information	Number of raw marks allocated in the unit
Unit 4: The Natural Environment and Species Survival	IA2	Examination length: 1 hour 30 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions and will also cover: ■ *How Science Works* ■ practical-related questions.	90
Unit 5: Energy, Exercise and Coordination	IA2	Examination length: 1 hour 45 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions and will also cover: ■ *How Science Works* ■ practical-related questions. A third of the marks is related to specified pre-released reading.	90
Unit 6 : Practical Biology and Investigative Skills	IA2	Examination length: 1 hour 30 minutes. The examination paper will include: ■ objective questions ■ structured questions ■ short-answer questions Students may be required to apply their knowledge and understanding of biology from both the IAS and IA2 units in planning a complete investigation in some detail. The examination paper will contain three questions. The examination paper will contain three questions. The first question will test students' knowledge and understanding of the experimental principles and applications of the practical work they have undertaken in Units 1, 2, 4 and 5. The second question will test students' ability to tabulate and manipulate raw data and to recognise anomalous results and explain how they may be dealt with appropriately. They will be expected to be able to suggest suitable statistical tests and interpret their results.	50

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Unit number and unit title	Level	Assessment information	Number of raw marks allocated in the unit
		The third question will test students' ability to plan a safe scientific investigation, suggest ways in which the data collected might be analysed and evaluate the limitations of their planned methodology. The examiners will use the *How Science Works* criteria and the criteria for the individual investigation when compiling this paper.	

Assessment objectives and weightings

		% in IAS	% in IA2	% in IAL
AO1	Knowledge and understanding of science and of *How Science Works*	30–34%	26–30%	30–34%
AO2	Application of knowledge and understanding of science and of *How Science Works*	34–40%	42–48%	38–44%
AO3	*How Science Works*	28%	26%	27%
		100%	100%	100%

Relationship of assessment objectives to units

Unit number	Assessment objective			
	AO1	AO2	AO3	Total for AO1, AO2 and AO3
Unit 1	8–9%	8–9%	3%	19–21%
Unit 2	8–9%	8–9%	3%	19–21%
Unit 3	1%	1–2%	8%	10–11%
Unit 4	7–8%	10–11%	2%	14–21%
Unit 5	6–7%	10–12%	2%	18–21%
Unit 6	–	1%	9%	10%
Total for International Advanced Level	30–34%	38–44%	27%	100%

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Qualification summary

Aims

The aims of the International Advanced Level in Biology enable students to:

- develop their interest in, and enthusiasm for, biology including developing an interest in further study and careers in the subject
- appreciate how society makes decisions about biology-related issues and how biology contributes to the success of the economy and society
- develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works*
- develop essential knowledge and understanding of different areas of biology and how they relate to each other.

IAS/IA2 knowledge and understanding

The International Advanced Level qualifications in Biology require students to:

- recognise, recall and show understanding of scientific knowledge
- select, organise and communicate relevant information in a variety of forms
- analyse and evaluate scientific knowledge and processes
- apply scientific knowledge and processes to unfamiliar situations
- assess the validity, reliability and credibility of scientific information.

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IAS/IA2 practical biology and investigative skills

The International Advanced Level qualifications in Biology require students to:

- use theories, models and ideas to develop and modify scientific explanations
- use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas
- use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems
- carry out experimental and investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data to provide evidence, recognising correlations and causal relationships
- evaluate methodology, evidence and data, and resolve conflicting evidence
- appreciate the tentative nature of scientific knowledge
- communicate information and ideas in appropriate ways using appropriate terminology
- consider applications and implications of science and appreciate their associated benefits and risks
- consider ethical issues in the treatment of humans, other organisms and the environment
- appreciate the role of the scientific community in validating new knowledge and ensuring integrity
- appreciate the ways in which science is used to inform decision making about issues to benefit society.

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How Science Works

How Science Works is a newly introduced section that builds on from the Key Stage 4 Programme of Study for science. The table below gives guidance on how these statements will be assessed in terms of what we expect the student to know, understand or be able to do. This table is referred to in each of the units. *How Science Works* will be assessed in the context of the unit content. *How Science Works* is mapped to the content in *Appendix 4*.

***How Science Works* Statements**	**Learning Outcome**
1 Use theories, models and ideas to develop and modify scientific explanations	a) Explain how the development of scientific theories involves hypothesising, collecting and interpreting data, and using creative thinking. b) Explain the importance of modelling as way of developing scientific understanding.
2 Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas	a) Distinguish between questions that science can address, and those which science cannot address. b) Identify scientific questions or problems within a given context. c) Apply scientific theories to answer scientific questions or address scientific problems.
3 Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems	a) Justify methods, techniques and processes used during scientific investigations, including use of ICT, to collect valid and reliable data and produce scientific theories for a chosen question or problem.
4 Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts	Produce a risk assessment before carrying out a range of practical work.
5 Analyse and interpret data to provide evidence, recognising correlations and causal relationships	a) Analyse data including use of: ■ descriptive statistics (mean, mode and median, error bars, standard deviation identification of outliers and range) ■ graphic representation to identify patterns and relationships (e.g. correlation and cause) ■ appropriate statistical tests (IA2 only). b) Interpret data with reference to the methods of analysis used.
6 Evaluate methodology, evidence and data, and resolve conflicting evidence	Evaluate the validity of inferences made from data in terms of the methods, techniques and processes used to collect data and analyse the data, recognising any systematic, random errors present or conflicting evidence.
7 Appreciate the tentative nature of scientific knowledge	Explain how scientific theories are developed, refined, supported or refuted as new data or new interpretations of data become available.
8 Communicate information and ideas in appropriate ways using appropriate terminology	Present scientific information using text, graphics and other media as appropriate using scientific terminology with reference to data and credible sources.
9 Consider applications and implications of science and appreciate their associated benefits and risks	a) Evaluate activities in terms of their associated benefits and risks to humans, other organisms and the environment. b) Discuss the risk associated with an activity in terms of the actual level of the risk and its potential consequences, associated uncertainties, and the factors affecting people's perception of the risk.

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How Science Works Statements	Learning Outcome
10 Consider ethical issues in the treatment of humans, other organisms and the environment	a) Identify ethical issues arising from the application of science as it impacts on humans, other organisms and the environment. b) Discuss scientific solutions from a range of ethical viewpoints.
11 Appreciate the role of the scientific community in validating new knowledge and ensuring integrity	a) Discuss the importance of critical evaluation of new data or new interpretations of data which challenge established scientific theories or propose new theories. b) Describe how the process of communication through journals and conferences, and peer review contribute to validation of new scientific theories by the scientific community.
12 Appreciate the ways in which society uses science to inform decision making	Discuss how science influences decisions on an individual, local, national or international level.

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B Specification overview

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Unit 5 Energy, Exercise and Coordination 39

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Unit 2 Development, Plants and the Environment 53

Unit 4 The Natural Environment and Species Survival 59

Unit 5 Energy, Exercise and Coordination 65

Generic units (concept and context) 71

Unit 3 Practical Biology and Research Skills 73

Unit 6 Practical Biology and Investigative Skills 77

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Course structure

- The Pearson Edexcel International Advanced Level in Biology comprises six units and contains an International Advanced Subsidiary subset of three IAS units.
- The International Advanced Subsidiary is the first half of the International Advanced Level course and consists of Units 1, 2 and 3. It may be awarded as a discrete qualification or contribute 50 per cent of the total International Advanced Level marks.
- The full International Advanced Level award consists of the three IAS units (Units 1, 2 and 3), plus three IA2 units (Units 4, 5 and 6) which make up the other 50 per cent of the International Advanced Level. Students wishing to take the full International Advanced Level must, therefore, complete all six units.
- The structure of this qualification allows teachers to construct a course of study that can be taught and assessed either as:
  - distinct modules of teaching and learning with related units of assessment taken at appropriate stages during the course; or
  - a linear course which is assessed in its entirety at the end.

Introduction to the concept and context approaches

Each unit may be taught based on either a concept approach or a context approach:

1. Concept-led approach – starts on page 19.

This approach begins with a study of the theories and principles of biology and then explores their practical applications.

2. Context-led approach – starts on page 45.

This approach begins with the consideration of an application that draws on many different areas of biology. The theories and principles of biology that apply to this application are then studied. This approach is based on the Salters–Nuffield Advanced Biology (SNAB) project.

The two approaches are based on common biological content and assessment. The difference is in the presentation of the content of Units 1, 2, 4 and 5 to reflect these approaches.

Teachers may select the approach that best meets the needs of their students. Centres may use both approaches, for example, by allowing one group of students to follow one approach and another group of students to follow the other approach. These different approaches lead to the same assessment for each unit. A mix of approaches can be used, if desired.

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Introduction to the recommended core practicals

The recommended core practicals are identified in each unit: **they are emboldened**. It is expected that all students will have experience of these practicals. Practical-related questions will be asked in the written examination papers and will be based on the knowledge and understanding of the recommended core practicals.

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C Biology unit content

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Concept-led approach

The following sections show how the specification may be taught using the concept-led appoach.

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C Biology unit content

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Unit 1 Lifestyle, Transport, Genes and Health

IAS compulsory unit — Externally assessed

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.

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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).

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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).

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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).

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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.

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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).

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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.

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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).

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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C Biology unit content

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Unit 1 Lifestyle, Transport, Genes and Health

IAS compulsory unit — Externally assessed

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.

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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).

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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).

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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).

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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.

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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.

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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.

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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).

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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.**

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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.

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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).

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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.

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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).

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.**

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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.

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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**

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Generic units (concept and context)

The following section contains details of the external assessments for Units 3 and 6.
The same external assessments are used for both the concept-led and context-led approaches.

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C Biology unit content

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Unit 3 Practical Biology and Research Skills

IAS compulsory unit

Externally assessed

9.1 Unit description

Introduction

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out a range of practical experiments and investigations covered in Units 1 and 2.

This unit will assess students' knowledge and understanding of experimental procedures and techniques that were developed when they conducted these experiments.

Development of practical skills, knowledge and understanding

Students should do a variety of practical work during the IAS course to develop their practical skills. This should help them to gain an understanding and knowledge of the practical techniques that are used in experimental work.

Centres should provide opportunities for students to plan experiments, implement their plans, collect data, analyse their data and draw conclusions to prepare them for the assessment of this unit.

Experiments should cover a range of different topic areas and require the use of a variety of practical techniques.

How Science Works

Students should be given the opportunity to develop their practical skills for *How Science Works* statements 2–6, as detailed on page 12 of the specification, by completing a range of different experiments that require a variety of different practical techniques.

Students should produce laboratory reports on their experimental work using appropriate scientific, technical and mathematical language, conventions and symbols in order to meet the requirements of *How Science Works* number 8.

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9.2 Assessment information

This unit is assessed by means of a written examination paper of 1 hour 30 minutes' duration. Students may be required to apply their knowledge and understanding of biology to situations that they have not seen before.

The total number of marks available for this examination paper is 40. It contributes 10 per cent to the International Advanced Level in Biology.

Students must have a calculator for this paper.

The examination will consist of two questions.

The first question will be based on an area of one (or more) of the specified core practicals, but will generally be set in a novel situation. Students will be expected to apply familiar core practical techniques to answer this question successfully. The number of marks for this question will be 20.

The second questions will be based on a partially complete visit/issue report that will be provided. Students will be required to comment on material already in the report and to suggest improvements or/and additions. Ten minutes reading time is built in.

The overall aim is to assess a student's ability to understand how to produce such a report as described in the criteria on page 76 of the specification. The number of marks for this question will be 20.

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9.3 Practical biology skills

Students should further develop their practical skills, whichever approach (concept or context) has been taken. Students should carry out the recommended core practicals and other practical investigations, which will require them to work safely, produce valid results and present data in the most appropriate format.

Students should carry out practical work during the IAS course, which should be verified by the teacher using the criteria below.

Other practical-related skills, including analysis and evaluation of data may be assessed in the externally assessed components for Units 1 and 2.

The teacher should verify students' ability to:

a Use apparatus skilfully and safely

- i Apparatus and materials are handled correctly and safely and manipulative techniques are used in an appropriate and safe manner.
- ii The practical work is carried out in an organised, methodical and safe manner, with due consideration of the wellbeing of living organisms and the environment.

b Produce and record reliable and valid results

- i Measurements and observations are made with precision and recorded in a structured manner; variables are identified and the validity and reliability of results are justified.
- ii Possible systematic errors and random errors in generating results are identified and explained.

c Present and analyse data

- i Use appropriate methods to analyse results, present data and identify trends, patterns and/or observations.
- ii Any apparent anomalies and inconsistencies are described, the methodology is evaluated and suggestions are made to improve or further the work of the investigation.

Students are expected to know the conventions for the collection and presentation of data set out in the document issued by the Institute of Biology to understand how to produce a visit/issue report:

Biological Nomenclature – Standard Terms and Expressions Used in the Teaching of Biology, 3rd Edition (Institute of Biology, 2000) ISBN 0900490365, or visit: www.iob.org.

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9.4 Assessment Criteria

Assessment Criteria	Level of response
1 Describe the biological methods and processes used in a chosen area of biology in the context of a problem or question based on a visit made or issue researched (HSW 1, 2, 6)	Identify and describe a question or problem in an area of biology relevant to a visit or issue researched.
	Describe the biological methods and processes involved in producing data or solutions to problems or questions relevant to a visit or issue researched.
	Explain how the methods and processes used in the chosen area of biology are appropriate in terms of producing both valid and reliable data or effective solutions to address the problem or question identified using graphs, photos, diagrams and tables that are appropriate, relevant and integrated with the report.
2 Identify applications and implications of the biology encountered within the context based on a visit or issue researched (HSW 9, 10)	Identify two implications (ethical, social, economic or environmental) of the applied biology encountered within the context of a visit or issue researched.
	Evaluate benefits and risks to humans, other organisms and the environment as appropriate of the implications of the applied biology being studied identified.
	Discuss alternative views or solutions for implications of the biology encountered within the context of a visit or issue.
3 Use information or arguments obtained from three or more sources (including at least one web-based and one not web-based) when researching a visit or issue (HSW 8, 11)	Use information or arguments obtained from three or more sources (including at least one web-based and one not web-based) when researching a visit or issue. Clearly identify any quotes from sources.
	Provide information about the source, author and date of three or more references used in the visit or issue report. Link references to the appropriate text in the visit or issue report.
	Evaluate at least two references used in the report.
4 Communicate clearly, concisely and logically with appropriate use of visuals (HSW 8)	Spelling, punctuation and grammar are correct, and the presentation is logical and concise. There is good use of technical language. Visuals are present, but not necessarily referred to in the text.

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Unit 6 Practical Biology and Investigative Skills

IA2 compulsory unit

Externally assessed

10.1 Unit description

Introduction

Students are expected to develop wide knowledge and understanding of experimental procedures and techniques throughout the whole of their International Advanced Level course. They are expected to become aware of how these techniques might be used to investigate interesting biological questions.

This unit will assess students' knowledge and understanding of experimental procedures and techniques and their ability to plan whole investigations, analyse data and to evaluate their results and experimental methodology.

Development of practical skills, knowledge and understanding

Students should undertake a variety of practical work and investigations during the IAS and IA2 course to develop their practical skills and extend their knowledge of useful procedures and techniques.

To prepare students effectively for this paper it is essential that centres provide opportunities for students to plan investigations, implement their plans, collect data, analyse their data, draw conclusions and evaluate their findings. It will be helpful to students for centres to approach the practical procedures and techniques named in the specification in the context of simple investigations rather than as isolated skills.

How Science Works

How Science Works is a major underlying theme for the whole International Advanced Level examination. This assessment is designed to test statements 2–6 of this theme. Full details are given on page 12 of the specification.

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10.2 Assessment information

This unit is assessed by means of a written examination paper of 1 hour 30 minutes' duration. Students may be required to apply their knowledge and understanding of biology from both the IAS and IA2 units in planning a complete investigation in some detail.

The total number of marks available for this examination paper is 50. It contributes 10 per cent to the International Advanced Level in Biology.

Students must have a calculator for this paper.

The examination will consist of three questions.

The first question will test students' knowledge and understanding of the experimental principles and applications of the practical work they have undertaken in Units 1, 2, 4 and 5.

The second question will test students' ability to tabulate and manipulate raw data and to recognise anomalous results and explain how they may be dealt with appropriately. They will be expected to suggest suitable statistical tests and interpret their results.

The third question will test students' ability to plan a safe scientific investigation, suggest ways in which the data collected might be analysed and evaluate the limitations of their planned methodology.

The examiners will use the *How Science Works* criteria and the criteria for the individual investigation when compiling this paper.

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10.3 Practical biology and investigative skills

Teachers should make the practical and investigative skills criteria available to students to enable them to understand what is expected of them.

Students should further develop their practical skills, whichever approach (concept or context) has been taken. Students should carry out the recommended core practicals in Units 4 and 5.

Students should carry out practical work during the IA2 course, which should be verified by the teacher using the criteria below.

Other practical-related skills, including analysis and evaluation of data may be assessed in the externally assessed components for Units 4 and 5.

The teacher should verify students' ability to:

a Use apparatus skilfully and safely

- i Apparatus and materials are handled correctly and safely and manipulative techniques are used in an appropriate and safe manner.
- ii The practical work is carried out in an organised, methodical and safe manner, with due consideration of the wellbeing of living organisms and the environment.

b Produce and record reliable and valid results

- i Measurements and observations are made with precision and recorded in a structured manner; variables are identified and the validity and reliability of results are justified.
- ii Possible systematic errors and random errors in generating results are identified and explained.

c Present and analyse data

- i Use appropriate methods to analyse results, present data and identify trends, patterns and/or observations.
- ii Any apparent anomalies and inconsistencies are described, the methodology is evaluated and suggestions are made to improve or further the work of the investigation.

Students are expected to know the conventions for the collection and presentation of data set out in the document issued by the Institute of Biology:

Biological Nomenclature – Standard Terms and Expressions Used in the Teaching of Biology, 3rd Edition (Institute of Biology, 2000) ISBN 0900490365, or visit: www.iob.org.

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D Assessment and additional information

Assessment information

Assessment requirements

For a summary of assessment requirements and assessment objectives, see *Section B: Specification overview*.

Entering candidates for the examinations for this qualification

Details of how to enter candidates for the examinations for this qualification can be found in the International Information Manual, copies of which are sent to all examinations officers. The information can also be found at: www.edexcel.com/international

Resitting of units

There is one resit opportunity allowed for each unit prior to claiming certification for the qualification. The best available result for each contributing unit will count towards the final grade.

After certification all unit results may be reused to count towards a new award. Students may re-enter for certification only if they have retaken at least one unit.

Results of units are held in the Pearson unit bank and have a shelf life limited only by the shelf life of this specification.

Awarding and reporting

The IAS qualification will be graded and certificated on a five-grade scale from A to E. The full International Advanced Level will be graded on a six-point scale A* to E. Individual unit results will be reported.

A pass in an International Advanced Subsidiary subject is indicated by one of the five grades A, B, C, D, E of which grade A is the highest and grade E the lowest. A pass in an International Advanced Subsidiary Level subject is indicated by one of the six grades A*, A, B, C, D, E of which grade A* is the highest and grade E the lowest. To be awarded an A* students will need to achieve an A on the full International Advanced Level qualification and an A* aggregate of the IA2 units. Students whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

Performance descriptions

Performance descriptions give the minimum acceptable level for a grade. See *Appendix 1* for the performance descriptions for this subject.

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Unit results

The minimum uniform marks required for each grade for each unit:

Unit 1

Unit grade	A	B	C	D	E
Maximum uniform mark = 120	**96**	**84**	**72**	**60**	**48**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–47.

Unit 2

Unit grade	A	B	C	D	E
Maximum uniform mark = 120	**96**	**84**	**72**	**60**	**48**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–47.

Unit 3

Unit grade	A	B	C	D	E
Maximum uniform mark = 60	**48**	**42**	**36**	**30**	**24**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–23.

Unit 4

Unit grade	A	B	C	D	E
Maximum uniform mark = 120	**96**	**84**	**72**	**60**	**48**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–47.

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Unit 5

Unit grade	A	B	C	D	E
Maximum uniform mark = 120	**96**	**84**	**72**	**60**	**48**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–47.

Unit 6

Unit grade	A	B	C	D	E
Maximum uniform mark = 60	**48**	**42**	**36**	**30**	**24**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–23.

Qualification results

The minimum uniform marks required for each grade:

International Advanced Subsidiary cash-in code XBI01

Qualification grade	A	B	C	D	E
Maximum uniform mark = 300	**240**	**210**	**180**	**150**	**120**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–119.

International Advanced Level cash-in code YBI01

Qualification grade	A	B	C	D	E
Maximum uniform mark = 600	**480**	**420**	**360**	**300**	**240**

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–239.

To be awarded an A* students will need to achieve an A on the full International Advanced Level qualification and an A* aggregate of the IA2 units.

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D Assessment and additional information

Language of assessment

Assessment of this specification will be available in English only. Assessment materials will be published in English only and all work submitted for examination must be produced in English.

Quality of written communication

Students will be assessed on their ability to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate.

Synoptic Assessment

In synoptic assessment there should be a concentration on the quality of assessment to ensure that it encourages the development of the holistic understanding of the subject.

Synopticity requires students to connect knowledge, understanding and skills acquired in different parts of the International Advanced Level course.

Synoptic assessment in the external Units 4 and 5 may draw on IAS material.

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Additional information

Malpractice

For up-to-date information on malpractice, please refer to the latest Joint Council for Qualifications (JCQ) Suspected Malpractice in Examinations and Assessments: Policies and Procedures document, available on the JCQ website: www.jcq.org.uk

Access arrangements and special requirements

Pearson's policy on access arrangements and special considerations for GCE, GCSE, IAL and Entry Level is designed to ensure equal access to qualifications for all students (in compliance with the Equality Act 2010) without compromising the assessment of skills, knowledge, understanding or competence.

Please see the JCQ website (www.jcq.org.uk) for their policy on access arrangements, reasonable adjustments and special considerations.

Please see our website (www.edexcel.com) for:

- the forms to submit for requests for access arrangements and special considerations
- dates for submissions of the forms.

Equality Act 2010

Please see our website (www.edexcel.com) for information on the Equality Act 2010.

Prior learning and progression

Prior learning

There are no prior learning or other requirements for this qualification.

Progression

This qualification supports progression into further education, training or employment.

Combinations of entry

Only units achieved from this qualification may contribute to the certification of the International Advanced Subsidiary in Biology or the International Advanced Level in Biology.

Student recruitment

Pearson's access policy concerning recruitment to our qualifications is that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

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D Assessment and additional information

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E Support, training and resources

Support

Pearson aim to provide the most comprehensive support for our qualifications. Here are just a few of the support services we offer:

- Subject Advisor – subject experts are on-hand to offer their expertise to answer any questions you may have on delivering the qualification and assessment.
- Subject Page – written by our Subject Advisors, the subject pages keep you up to date with the latest information on your subject.
- Subject Communities – exchange views and share information about your subject with other teachers.
- Training – see 'Training' below for full details.

For full details of all the teacher and student support provided by Pearson to help you deliver our qualifications, please visit:
www.edexcel.com/ial/biology/support

Training

Our programme of professional development and training courses, covering various aspects of the specification and examinations, are arranged each year on a regional basis. Pearson training is designed to fit you, with an option of face-to-face, online or customised training so you can choose where, when and how you want to be trained.

Face-to-face training
Our programmes of face-to-face training have been designed to help anyone who is interested in, or currently teaching, a Pearson Edexcel qualification. We run a schedule of events throughout the academic year to support you and help you to deliver our qualifications.

Online training
Online training is available for international centres who are interested in, or currently delivering our qualifications. This delivery method helps us run training courses more frequently to a wider audience.

To find out more information or to book a place please visit:
www.edexcel.com/training

Alternatively, email internationaltfp@pearson.com
or telephone +44 (0) 44 844 576 0025

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E Support, training and resources

Resources

Pearson is committed to ensuring that teachers and students have a choice of resources to support their teaching and study.

Teachers and students can continue to use their existing GCE A level resources for International Advanced Levels.

To search for Pearson GCE resources, please visit: www.pearsonschools.co.uk

To search for endorsed resources from other publishers, please visit: www.edexcel.com/resources

Specifications, Sample Assessment Materials and Teacher Support Materials

Specifications, Sample Assessment Materials (SAMs) and Teacher Support Materials (TSMs) can be downloaded from the International Advanced Level subject pages.

To find a complete list of supporting documents, including the specification, SAMs and TSMs, please visit: www.edexcel.com/ial/biology

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F Appendices

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Appendix 1 Performance descriptions

Introduction

Performance descriptions describe the outcomes of learning and levels of attainment likely to be demonstrated by a representative candidate performing at the A/B and E/U boundaries for IAS and IA2.

In practice most candidates will show uneven profiles across the attainments listed, with strengths in some areas compensating in the award process for weaknesses or omissions elsewhere. Performance descriptions illustrate expectations at the A/B and E/U boundaries of the IAS and IA2 as a whole; they have not been written at unit level.

Grade A/B and E/U boundaries should be set using professional judgement. The judgement should reflect the quality of candidates' work, informed by the available technical and statistical evidence. Performance descriptions are designed to assist examiners in exercising their professional judgement. They should be interpreted and applied in the context of individual specifications and their associated units. However, performance descriptions are not designed to define the content of specifications and units.

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IAS performance descriptors for Biology

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Assessment objectives	**Knowledge and understanding of science and of *How Science Works*** Candidates should be able to: ■ recognise, recall and show understanding of scientific knowledge ■ select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of *How Science Works*** Candidates should be able to: ■ analyse and evaluate scientific knowledge and processes ■ apply scientific knowledge and processes to unfamiliar situations including those related to issues ■ assess the validity, reliability and credibility of scientific information.	***How Science Works*** Candidates should be able to: ■ demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods ■ make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy ■ analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of most principles, concepts and facts from the IAS specification b) select relevant information from the IAS specification c) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument b) describe significant trends and patterns shown by data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly c) comment critically on statements, conclusions or data d) carry out accurately most of the calculations specified for IAS e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues c) make observations and measurements with appropriate precision and record them methodically d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.

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	Assessment objective 1	Assessment objective 2	Assessment objective 3
E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles and facts from the IAS specification b) select some relevant information from the IAS specification c) present information using basic terminology from the IAS specification.	Candidates characteristically: a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument b) describe some trends or patterns shown by data presented in tabular or graphical form c) identify, when directed, inconsistencies in conclusions or data d) carry out some steps within calculations e) translate data successfully from one form to another, in some contexts.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques and comment on ethical issues c) make observations and measurements and record them d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

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Appendix 1 Performance descriptions

IA2 performance descriptors for Biology

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Assessment objectives	**Knowledge and understanding of science and of *How Science Works*** Candidates should be able to: ■ recognise, recall and show understanding of scientific knowledge ■ select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of *How Science Works*** Candidates should be able to: ■ analyse and evaluate scientific knowledge and processes ■ apply scientific knowledge and processes to unfamiliar situations including those related to issues ■ assess the validity, reliability and credibility of scientific information.	***How Science Works*** Candidates should be able to: ■ demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods ■ make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy ■ analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate detailed knowledge and understanding of most principles, concepts and facts from the IA2 specification b) select relevant information from the IA2 specification c) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving several steps in the argument b) describe significant trends and patterns shown by complex data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly c) evaluate critically any statements, conclusions or data d) carry out accurately most of the calculations specified for IA2; and apply the principles of statistical analysis when directed e) translate successfully data that is presented as prose, diagrams, drawings, tables or graphs from one form to another f) select a wide range of facts, principles and concepts from both IAS and IA2 specifications g) link together appropriate facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques and comment effectively on ethical issues c) make observations and measurements with appropriate precision and record these methodically d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts e) use an appropriate statistical technique to assess the validity of a hypothesis.

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	Assessment objective 1	Assessment objective 2	Assessment objective 3
E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles, concepts and facts from the IA2 specification b) select some relevant information from the IA2 specification c) present information using basic terminology from the IA2 specification.	Candidates characteristically: a) apply given principles or concepts in familiar and new contexts involving a few steps in the argument b) describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form c) identify, when directed, inconsistencies in conclusions or data d) carry out some steps within calculations e) translate data successfully from one form to another, in some contexts f) select some facts, principles and concepts from both IAS and IA2 specifications g) put together some facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques and comment on ethical issues c) make observations and measurements and record them d) interpret, explain and communicate some of the results of their own and others' experimental and investigative activities, in appropriate contexts e) use a given statistical technique.

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Appendix 1 Performance descriptions

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Appendix 2 Codes

Type of code	Use of code	Code number
Unit codes	Each unit is assigned a unit code. This unit code is used as an entry code to indicate that a student wishes to take the assessment for that unit. Centres will need to use the entry codes only when entering students for their examination.	Unit 1 – WBI01 Unit 2 – WBI02 Unit 3 – WBI03 Unit 4 – WBI04 Unit 5 – WBI05 Unit 6 – WBI06
Cash-in codes	The cash-in code is used as an entry code to aggregate the student's unit scores to obtain the overall grade for the qualification. Centres will need to use the entry codes only when entering students for their qualification.	IAS – XBI01 IAL – YBI01
Entry codes	The entry codes are used to: 1 enter a student for the assessment of a unit 2 aggregate the student's unit scores to obtain the overall grade for the qualification.	Please refer to the *Pearson Information Manual,* available on our website (www.edexcel.com).

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Appendix 2 Codes

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Appendix 3 Glossary of terms used

Advantages, disadvantages
Here there will be two (or more) sets of data, structures, functions, processes or events to be referred to and the answer must relate to both. One process, or whatever, is required to be compared with another. It is important that the answers are comparative and that the feature being referred to is clearly stated.

Analyse and interpret
Identify, with reasons, the essential features of the information or data given. This may involve some manipulation of the data.

Appreciate
Show an awareness of the significance of, but without detailed knowledge of, the underlying principles.

Compare, contrast, distinguish between, differs from
As with advantages and disadvantages, here there will be two (or more) sets of data, structures, functions, processes or events to be referred to and the answer must relate to both. It is important to select equivalent points and keep them together.

Compare generally indicates that similarities as well as differences are expected; contrast, distinguish between or differs from indicate that the focus should be on the differences.

Demonstrate
Show the effects, probably through practical experiment.

Describe
This may be related to a biological event or process, or to data presented in a table, graph or other form. The description must be concise and straightforward, using relevant biological terms rather than vague generalisations. The trend should be presented in words or translated into another form. If interpreting numerical data, it is often appropriate to refer to the figures, and these should be 'manipulated' in some way, for instance the trend could be quantified or the percentage difference over a period of time calculated.

Discuss
Give a considered account of a particular topic about which a degree of uncertainty exists.

Distinguish
Identify appropriate differences in a given context.

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Appendix 3 Glossary of terms used

Explain, give explanations, give reasons
The answer would be expected to draw on biological knowledge to give reasons or explanations for the information or data given. Usually 2- or 3-mark answers are required and the answer should go beyond just repetition or reorganisation of the information or data presented. It is reasonable to expect that if a student is explaining something they are also able to describe it.

Make a link
Point out the connection between separate points.

Name, state, give
Indicate that short, factual answers are needed, possibly with precise use of biological terms or the name of a structure. Often one-word answers are sufficient.

Recall
Present knowledge gained at Key Stage 4 through the study of the National Curriculum science programme and through the study of units in this specification.

Review
Make a general survey of an extensive topic.

Suggest/suggestion
Implies that the answer may include material or ideas that have not been learnt directly from the specification. A reasonable suggestion, using biological knowledge and understanding of related topics, is required.

Summarise
Give a concise account of the main points.

Understand
Describe and explain the underlying principles and apply the knowledge to novel situations.

Using the information in the diagram/on the graph/in the table/features visible in the diagram
Refer only to the information presented in the question and not other examples or features, which may be perfectly correct but are not shown and are, therefore, not what the examiners require.

In answers requiring the use of more than one word technical terms should be given in a correct biological context.

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Appendix 4 How Science Works mapping

The first section of the content of all topics map to the *How Science Works* statements, i.e. Unit 1, Topic 1, statement 1 (represented as 1.1.1); 1.2.1; 2.3.1; 2.4.1; 4.5.1; 4.6.1; 5.6.1 and 5.7.1. In addition, the *How Science Works* statements map to the following content:

***How Science Works* statement**	**Unit**	**Topic**	**Content**
1 Use theories, models and ideas to develop and modify scientific explanations.	1	2	2
	4	5	19
	4	6	16
	5	8	12
2 Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas.	1	1	9
	1	1	16
	1	2	5
	1	2	9
	2	3	7
	2	3	12
	2	4	7
	2	4	8
	2	4	9
	4	5	11
	4	5	17
	4	6	6
	4	6	7
	4	6	18
	5	7	6
	5	7	14
	5	8	15

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Appendix 4 How Science Works mapping

How Science Works statement	Unit	Topic	Content
3 Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems.	1	1	9
	1	1	16
	1	2	5
	1	2	9
	2	3	7
	2	3	12
	2	4	7
	2	4	8
	2	4	9
	4	5	11
	4	5	17
	4	6	6
	4	6	7
	4	6	18
	5	7	6
	5	7	14
	5	8	15
4 Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.	1	1	9
	1	1	16
	1	2	5
	1	2	9
	2	3	7
	2	3	12
	2	4	7
	2	4	8
	2	4	9
	4	5	11
	4	5	17
	4	6	6
	4	6	7
	4	6	18
	5	7	6
	5	7	14
	5	8	15

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How Science Works statement	Unit	Topic	Content
5 Analyse and interpret data to provide evidence, recognising correlations and causal relationships.	1	1	9
	1	1	14
	1	1	16
	1	1	17
	1	1	18
	1	2	5
	1	2	9
	2	3	7
	2	3	12
	2	4	7
	2	4	8
	2	4	9
	4	5	11
	4	5	17
	4	5	18
	4	6	6
	4	6	7
	4	6	18
	5	7	6
	5	7	14
	5	7	18
	5	8	15
6 Evaluate methodology, evidence and data, and resolve conflicting evidence.	1	1	19
	2	3	12
	5	7	6
	5	8	13
	5	8	15
7 Appreciate the tentative nature of scientific knowledge.	1	2	11
	2	3	14
	4	5	19
	5	8	11

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Appendix 4 How Science Works mapping

How Science Works statement	Unit	Topic	Content
8 Communicate information and ideas in appropriate ways using appropriate terminology.	1	1	9
	1	1	16
	1	2	5
	1	2	9
	2	3	7
	2	3	12
	2	4	7
	2	4	8
	2	4	9
	4	5	11
	4	5	17
	4	6	6
	4	6	7
	4	6	18
	5	7	6
	5	7	14
	5	8	15
9 Consider applications and implications of science and appreciate their associated benefits and risks.	1	1	13
	1	1	20
	1	2	19
	4	5	9
	5	8	21
10 Consider ethical issues in the treatment of humans, other organisms and the environment.	1	1	9
	1	2	20
	5	7	20
	5	8	15
	5	8	16
11 Appreciate the role of the scientific community in validating new knowledge and ensuring integrity.	1	2	11
	2	4	14
	4	5	23
12 Appreciate the ways in which society uses science to inform decision making.	1	1	15
	2	3	11
	4	5	20
	4	6	19

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Content mapped to *How Science Works*

IAS unit	Topic	Content	*How Science Works* statement(s)
1	1	1	4; 5
		9	2; 3; 4; 5; 8; 10
		13	9
		14	5
		15	12
		16	2; 3; 4; 5; 8
		17	5
		18	5
		19	6
		20	9
	2	1	4; 5
		2	1
		5	2; 3; 4; 5; 8
		9	2; 3; 4; 5; 8
		11	7; 11
		20	10
2	3	1	4; 5
		7	2; 3; 4; 5; 8
		11	12
		12	2; 3; 4; 5; 6; 8
		14	7
	4	1	4; 5
		7	2; 3; 4; 5; 8
		8	2; 3; 4; 5; 8
		9	2; 3; 4; 5; 8
		14	11

IA2 unit	Topic	Content	*How Science Works* statement(s)
4	5	1	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12
		9	9
		11	2; 3; 4; 5; 8
		17	2; 3; 4; 5; 8
		18	5
		19	1; 7
		20	12
		23	11
	6	1	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12
		6	2; 3; 4; 5; 8
		7	2; 3; 4; 5; 8
		16	1
		18	2; 3; 4; 5; 8
		19	12
5	7	1	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12
		6	2; 3; 4; 5; 6; 8
		14	2; 3; 4; 5; 8
		18	5
		20	10
	8	1	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12
		11	7
		12	1
		13	6
		15	2; 3; 4; 5; 6; 8; 10
		16	10
		21	9

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Appendix 4 How Science Works mapping

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Appendix 5 Mathematical requirements

An understanding of the following, as applied to the analysis of biological data, is expected and may be assessed in relevant units of the specification. These requirements should not be taught separately from their applications within biology; an integrated approach is expected.

1. Arithmetic and numerical computation	Recognise and use expressions in decimal and standard form.
	Use ratios, fractions and percentages.
	Make estimates of the results of calculations (without using a calculator).
	Use calculators to find and use power, exponential and logarithmic functions.
2. Handling data	Use an appropriate number of significant figures.
	Find arithmetic means.
	Construct and interpret frequency tables and diagrams, bar charts and histograms.
	Understand simple probability.
	Understand the principles of sampling as applied to scientific data.
	Understand the terms mean, median and mode.
	Use a scatter diagram to identify a correlation between two variables.
	Use a simple statistical test.
3. Algebra	Change the subject of an equation.
	Substitute numerical values into algebraic equations using appropriate units for physical quantities
4. Graphs	Translate information between graphical, numerical and algebraic forms.
	Plot two variables from experimental or other data.
	Calculate rate of change from a graph showing a linear relationship.

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