edexcel

INTERNATIONAL ADVANCED LEVEL

BIOLOGY

SPECIFICATION

Pearson Edexcel International Advanced Subsidiary in Biology (XBI11)
Pearson Edexcel International Advanced Level in Biology (YBI11)
First teaching September 2018
First examination from January 2019
First certification from August 2019 (International Advanced Subsidiary) and August 2020 (International Advanced Level)

Pearson

Edexcel, BTEC and LCCI qualifications

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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.

References to third party material made in this specification are made in good faith. Pearson does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

All information in this specification is correct at time of going to publication.

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Contents

About this specification

The Pearson Edexcel International Advanced Subsidiary in Biology and the Pearson Edexcel International Advanced Level in Biology are part of a suite of International Advanced Level qualifications offered by Pearson.

These qualifications are not accredited or regulated by any UK regulatory body.

Key features

This specification includes the following key features.

Structure

The Pearson Edexcel International Advanced Subsidiary in Biology and the Pearson Edexcel International Advanced Level in Biology are modular qualifications. The Advanced Subsidiary can be claimed on completion of the International Advanced Subsidiary (IAS) units.

The International Advanced Level can be claimed on completion of all the units (IAS and IA2 units).

Content

The content is relevant for students who have achieved a GCSE in Biology and who want to study this subject at a higher level. The content has been updated from the previous Pearson Edexcel International Advanced Subsidiary in Biology and Pearson Edexcel International Advanced Level in Biology qualifications. It covers the major topics in biology, including biological molecules, diet, transport, health, cells, development, biodiversity, conservation, energy, the environment, microbiology, immunity, respiration, the internal environment, coordination and gene technology.

Assessment

Assessment consists of three written papers at IAS level that are externally assessed. The International A level consists of three further written papers that are externally assessed.

Approach

Students will develop their knowledge and understanding of biology by applying the concepts in this specification to a range of different problems, set in a variety of contexts. Students will need to apply mathematical skills to the problems.

Students will also develop their practical skills. This specification includes 18 core practical activities, which is the minimum number of practical activities that students will carry out. Centres are encouraged to include additional practical activities to develop students' practical skills further.

Specification updates

This specification is Issue 1 and is valid for first teaching from September 2018. If there are any significant changes to the specification, we will inform centres in writing. Changes will also be posted on our website.

For more information please visit qualifications.pearson.com

Using this specification

This specification gives teachers guidance and encourages effective delivery of these qualifications. The following information will help you get the most out of the content and guidance.

Compulsory content: as a minimum, all the topics in the content must be taught. The word 'including' in content specifies the detail of what must be covered.

Assessments: use a range of material and are not limited to the examples given. Teachers should deliver these qualifications using a good range of examples to support the assessment of the content.

Depth and breadth of content: teachers should use the full range of content and all the assessment objectives given in the subject content section.

Qualification aims and objectives

The aims and objectives of these qualifications are to enable students to develop:

- essential knowledge and understanding of different areas of the subject and how they relate to each other
- a deep appreciation of the skills, knowledge and understanding of scientific methods
- competence and confidence in a variety of practical, mathematical and problem-solving skills
- their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject.

Qualification abbreviations used in this specification

The following abbreviations appear in this specification:

International Advanced Subsidiary – IAS

International A2 – IA2 (the additional content required for an IAL)

International Advanced Level – IAL.

Why choose Edexcel qualifications?

Pearson – the world's largest education company

All Edexcel academic qualifications, including our new International AS and A Level suite, are produced by Pearson, the UK's largest awarding organisation. With over 3.4 million students studying our academic and vocational qualifications worldwide, we offer internationally recognised qualifications to schools, colleges and employers globally.

Pearson is recognised as the world's largest education company, allowing us to drive innovation and provide comprehensive support for Edexcel students to acquire the knowledge and skills they need for progression in study, work and life.

A heritage you can trust

The background to Pearson becoming the UK's largest awarding organisation began in 1836, when a royal charter gave the University of London its first powers to conduct exams and confer degrees on its students. Edexcel qualifications build on experience of over 150 years in international education, and have a firm academic foundation, built on the traditions and rigour associated with Britain's educational system.

To find out more about our Edexcel heritage please visit our website: qualifications.pearson.com/en/about-us/about-pearson/our-history

Results you can trust

Pearson's leading online marking technology has been shown to produce exceptionally reliable results, demonstrating that at every stage, Edexcel qualifications maintain the highest standards.

Developed to Pearson's world-class qualifications standards

Pearson's world-class standards mean that all Edexcel qualifications are developed to be rigorous, demanding, inclusive and empowering. We work collaboratively with a panel of educational thought-leaders and assessment experts to ensure that Edexcel qualifications are globally relevant, represent world-class best practice and maintain a consistent standard.

For more information on the world-class qualification process and principles please go to *Appendix 2: Pearson World Class Qualification design principles* or visit our website: uk.pearson.com/world-class-qualifications

Why choose Pearson Edexcel International Advanced Subsidiary/Advanced Level qualifications in Biology?

We have listened to feedback from all parts of the international school education community, including a large number of teachers. Our International Advanced Subsidiary and Advanced Levels have been developed to be engaging for international learners; and to give them the necessary skills to support progression to further study in biology, as well as to a wide range of other subjects.

Key qualification features – using feedback from teachers, we have retained several key features which we know you value. These include:

- modular assessment, offered at different times of year to suit your delivery model
- practical skills assessed through a dedicated examination unit both at AS (Unit 3) and at A Level (Unit 6)
- comparable content with the UK GCE AS and A Level – giving confidence to students, teachers and universities on comparability of the specifications
- a range of question types in exams – testing breadth of knowledge, as well as allowing depth of understanding to be examined.

Clear and straightforward question papers – our question papers are clear and accessible for students of all ability ranges, and use a series of well-defined command words. Our mark schemes are straightforward so that the assessment requirements are clear.

Broad and deep development of learners' skills – we designed the International Advanced Subsidiary and International Advanced Level qualifications to extend learners' knowledge by broadening and deepening skills. For example learners will:

- develop and use a range of mathematical skills that support their knowledge and understanding of biology
- gain experience in a variety of practical techniques and procedures, which will be assessed separately in Units 3 and 6
- widen their learning through a number of key transferable skills, which may be cognitive, intrapersonal or interpersonal (see *Appendix 3: Transferable skills*).

Progression – these qualifications enable successful progression to further education courses in biological sciences. Through our world-class qualification development process we have consulted with a number of universities in the UK, as well as internationally, to validate the appropriateness of these qualifications, including content, skills and assessment structure.

Our International Advanced Subsidiary and Advanced Levels in Biology sit within our wider subject offer for sciences. We also offer International Advanced Subsidiary and Advanced Levels in Chemistry, Physics and Psychology, and in Mathematics and Further Mathematics.

More information can be found on our website (qualifications.pearson.com) on the Edexcel International Advanced Level pages.

Supporting you in planning and implementing these qualifications

Planning

- Our *Getting Started Guide* gives you an overview of the Pearson Edexcel International Advanced Subsidiary and Advanced Levels in Biology to help you understand the changes to content and assessment, and what these changes mean for you and your students.
- We will provide you with an editable course planner and scheme of work to save you time in planning and help you to put together teaching strategies for delivering the specification content.
- Our mapping documents highlight key differences between the new and legacy qualifications to help you understand the changes made to the new specifications.

Teaching and learning

- Course planners and schemes of work – to help you to put together teaching strategies for delivering the specification content.
- Practical Skills Guides and Mathematical Skills Guides – to help you ensure that students are developing these skills, both of which form a key part of the assessment of the new International Advanced Subsidiary and Advanced Levels.
- Getting Ready to Teach and other training events – available locally and online.
- Printed textbooks and digital teaching resources – promote 'any time, any place' learning to improve student motivation and encourage new ways of working.

Preparing for exams

We will also provide a range of resources to help you prepare your students for the assessments, including:

- specimen papers to support formative assessments and mock exams
- examiner commentaries on questions following each examination series.

ResultsPlus

ResultsPlus provides the most detailed analysis available of your students' examination performance. It can help you identify the topics and skills where further learning would benefit your students.

examWizard

A free online resource, containing a bank of past paper questions, designed to support students and teachers with examination preparation and assessment.

Training events

In addition to online training, we host a series of training events each year for teachers to deepen their understanding of our qualifications.

Get help and support

Our Subject Advisor service will ensure that you receive help and guidance from us. You can sign up to receive our science newsletter, containing qualification updates and product and service news. You can contact our Science Advisor team through the science pages of the Pearson Qualifications homepage (qualifications.pearson.com), or by emailing TeachingScience@pearson.com

Qualification at a glance

Qualification overview

Pearson Edexcel International Advanced Subsidiary in Biology

This qualification consists of three externally-examined units.

The International Advanced Subsidiary (IAS) is the first half of the International Advanced Level qualification and consists of three IAS units, Units 1, 2 and 3. This qualification can be awarded as a discrete qualification or can contribute 50% towards the International Advanced Level qualification.

The qualification will include questions that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). Overall, a minimum of 10% of the marks across the papers will be awarded for mathematics at Level 2 or above.

Pearson Edexcel International Advanced Level in Biology

This qualification consists of six externally-examined units.

The International Advanced Level consists of the three IAS units (Units 1, 2 and 3) plus three IA2 units (Units 4, 5 and 6). Students wishing to take the International Advanced Level must, therefore, complete all six units.

The qualification will include questions that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). Overall, a minimum of 10% of the marks across the papers will be awarded for mathematics at Level 2 or above.

Course of study

The structure of these qualifications allows teachers to construct a course of study that can be taught and assessed as either:

- distinct modules of teaching and learning with related units of assessment taken at appropriate stages during the course; or
- a linear course assessed in its entirety at the end.

Content and assessment overview

IAS **Unit 1: Molecules, Diet, Transport and Health**	***Unit code: WBI11/01**	
Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: January 2019 80 marks	40% of the total IAS	20% of the total IAL
Content overview • Molecules, Transport and Health • Membranes, Proteins, DNA and Gene Expression		
Assessment overview • The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions. • The paper will include a minimum of 8 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.		

IAS **Unit 2: Cells, Development, Biodiversity and Conservation**	***Unit code: WBI12/01**	
Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: June 2019 80 marks	40% of the total IAS	20% of the total IAL
Content overview • Cell Structure, Reproduction and Development • Plant Structure and Function, Biodiversity and Conservation		
Assessment overview • The paper may include multiple-choice, short open, open-response, calculations and extended-writing questions. • The paper will include a minimum of 8 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.		

IAS **Unit 3: Practical Skills in Biology I**	***Unit code: WBI13/01**	
Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2019 50 marks	20% of the total IAS	10% of the total IAL
Content overview 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 in Units 1 and 2.		
Assessment overview • The paper may include short-open, open-response and calculation questions. • The paper will include a minimum of 5 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding of practical skills to familiar and unfamiliar situations.		

IA2 **Unit 4: Energy, Environment, Microbiology and Immunity**	***Unit code: WBI14/01**	
Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: January 2020 90 marks	40% of the total IA2	20% of the total IAL
Content overview • Energy Flow, Ecosystems and the Environment • Microbiology, Immunity and Forensics		
Assessment overview • The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions. • The paper will include a minimum of 9 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.		

IA2 **Unit 5: Respiration, Internal Environment, Coordination and Gene Technology**	***Unit code: WBI15/01**	
Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: June 2020 90 marks	40% of the total IA2	20% of the total IAL
Content overview • Respiration, Muscles and the Internal Environment • Coordination, Response and Gene Technology		
Assessment overview • The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions. • Pre-released reading (scientific article) will be provided for this assessment. • The paper will include a minimum of 9 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.		

IA2 **Unit 6: Practical Skills in Biology II**	***Unit code: WBI16/01**	
Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2020 50 marks	20% of the total IA2	10% of the total IAL
Content overview Students are expected to develop further the experimental skills and the knowledge and understanding of experimental techniques they acquired in Units 1 and 2, by carrying out a range of practical experiments and investigations while they study Units 4 and 5. This unit will assess students' knowledge and understanding of the experimental procedures and techniques that were developed in Units 1, 2, 4 and 5.		
Assessment overview • The paper may include short-open, open-response and calculation questions. • The paper will include a minimum of 5 marks that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). • Students will be expected to apply their knowledge and understanding of practical skills to familiar and unfamiliar situations.		

*See *Appendix 1: Codes* for a description of this code and all other codes relevant to these qualifications.

Calculators

Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.

Biology content

Content overview

Students are expected to demonstrate and apply the knowledge, understanding and skills described in the content. They are also expected to analyse, interpret and evaluate a range of scientific information, ideas and evidence using their knowledge, understanding and skills.

To demonstrate their knowledge, students should be able to undertake a range of activities, including the ability to recall, describe and define, as appropriate.

To demonstrate their understanding, students should be able to explain ideas and use their knowledge to apply, analyse, interpret and evaluate, as appropriate.

Students should develop their ability to apply mathematical skills to biology throughout the course. These mathematical skills include the ability to change the subject of an equation, substitute numerical values and solve algebraic equations using decimal and standard form, ratios, fractions and percentages. Further details of the skills that should be developed are given in *Appendix 6: Mathematical skills and exemplifications*. Students should also be familiar with *Système Internationale d'Unités* (SI) units and their prefixes, be able to estimate physical quantities and know the limits of physical measurements.

Practical work is central to any study of biology. For this reason, the specification includes 18 core practical activities that form a thread linking theoretical knowledge and understanding to practical scenarios. In following this thread, students will build on practical skills learned at GCSE (or equivalent), becoming confident practical biologists, handling apparatus competently and safely. Using a variety of apparatus and techniques, they should be able to design and carry out both the core practical activities and their own investigations, collecting data which can be analysed and used to draw valid conclusions.

Questions in examination papers will aim to assess the knowledge and understanding that students gain while carrying out practical activities, within the context of the 18 core practical activities, as well as in novel practical scenarios. Success in questions that indirectly assess practical skills will come more naturally to those students who have a solid foundation of laboratory practice and who, having carried out practical skills, have a thorough understanding of practical techniques. Where possible, therefore, teachers should consider adding additional experiments to the core practical activities.

Students will be assessed on their practical skills in Papers 3 and 6. These papers will include testing the skills of students in planning practical work – both in familiar and unfamiliar applications – including risk management and the selection of apparatus, with reasons.

When data handling, students will be expected to use significant figures appropriately, to process data and to plot graphs.

Students should be encouraged to use information technology throughout the course.

Units

Unit 1: Molecules, Diet, Transport and Health

IAS compulsory unit

Externally assessed

Unit description

Introduction

This unit includes a consideration of molecules that are important in biology – including water, carbohydrates, lipids, proteins and nucleic acids, providing a basis for many areas of biology. This leads to the relevance of diet to health and the cardiovascular system in particular. The unit includes cell membrane transport processes, such as diffusion and active transport, proteins, enzymes and protein synthesis. This unit also includes an understanding of the genetic code and how mutations can result in disorders. Students will also consider techniques for genetic screening and the associated ethical and social issues.

Practical skills

In order to develop their practical skills, students should be encouraged to carry out a range of core practical experiments related to this topic. There are also opportunities to carry out additional practical work, such as investigating the structure of a mammalian heart.

Mathematical skills

There are opportunities for the development of mathematical skills in this unit, including tabulation and graphical treatment of data, concentrations and using appropriate units for physical quantities, calculation of percentage changes, and finding the initial rate of enzyme-catalysed reactions. (Please see *Appendix 6: Mathematical skills and exemplifications* for further information.)

Assessment information

- First assessment: January 2019.
- The assessment is 1 hour and 30 minutes.
- The assessment is out of 80 marks.
- Students must answer all questions.
- The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions.
- The paper will include a minimum of 8 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.
- Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.

Topic 1 – Molecules, Transport and Health

Students will be assessed on their ability to:

1.1	understand the importance of water as a solvent in transport, including its dipole nature
1.2	(i) know the difference between monosaccharides, disaccharides and polysaccharides, including glycogen and starch (amylose and amylopectin) (ii) be able to relate the structures of monosaccharides, disaccharides and polysaccharides to their roles in providing and storing energy *β-glucose and cellulose are not required in this topic.*
1.3	**CORE PRACTICAL 1** **Use a semi-quantitative method with Benedict's reagent to estimate the concentrations of reducing sugars and with iodine solution to estimate the concentrations of starch, using colour standards.**
1.4	know how monosaccharides (glucose, fructose and galactose) join together to form disaccharides (maltose, sucrose and lactose) and polysaccharides (glycogen, amylose and amylopectin) through condensation reactions forming glycosidic bonds, and how these can be split through hydrolysis reactions
1.5	(i) know how a triglyceride is synthesised by the formation of ester bonds during condensation reactions between glycerol and three fatty acids (ii) know the differences between saturated and unsaturated lipids
1.6	understand why many animals have a heart and circulation (mass transport to overcome the limitations of diffusion in meeting the requirements of organisms)
1.7	understand how the structures of blood vessels (capillaries, arteries and veins) relate to their functions
1.8	know the cardiac cycle (atrial systole, ventricular systole and cardiac diastole) and relate the structure and operation of the mammalian heart, including the major blood vessels, to its function *Details of myogenic stimulation not needed at IAS.*

RECOMMENDED ADDITIONAL PRACTICAL **Investigate the structure of a mammalian heart by dissection.**	
1.9	(i) understand the role of haemoglobin in the transport of oxygen and carbon dioxide (ii) understand the oxygen dissociation curve of haemoglobin, the Bohr effect and the significance of the oxygen affinity of fetal haemoglobin compared with adult haemoglobin
1.10	understand the course of events that leads to atherosclerosis (endothelial dysfunction, inflammatory response, plaque formation, raised blood pressure)
1.11	understand the blood clotting process (thromboplastin release, conversion of prothrombin to thrombin and fibrinogen to fibrin) and its role in cardiovascular disease (CVD)
1.12	know how factors such as genetics, diet, age, gender, high blood pressure, smoking and inactivity increase the risk of cardiovascular disease (CVD)
1.13	understand the link between dietary antioxidants and the risk of cardiovascular disease (CVD)
1.14	**CORE PRACTICAL 2** **Investigate the vitamin C content of food and drink.**
1.15	be able to analyse and interpret quantitative data on illness and mortality rates to determine health risks, including distinguishing between correlation and causation and recognising conflicting evidence
1.16	be able to evaluate the design of studies used to determine health risk factors, including sample selection and sample size used to collect data that is both valid and reliable
1.17	understand why people's perception of risks are often different from the actual risks, including underestimating and overestimating the risks due to diet and other lifestyle factors in the development of heart disease
1.18	(i) be able to analyse data on the possible significance for health of blood cholesterol levels and levels of high-density lipoproteins (HDLs) and low-density lipoproteins (LDLs) (ii) know the evidence for a causal relationship between blood cholesterol levels (total cholesterol and LDL cholesterol) and cardiovascular disease (CVD)
1.19	understand how people use scientific knowledge about the effect of diet, including obesity indicators, such as body mass index and waist-to-hip ratio, exercise and smoking to reduce their risk of coronary heart disease
1.20	know the benefits and risks of treatments for cardiovascular disease (CVD) (antihypertensives, statins, anticoagulants and platelet inhibitors)

Topic 2 – Membranes, Proteins, DNA and Gene Expression

Students will be assessed on their ability to:

2.1	(i) know the properties of gas exchange surfaces in living organisms (large surface area to volume ratio, thickness of surface and difference in concentration) (ii) understand how the rate of diffusion is dependent on these properties and can be calculated using Fick's Law of Diffusion (iii) understand how the structure of the mammalian lung is adapted for rapid gaseous exchange
2.2	(i) know the structure and properties of cell membranes (ii) understand how models such as the fluid mosaic model of membrane structure are interpretations of data used to develop scientific explanations of the structure and properties of cell membranes
2.3	**CORE PRACTICAL 3** **Investigate membrane properties including the effect of alcohol and temperature on membrane permeability.**
2.4	understand what is meant by osmosis in terms of the movement of free water molecules through a partially permeable membrane, down a water potential gradient
RECOMMENDED ADDITIONAL PRACTICAL **Investigate tissue water potentials using plant tissue and graded concentrations of a solute.**	
2.5	(i) understand what is meant by passive transport (diffusion, facilitated diffusion), active transport (including the role of ATP as an immediate source of energy), endocytosis and exocytosis (ii) understand the involvement of carrier and channel proteins in membrane transport
2.6	(i) know the basic structure of an amino acid *Structures of specific amino acids are not required.* (ii) understand the formation of polypeptides and proteins (amino acid monomers linked by condensation reactions to form peptide bonds) (iii) understand the significance of a protein's primary structure in determining its secondary structure, three-dimensional structure and properties (globular and fibrous proteins and the types of bonds involved in its three-dimensional structure) (iv) know the molecular structure of a globular protein and a fibrous protein and understand how their structures relate to their functions (including haemoglobin and collagen)
RECOMMENDED ADDITIONAL PRACTICAL **Use a semi-quantitative method to estimate protein concentration using biuret reagent and colour standards.**	
2.7	(i) understand the mechanism of action and the specificity of enzymes in terms of their three-dimensional structure (ii) understand that enzymes are biological catalysts that reduce activation energy (iii) know that there are intracellular enzymes catalysing reactions inside cells and extracellular enzymes catalysing reactions outside cells

2.8	**CORE PRACTICAL 4** **Investigate the effect of temperature, pH, enzyme concentration and substrate concentration on the initial rate of enzyme-catalysed reactions.**
2.9	(i) know the basic structure of mononucleotides (deoxyribose or ribose linked to a phosphate and a base, including thymine, uracil, adenine, cytosine or guanine) and the structures of DNA and RNA (polynucleotides composed of mononucleotides linked by condensation reactions to form phosphodiester bonds) (ii) know how complementary base pairing and the hydrogen bonding between two complementary strands are involved in the formation of the DNA double helix
2.10	(i) understand the process of DNA replication, including the role of DNA polymerase (ii) understand how Meselson and Stahl's classic experiment provided new data that supported the accepted theory of replication of DNA and refuted competing theories
2.11	understand the nature of the genetic code (triplet code, non-overlapping and degenerate)
2.12	know that a gene is a sequence of bases on a DNA molecule that codes for a sequence of amino acids in a polypeptide chain
2.13	(i) understand the process of protein synthesis (transcription and translation), including the role of RNA polymerase, translation, messenger RNA, transfer RNA, ribosomes and the role of start and stop codons (ii) understand the roles of the DNA template (antisense) strand in transcription, codons on messenger RNA and anticodons on transfer RNA
2.14	(i) understand how errors in DNA replication can give rise to mutations (substitution, insertion and deletion of bases) (ii) know that some mutations will give rise to cancer or genetic disorders, but that many mutations will have no observable effect
2.15	(i) understand what is meant by the terms *gene, allele, genotype, phenotype, recessive, dominant, codominance, homozygote* and *heterozygote* (ii) understand patterns of inheritance, including the interpretation of genetic pedigree diagrams, in the context of monohybrid inheritance (iii) understand sex linkage on the X chromosome, including red-green colour blindness in humans
2.16	understand how the expression of a gene mutation in people with cystic fibrosis impairs the functioning of the gaseous exchange, digestive and reproductive systems
2.17	(i) understand the uses of genetic screening, including the identification of carriers, pre-implantation genetic diagnosis (PGD) and prenatal testing, including amniocentesis and chorionic villus sampling (ii) understand the implications of prenatal genetic screening
2.18	be able to identify and discuss the ethical and social issues relating to genetic screening from a range of ethical viewpoints, including religious, moral and social implications

Unit 2: Cells, Development, Biodiversity and Conservation

IAS compulsory unit

Externally assessed

Unit description

Introduction	This unit starts with the cell as the basic unit of all living organisms, leading to cell division, formation of gametes, fertilisation and the continuity of life. The roles of stem cells, gene expression, and the influence of the environment and epigenetics on phenotypes are also included. Cell development leads to an understanding of the structure and functions of plant cells, and how plants may be exploited by humans for fibres and as sources of drugs. This unit also considers the diversity of life and how biodiversity can be measured. The unit ends with an account of reasons for changes in populations over time, and the methods used by zoos and seed banks for the conservation of endangered species and their genetic diversity.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of core practical experiments related to this topic. There are also opportunities to carry out additional practical work, such as investigating factors affecting the growth of pollen tubes.
Mathematical skills	There are opportunities for the development of mathematical skills in this unit, including using ratios, percentages and fractions, substituting values into algebraic equations, calculation of magnification, understanding the terms *mean*, *mode* and *median*, constructing and interpreting frequency tables, bar charts and histograms. (Please see *Appendix 6: Mathematical skills and exemplifications* for further information.)

Assessment information

- First assessment: June 2019.
- The assessment is 1 hour and 30 minutes.
- The assessment is out of 80 marks.
- Students must answer all questions.
- The paper may include multiple-choice, short open, open-response, calculations and extended-writing questions.
- The paper will include a minimum of 8 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.
- Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.

Topic 3 – Cell Structure, Reproduction and Development

Students will be assessed on their ability to:

3.1	know that all living organisms are made of cells, sharing some common features
3.2	understand how the cells of multicellular organisms are organised into tissues, tissues into organs and organs into organ systems
3.3	(i) know the ultrastructure of eukaryotic cells, including nucleus, nucleolus, ribosomes, rough and smooth endoplasmic reticulum, mitochondria, centrioles, lysosomes and Golgi apparatus (ii) understand the function of the organelles listed in (i)
3.4	understand the role of the rough endoplasmic reticulum (rER) and the Golgi apparatus in protein transport within cells, including their role in the formation of extracellular enzymes
3.5	(i) know the ultrastructure of prokaryotic cells, including cell wall, capsule, plasmid, flagellum, pili, ribosomes and circular DNA (ii) knderstand the function of the structures listed in (i)
3.6	be able to recognise the organelles in **3.3** from electron microscope (EM) images
3.7	(i) know how magnification and resolution can be achieved using light and electron microscopy (ii) understand the importance of staining specimens in microscopy
3.8	**CORE PRACTICAL 5** **(i) use a light microscope to make observations and labelled drawings of suitable animal cells** **(ii) use a graticule with a microscope to make measurements and understand the concept of scale**
3.9	(i) know that a locus is the location of genes on a chromosome (ii) understand the linkage of genes on a chromosome
3.10	understand the role of meiosis in ensuring genetic variation through the production of non-identical gametes as a consequence of independent assortment of chromosomes in metaphase I and crossing over of alleles between chromatids in prophase I *Names of the stages of prophase are not required.*
3.11	understand how mammalian gametes are specialised for their functions (including the acrosome in sperm and the zona pellucida in the egg cell)
3.12	know the process of fertilisation in mammals, including the acrosome reaction, the cortical reaction and the fusion of nuclei
3.13	know the process of fertilisation in flowering plants, starting with the growth of a pollen tube and ending with the fusion of nuclei
RECOMMENDED ADDITIONAL PRACTICAL **Investigate factors affecting the growth of pollen tubes.**	
3.14	understand the role of mitosis and the cell cycle in producing genetically identical daughter cells for growth and asexual reproduction

3.15	**CORE PRACTICAL 6** **Prepare and stain a root tip squash to observe the stages of mitosis.**
3.16	be able to calculate mitotic indices
3.17	(i) understand what is meant by the terms *stem cell*, *pluripotent* and *totipotent*, *morula* and *blastocyst* (ii) be able to discuss the ways in which society uses scientific knowledge to make decisions about the use of stem cells in medical therapies
3.18	understand how cells become specialised through differential gene expression, producing active mRNA, leading to the synthesis of proteins which, in turn, control cell processes or determine cell structure in animals and plants
3.19	understand how one gene can give rise to more than one protein through post-transcriptional changes to messenger RNA (mRNA)
3.20	(i) understand how phenotype is the result of an interaction between genotype and the environment (ii) know how epigenetic modification, including DNA methylation and histone modification, can alter the activation of certain genes (iii) understand how epigenetic modifications can be passed on following cell division
3.21	understand how some phenotypes are affected by multiple alleles for the same gene, or by polygenic inheritance, as well as the environment, and how polygenic inheritance can give rise to phenotypes that show continuous variation

Topic 4 – Plant Structure and Function, Biodiversity and Conservation

Students will be assessed on their ability to:

4.1	(i) know the structure and ultrastructure of plant cells including cell wall, chloroplast, amyloplast, vacuole, tonoplast, plasmodesmata, pits and middle lamella and be able to compare it with animal cells (ii) understand the function of the structures listed in (i)
4.2	be able to recognise the organelles in **4.1** from electron microscope (EM) images
4.3	understand the structure and function of the polysaccharides starch and cellulose, including the role of hydrogen bonds between the β-glucose molecules in the formation of cellulose microfibrils
4.4	understand how the arrangement of cellulose microfibrils and secondary thickening in plant cell walls contributes to the physical properties of xylem vessels and sclerenchyma fibres in plant fibres that can be exploited by humans
4.5	know the similarities and differences between the structures of, the position in the stem, and the function of sclerenchyma fibres (support), xylem vessels (support and transport of water and mineral ions) and phloem (translocation of organic solutes)
4.6	**CORE PRACTICAL 7** **Use a light microscope to:** **(i) make observations, draw and label plan diagrams of transverse sections of roots, stems and leaves** **(ii) make observations, draw and label cells of plant tissues** **(iii) identify sclerenchyma fibres, phloem, sieve tubes and xylem vessels and their location.**
4.7	understand how the uses of plant fibres and starch may contribute to sustainability, including plant-based products to replace oil-based plastics
4.8	understand the importance of water and inorganic ions (nitrate, calcium ions and magnesium ions) to plants
RECOMMENDED ADDITIONAL PRACTICAL **Investigate plant mineral deficiencies.**	
4.9	**CORE PRACTICAL 8** **Determine the tensile strength of plant fibres.**
4.10	understand the conditions required for bacterial growth
4.11	know that substances derived from plants can have antimicrobial and other therapeutic properties
4.12	**CORE PRACTICAL 9** **Investigate the antimicrobial properties of plants, including aseptic techniques for the safe handling of bacteria.**
4.13	understand the development of drug testing from historic to contemporary protocols, including William Withering's digitalis soup, double blind trials, placebo and three-phased testing

4.14	(i) understand that classification is a means of organising the variety of life based on relationships between organisms using differences and similarities in phenotypes and in genotypes, and is built around the species concept (ii) understand the process and importance of critical evaluation of new data by the scientific community leading to new taxonomic groupings, based on molecular evidence, including the three-domain system (Archaea, Bacteria and Eukarya)
4.15	know that, over time, the variety of life has become extensive but is now being threatened by human activity
4.16	understand what is meant by the terms *biodiversity* and *endemism*
4.17	know how biodiversity can be measured within a habitat using species richness, and within a species using genetic diversity by calculating the heterozygosity index: $\text{heterozygosity index} = \frac{\text{number of heterozygotes}}{\text{number of individuals in the population}}$
4.18	understand how biodiversity can be compared in different habitats using the formula to calculate an index of diversity (D): $D = \frac{N(N-1)}{\Sigma n(n-1)}$
4.19	understand the concept of niche and be able to discuss examples of adaptations of organisms to their environment (behavioural, anatomical and physiological)
4.20	(i) understand how the Hardy-Weinberg equation can be used to see whether a change in allele frequency is occurring in a population over time (ii) understand that changes in allele frequency can come about as a result of mutation and natural selection (iii) understand that reproductive isolation can lead to accumulation of different genetic information in populations, potentially leading to the formation of new species
4.21	be able to evaluate the methods used by zoos and seed banks in the conservation of endangered species and their genetic diversity, including scientific research, captive breeding programmes, reintroduction programmes and education

Unit 3: Practical Skills in Biology I

IAS compulsory unit

Externally assessed

Unit description

Introduction

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out the core practicals and other recommended practical investigations and experiments while they study Units 1 and 2. This will require them to work safely, produce valid results and present data in the most appropriate format.

This unit will assess students' ability to apply their knowledge and understanding of experimental design, procedures and techniques developed throughout Units 1 and 2.

Practical skills identified for assessment

- Solve problems set in practical contexts.
- Apply scientific knowledge to practical contexts.
- Comment on experimental design and evaluate scientific methods.
- Present data in appropriate ways.
- Evaluate results and draw conclusions with reference to measurement uncertainties and errors.
- Identify variables, including those that must be controlled
- Plot and interpret graphs.
- Process and analyse data using appropriate mathematical skills (see *Appendix 6: Mathematical skills and exemplifications*).
- Know and understand how to use a wide range of apparatus, materials and techniques safely, appropriate to the knowledge and understanding in this specification.
- Plan an investigation to test a hypothesis.

Practical skills to be developed through teaching and learning

- Apply investigative approaches and methods to practical work.
- Use a range of practical equipment and materials safely and correctly.
- Follow written instructions.
- Make and record observations.
- Present information and data in a scientific way.
- Use appropriate software and tools to collect and process data.
- Use online and offline research skills, including websites, textbooks and other printed scientific sources of information.
- Cite sources of information correctly.
- Use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in this specification.

Assessment information

- First assessment: June 2019.
- The assessment is 1 hour and 20 minutes.
- The assessment is out of 50 marks.
- Students must answer all questions.
- The paper may include calculations, short open, open-response and calculation questions.
- The paper will include a minimum of 5 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.

Planning

Questions on Unit 3 may require students to plan and evaluate an investigation, based on the practical activities included in Units 1 and 2.

Students will be assessed on their ability to:

Plan an experiment

- identify the apparatus required
- identify the dependent and independent variables, standardised or controlled variables
- describe how to measure relevant variables using the most appropriate instrument and correct measuring techniques
- identify and state how to control all other relevant variables to make it a fair test
- discuss whether repeat readings are appropriate
- identify health and safety issues and discuss how they may be dealt with
- discuss how the data collected will be used
- identify possible sources of uncertainty and/or systematic error and explain how they may be reduced or eliminated
- comment on the implications of biology (for example benefits/risks) and on its context (for example social/environmental/historical).

Implementation and measurements

Students will be assessed on their ability to:

Implementation and measurements	• comment on the number of readings taken • comment on the range of measurements taken • comment on significant figures • check a reading that is inconsistent with other readings, for example a point that is not on the line of a graph • comment on how the experiment may be improved, possibly by using additional apparatus (for example to reduce errors).

Processing results

Students may be provided with experimental data in a tabulated or graphical form.

Students will be assessed on their ability to:

Processing results	• perform calculations, using the correct number of significant figures • plot results on a graph using an appropriate scale • use the correct units throughout • comment on the relationship obtained from the graph • determine the relationship between two variables or determine a constant with the aid of a graph, for example by determining the gradient using a large triangle • suggest realistic modifications to reduce errors • suggest realistic modifications to improve the experiment • discuss uncertainties, qualitatively and quantitatively.

Unit 4: Energy, Environment, Microbiology and Immunity

IA2 compulsory unit

Externally assessed

Unit description

Introduction	This unit begins with energy capture in photosynthesis and the synthesis of organic compounds by plants, and the flow of energy in ecosystems. This is followed by a consideration of the carbon cycle and how disruption of this cycle may lead to climate change. Students will also consider changes that occur in populations, both in the short term and long term, as a result of mutation and natural selection. The unit continues with an introduction to the diversity and features of microorganisms and how hosts respond to infection by pathogens. This leads to a consideration of the role of microorganisms in decomposition of organic materials and the techniques and applications of polymerase chain reaction (PCR) and gel electrophoresis.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of core practical experiments related to this topic.
Mathematical skills	There are opportunities for the development of mathematical skills in this unit, including tabulation and graphical treatment of data, understanding the principles of sampling, exponential and logarithmic functions and the use of statistics. (Please see *Appendix 6: Mathematical skills and exemplifications* for further information.)

Assessment information

- First assessment: January 2020.
- The assessment is 1 hour and 45 minutes.
- The assessment is out of 90 marks.
- Students must answer all questions.
- The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions.
- The paper will include synoptic questions that may draw on two or more different topics.
- The paper will include a minimum of 9 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.
- Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.

Topic 5 – Energy Flow, Ecosystems and the Environment

Students will be assessed on their ability to:

5.1	understand the overall reaction of photosynthesis as requiring energy from light to split apart the strong bonds in water molecules, storing the hydrogen in a fuel (glucose) by combining it with carbon dioxide and releasing oxygen into the atmosphere
5.2	understand how photophosphorylation of ADP requires energy and that hydrolysis of ATP provides an immediate supply of energy for biological processes
5.3	understand the light-dependent reactions of photosynthesis, including how light energy is trapped by exciting electrons in chlorophyll and the role of these electrons in generating ATP, reducing NADP in cyclic and non-cyclic photophosphorylation and producing oxygen through photolysis of water
5.4	(i) understand the light-independent reactions as reduction of carbon dioxide using the products of the light-dependent reactions (carbon fixation in the Calvin cycle, the role of GP, GALP, RuBP and RUBISCO) (ii) know that the products are simple sugars that are used by plants, animals and other organisms in respiration and the synthesis of new biological molecules (polysaccharides, amino acids, proteins, lipids and nucleic acids)
5.5	understand the structure of chloroplasts in relation to their role in photosynthesis
5.6	understand what is meant by the terms *absorption spectrum* and *action spectrum*
5.7	understand that chloroplast pigments can be separated using chromatography and the pigments identified using Rf values
5.8	**CORE PRACTICAL 10** **Investigate the effects of light intensity, light wavelength, temperature and availability of carbon dioxide on the rate of photosynthesis using a suitable aquatic plant.**
5.9	(i) understand the relationship between gross primary productivity (GPP), net primary productivity (NPP) and plant respiration (R) (ii) be able to calculate net primary productivity
5.10	know how to calculate the efficiency of biomass and energy transfers between trophic levels
5.11	understand what is meant by the terms *population*, *community*, *habitat* and *ecosystem*
5.12	understand that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors
5.13	understand how the concept of niche accounts for the distribution and abundance of organisms in a habitat

5.14	**CORE PRACTICAL 11** **Carry out a study of the ecology of a habitat, such as using quadrats and transects to determine the distribution and abundance of organisms, and measuring abiotic factors appropriate to the habitat.**
5.15	understand the stages of succession from colonisation to the formation of a climax community
5.16	understand the different types of evidence for climate change and its causes, including records of carbon dioxide levels, temperature records, pollen in peat bogs and dendrochronology, recognising correlations and causal relationships
5.17	understand the causes of anthropogenic climate change, including the role of greenhouse gases in the greenhouse effect
5.18	understand how knowledge of the carbon cycle can be applied to methods to reduce atmospheric levels of carbon dioxide
5.19	(i) understand that data can be extrapolated to make predictions and that these are used in models of future climate change (ii) understand that models for climate change have limitations
5.20	understand the effects of climate change (changing rainfall patterns and changes in seasonal cycles) on plants and animals (distribution of species, development and lifecycles)
5.21	understand the effect of temperature on the rate of enzyme activity and its impact on plants, animals and microorganisms, to include Q_{10}
5.22	**CORE PRACTICAL 12** **Investigate the effects of temperature on the development of organisms (such as seedling growth rate or brine shrimp hatch rates), taking into account the ethical use of organisms.**
5.23	understand how evolution (a change in allele frequency) can come about through gene mutation and natural selection
5.24	understand how isolation reduces gene flow between populations, leading to allopatric or sympatric speciation
5.25	understand the way in which scientific conclusions about controversial issues, such as what actions should be taken to reduce climate change, or the degree to which humans are affecting climate change, can sometimes depend on who is reaching the conclusions
5.26	understand how reforestation and the use of sustainable resources, including biofuels, are examples of the effective management of the conflict between human needs and conservation

Topic 6 – Microbiology, Immunity and Forensics

Students will be assessed on their ability to:

6.1	understand the principles and techniques involved in culturing microorganisms, using aseptic technique
6.2	understand the different methods of measuring the growth of microorganisms, as illustrated by cell counts, dilution plating, mass and optical methods (turbidity)
6.3	understand the different phases of a bacterial growth curve (lag phase, exponential phase, stationary phase and death phase) and be able to calculate exponential growth rate constants
6.4	**CORE PRACTIAL 13** **Investigate the rate of growth of microorganisms in a liquid culture, taking into account the safe and ethical use of organisms.**
6.5	(i) be able to compare the structure of bacteria and viruses (nucleic acid, capsid structure and envelope) with reference to Ebola virus, tobacco mosaic virus (TMV), human immunodeficiency virus (HIV) and lambda phage (λ phage) (ii) understand what is meant by the terms *lytic* and *latency*
6.6	understand how *Mycobacterium tuberculosis* and human immunodeficiency virus (HIV) infect human cells, causing symptoms that may result in death
6.7	(i) know the major routes pathogens may take when entering the body (ii) understand the role of barriers in protecting the body from infection, including skin, stomach acid, and gut and skin flora
6.8	understand the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon and phagocytosis
6.9	understand the roles of antigens and antibodies in the body's immune response including the involvement of plasma cells, macrophages and antigen-presenting cells
6.10	understand the differences between the roles of B cells (B memory and B effector cells), and T cells (T helper, T killer and T memory cells) in the host's immune response
6.11	understand how individuals may develop immunity (natural, artificial, active and passive)
6.12	understand how the theory of an 'evolutionary race' between pathogens and their hosts is supported by evasion mechanisms shown by pathogens
6.13	understand the difference between bacteriostatic and bactericidal antibiotics
6.14	**CORE PRACTICAL 14** **Investigate the effect of different antibiotics on bacteria.**
6.15	know how an understanding of the contributory causes of hospital-acquired infections has led to codes of practice regarding antibiotic prescription and hospital practice that relate to infection prevention and control

6.16	know the role of microorganisms in the decomposition of organic matter and the recycling of carbon
6.17	know how DNA can be amplified using the polymerase chain reaction (PCR)
6.18	know how gel electrophoresis can be used to separate DNA fragments of different length
6.19	understand how DNA profiling is used for identification and determining genetic relationships between organisms (plants and animals)
6.20	understand how to determine the time of death of a mammal by examining the extent of decomposition, stage of succession, forensic entomology, body temperature and degree of muscle contraction

Unit 5: Respiration, Internal Environment, Coordination and Gene Technology

IA2 compulsory unit

Externally assessed

Unit description

Introduction	Following on from energy and the environment in Unit 4, this unit starts by considering energy within organisms and how energy is made available for processes, including muscle contraction. There are further details of some of the topics in AS, including coordination of the heartbeat. Students will also consider some aspects of maintenance of the internal environment, with specific references to kidney function and the mode of action of hormones. This leads on to the topic of coordination in mammals and in flowering plants, the effects of drugs on the nervous system and how modern techniques of gene technology are used for the production of drugs. Modern aspects of gene technology, including the use of microarrays, provide a foundation for further study in this area.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of core practical experiments related to this topic. There are also opportunities to carry out additional practical work, such as investigating habituation.
Mathematical skills	There are opportunities for the development of mathematical skills in this unit, including using ratios, constructing and interpreting frequency tables, bar charts and histograms and the use of statistical tests. (Please *see Appendix 6: Mathematical skills and exemplifications* for further information.)

Assessment information

- First assessment: June 2020.
- The assessment is 1 hour and 45 minutes.
- The assessment is out of 90 marks.
- Students must answer all questions.
- The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions.
- The pre-released scientific article will underpin one question of the paper. This question carries 20 Marks.
- The paper will include synoptic questions that may draw on two or more different topics.
- The paper will include a minimum of 9 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.
- Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.

Topic 7 – Respiration, Muscles and the Internal Environment

Students will be assessed on their ability to:

7.1	(i) understand the overall reaction of aerobic respiration as splitting of the respiratory substrate to release carbon dioxide as a waste product and reuniting hydrogen with atmospheric oxygen with the release of large amounts of energy (ii) understand that respiration is a many-stepped process, with each step controlled and catalysed by a specific intracellular enzyme *Names of specific enzymes are not required.*
7.2	understand the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP by substrate level phosphorylation, reduced coenzyme, pyruvate and lactate *Details of intermediate stages and compounds are not required.*
7.3	understand the role of the link reaction and the Krebs cycle in the complete oxidation of glucose and formation of carbon dioxide (CO_2) by decarboxylation, ATP by substrate level phosphorylation, reduced NAD and reduced FAD by dehydrogenation (names of other compounds are not required) and that these steps take place in mitochondria, unlike glycolysis which occurs in the cytoplasm
7.4	understand how ATP is synthesised by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATP synthase
7.5	understand what happens to lactate after a period of anaerobic respiration in animals
7.6	understand what is meant by the term *respiratory quotient* (*RQ*)
7.7	**CORE PRACTICAL 15** **Use an artificial hydrogen carrier (redox indicator) to investigate respiration in yeast.**
7.8	**CORE PRACTICAL 16** **Use a simple respirometer to determine the rate of respiration and RQ of a suitable material (such as germinating seeds or small invertebrates).**
7.9	know the way in which muscles, tendons, the skeleton and ligaments interact to enable movement, including antagonistic muscle pairs, extensors and flexors
7.10	(i) know the structure of a mammalian skeletal muscle fibre (ii) understand the structural and physiological differences between fast and slow twitch muscle fibres
7.11	understand the process of contraction of skeletal muscle in terms of the sliding filament theory, including the role of actin, myosin, troponin, tropomyosin, calcium ions (Ca^{2+}), ATP and ATPase
7.12	(i) know the myogenic nature of cardiac muscle (ii) understand how the normal electrical activity of the heart coordinates the heartbeat, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN), the bundle of His and the Purkyne fibres (iii) understand how the use of electrocardiograms (ECGs) can aid in the diagnosis of abnormal heart rhythms

7.13	(i) be able to calculate cardiac output (ii) understand how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre in the medulla oblongata
7.14	understand the role of adrenaline in the fight or flight response
7.15	**CORE PRACTICAL 17** **Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation, and oxygen consumption using data from spirometer traces.**
7.16	(i) understand what is meant by the terms *negative feedback* and *positive feedback control* (ii) understand the principle of negative feedback in maintaining systems within narrow limits
7.17	understand what is meant by the term *homeostasis* and its importance in maintaining the body in a state of dynamic equilibrium during exercise, including the role of the hypothalamus in thermoregulation
7.18	know the gross and microscopic structure of the mammalian kidney
7.19	understand how urea is produced in the liver from excess amino acids (*details of the ornithine cycle are not required*) and how it is removed from the bloodstream by ultrafiltration
7.20	understand how solutes are selectively reabsorbed in the proximal tubule and how the loop of Henle acts as a countercurrent multiplier to increase the reabsorption of water
7.21	understand how the pituitary gland and osmoreceptors in the hypothalamus, combined with the action of antidiuretic hormone (ADH), bring about negative feedback control of mammalian plasma concentration and blood volume
7.22	understand how genes can be switched on and off by DNA transcription factors, including the role of peptide hormones acting extracellularly and steroid hormones acting intracellularly

Topic 8 – Coordination, Response and Gene Technology

Students will be assessed on their ability to:

8.1	know the structure and function of sensory, relay and motor neurones, including Schwann cells and myelination
8.2	understand how the nervous system of organisms can cause effectors to respond to a stimulus
8.3	know the structure and function of a spinal reflex arc, including grey matter and white matter of the spinal cord
8.4	understand how a nerve impulse (action potential) is conducted along an axon, including changes in membrane permeability to sodium and potassium ions
8.5	understand the role of myelination in saltatory conduction
8.6	(i) know the structure and function of synapses in nerve impulse transmission, including the role of neurotransmitters and acetylcholine (ii) understand how the pupil dilates and contracts
8.7	understand how the effects of drugs can be caused by their influence on nerve impulse transmission, illustrated by nicotine, lidocaine and cobra venom alpha toxin, the use of L-DOPA in the treatment of Parkinson's disease and the action of MDMA (ecstasy)
8.8	understand how the nervous systems of organisms can detect stimuli with reference to rods in the retina of mammals, the roles of rhodopsin, opsin, retinal, sodium ions, cation channels and hyperpolarisation of rod cells in forming action potentials in the optic neurones
8.9	understand what is meant by the term *habituation*
RECOMMENDED ADDITIONAL PRACTICAL **Investigate habituation to a stimulus.**	
8.10	know that the mammalian nervous system consists of the central and peripheral nervous systems
8.11	understand how phytochrome, auxin (IAA) and gibberellins bring about responses in plants, including their effects on transcription
8.12	**CORE PRACTICAL 18** **Investigate the production of amylase in germinating cereal grains.**
8.13	understand how coordination in animals is brought about through nervous and hormonal control
8.14	know the location and main functions of the cerebral hemispheres, hypothalamus, pituitary gland, cerebellum and medulla oblongata of the human brain
8.15	understand how magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and computed tomography (CT) are used in medical diagnosis and the investigation of brain structure and function

8.16	understand how imbalances in certain naturally-occurring brain chemicals can contribute to ill health, including dopamine in Parkinson's disease and serotonin in depression, and to the development of new drugs
8.17	know how drugs can be produced using genetically modified organisms (plants, animals and microorganisms)
8.18	understand how recombinant DNA can be produced, including the roles of restriction endonucleases and DNA ligase
8.19	understand how recombinant DNA can be inserted into other cells
8.20	know how microarrays can be used to identify active genes
8.21	understand what is meant by the term *bioinformatics*
8.22	understand the risks and benefits associated with the use of genetically modified organisms

Unit 6: Practical Skills in Biology II

IA2 compulsory unit

Externally assessed

Unit description

Introduction

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 carry out the core practicals and other recommended practical investigations and experiments while they study Units 4 and 5.

Students are expected to become aware of how these techniques and procedures might be used to investigate interesting biological questions.

This unit will assess students' ability to apply their 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.

Practical skills identified for assessment

- Solve problems set in practical contexts.
- Apply scientific knowledge to practical contexts.
- Comment on experimental design and evaluate scientific methods.
- Present data in appropriate ways.
- Evaluate results and draw conclusions with reference to measurement uncertainties and errors.
- Identify variables, including those that must be controlled.
- Plot and interpret graphs.
- Process and analyse data using appropriate mathematical skills (see *Appendix 6: Mathematical skills and exemplifications*).
- Know and understand how to use a wide range of apparatus, materials and techniques safely, appropriate to the knowledge and understanding in this specification.
- Plan an investigation to test a hypothesis.

Practical skills to be developed through teaching and learning	• Apply investigative approaches and methods to practical work. • Use a range of practical equipment and materials safely and correctly. • Follow written instructions. • Make and record observations. • Present information and data in a scientific way. • Use appropriate software and tools to collect and process data. • Use online and offline research skills, including websites, textbooks and other printed scientific sources of information. • Cite sources of information correctly. • Use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding in this specification.

Assessment information

- First assessment: June 2020.
- The assessment is 1 hour and 20 minutes.
- The assessment is out of 50 marks.
- Students must answer all questions.
- The paper may include calculations, short-open, open-response and calculation questions.
- The paper will include synoptic questions that may draw on all topics.
- The paper will include a minimum of 5 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. *Please see Appendix 8: Use of calculators.*

Planning

Questions on Unit 6 may require students to plan an investigation to test a hypothesis, based on the practical activities included in Units 1, 2, 4 and 5.

Students will be assessed on their ability to:

Plan an experiment	• identify the most appropriate apparatus, giving details. Apparatus may include the range and resolution of instruments and/or relevant dimensions of apparatus (for example the area of a quadrat used for an ecological investigation) • formulate a null hypothesis • identify the dependent and independent variables, standardised or controlled variables • discuss calibration of instruments, for example whether a meter reads zero before measurements are made • describe how to measure relevant variables using the most appropriate instrument(s) and techniques • identify and state how to control all other relevant variables to make it a fair test • discuss whether repeat readings are appropriate • identify health and safety issues and discuss how they may be dealt with • identify any ethical issues involved with the use of living organisms • discuss how the data collected will be used.

Implementation and measurements

Students may be expected to evaluate an investigation and suggest limitations.

Students will be assessed on their ability to:

Implementation and measurements	• comment on how the experiment could have been improved, possibly by using additional apparatus (for example to reduce errors) • comment on the number of readings taken • comment on the range of measurements taken • comment on significant figures – students may be required to identify and/or round up any incorrect figures in a table of results • identify and/or amend units that are incorrect • identify and check a reading that is inconsistent with other readings, for example a point that is not on the line of a graph.

Analysis

Students may be expected to explain how data collected should be presented and analysed.

Students will be assessed on their ability to:

Analyse data	• explain how data should be tabulated, with appropriate units • perform calculations, using the correct number of significant figures • plot results on a graph using an appropriate scale and units – the graph could be logarithmic in nature • use the correct units throughout • comment on the trend/pattern obtained • determine the relationship between two variables or determine a constant with the aid of the graph, for example by determining the gradient using a large triangle • suggest realistic modifications to reduce errors • suggest realistic modifications to improve the experiment.

Assessment information

Assessment requirements

The Pearson Edexcel International Advanced Subsidiary in Biology consists of three externally-examined units.

The Pearson Edexcel International Advanced Level in Biology consists of six externally-examined units.

Students must complete all assessments.

Please see the *Assessment availability and first award* section for information on from when the assessment for each unit will be available.

Unit	IAS or IA2	Assessment information	Number of raw marks allocated in the unit
Unit 1: Molecules, Diet, Transport and Health	IAS	Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: January 2019	80 marks
Unit 2: Cells, Development, Biodiversity and Conservation	IAS	Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: June 2019	80 marks
Unit 3: Practical Skills in Biology I	IAS	Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2019	50 marks

Unit	IAS or IA2	Assessment information	Number of raw marks allocated in the unit
Unit 4: Energy, Environment, Microbiology and Immunity	IA2	Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: January 2020	90 marks
Unit 5: Respiration, Internal Environment, Coordination and Gene Technology	IA2	Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: June 2020	90 marks
Unit 6: Practical Skills in Biology II	IA2	Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2020	50 marks

Sample assessment materials

Sample papers and mark schemes can be found in the *Pearson Edexcel International Advanced Subsidiary/Advanced Level in Biology Sample Assessment Materials (SAMs)* document.

A full list of command words that will be used in the assessment across the IAS/IAL Science qualifications can be found in *Appendix 7: Taxonomy*.

Assessment objectives and weightings

		% in IAS	% in IA2	% in IAL
AO1	Demonstrate knowledge and understanding of science	36–39	31–34	34–37
AO2	(a) Application of knowledge and understanding of science in familiar and unfamiliar contexts.	34–36	33–36	33–36
	(b) Analysis and evaluation of scientific information to make judgments and reach conclusions.	9–11	14–16	11–14
AO3	Experimental skills in science, including analysis and evaluation of data and methods	17–18	17–18	17–18

Relationship of assessment objectives to units for the International Advanced Subsidiary qualification

Unit number	Assessment objective (%)			
	AO1	AO2a	AO2b	AO3
Unit 1	17–18	17–18	4.5–5.5	0
Unit 2	17–18	17–18	4.5–5.5	0
Unit 3	2–3	0	0	17–18
Total for International Advanced Subsidiary	36–39	34–36	9–11	17–18

Relationship of assessment objectives to units for the International Advanced Level qualification

Unit number	Assessment objective (%)			
	AO1	AO2a	AO2b	AO3
Unit 1	8.5–9.0	8.5–9.0	2.2–2.8	0
Unit 2	8.5–9.0	8.5–9.0	2.2–2.8	0
Unit 3	1–1.5	0	0	8.8–9.2
Unit 4	7.3–7.8	8.4–8.9	3.6–4.0	0
Unit 5	7.3–7.8	8.4–8.9	3.6–4.0	0
Unit 6	1–1.5	0	0	8.8–9.2
Total for International Advanced Level	34–37	33–36	11–14	17–18

NB Totals have been rounded either up or down.

Assessment availability and first award

Unit	January 2019	June 2019	October 2019	January 2020	June 2020
1	✓	✓	✓	✓	✓
2	×	✓	✓	✓	✓
3	×	✓	✓	✓	✓
4	×	×	×	✓	✓
5	×	×	×	×	✓
6	×	×	×	×	✓
IAS award	×	✓	✓	✓	✓
IAL award	×	×	×	×	✓

From June 2020, **all six units will be assessed** in January, June and October for the lifetime of the qualification.

From June 2020, **IAL and IAS will both be awarded** in January, June and October for the lifetime of the qualification.

Administration and general information

Entries and resitting of units

Entries

Details of how to enter students for the examinations for these qualifications can be found in our *International Information Manual*. A copy is made available to all examinations officers and is available on our website, qualifications.pearson.com

Resitting of units

Students can resit any unit irrespective of whether the qualification is to be cashed in. If a student resits a unit more than once, only the better of the two most recent attempts of that unit will be available for aggregation to a qualification grade. Please refer to the *Entry, Aggregation and Certification* document on our website: qualifications.pearson.com/IAL-entry-certification-procedures

Access arrangements, reasonable adjustments, special consideration and malpractice

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the UK Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Language of assessment

Assessment of these qualifications will be available in English only. All student work must be in English.

We recommend that students are able to read and write in English at Level B2 of the Common European Framework of Reference for Languages.

Access arrangements

Access arrangements are agreed before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual student with a disability without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a student with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular student may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, including:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, timeframes or affects the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a student's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate their level of attainment in an assessment.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration please refer to the JCQ website: www.jcq.org.uk

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form can be emailed to pqsmalpractice@pearson.com or posted to: Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice).

The form, supporting documentation and as much information as possible can be emailed to pqsmalpractice@pearson.com or posted to: Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More-detailed guidance on malpractice can be found in the latest version of the document *JCQ General and vocational qualifications Suspected Malpractice in Examinations and Assessments,* available at www.jcq.org.uk/exams-office/malpractice

Awarding and reporting

The Pearson Edexcel International Advanced Subsidiary in Biology will be graded on a five-grade scale from A to E. The Pearson Edexcel International Advanced Level in Biology will be graded on a six-point scale from A* to E. Individual unit results will be reported. Only Units 1, 2 and 3 will contribute to the International Advanced Subsidiary grade. All six units will contribute to the International Advanced Level grade.

The first certification opportunity for the Pearson Edexcel International Advanced Subsidiary in Biology will be in August 2019. The first certification opportunity for the Pearson Edexcel International Advanced Level in Biology will be in August 2020.

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 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.

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.

Unit results

Students will receive a uniform mark between 0 and the maximum uniform mark for each unit.

The uniform marks at each grade threshold for each unit are:

Units 1, 2, 4 and 5

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

Units 3 and 6

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

Qualification results

The minimum uniform marks required for each grade:

International Advanced Subsidiary (cash-in code: XBI11)

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

Students with a uniform mark in the range 0–119 will be Unclassified (U).

International Advanced Level (cash-in code: YBI11)

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

Students with a uniform mark in the range 0–239 will be Unclassified (U).

To be awarded an A*, students will need to achieve an A for the International Advanced Level qualification (at least 480 uniform marks) and at least 90% of the total uniform marks available across the IA2 units combined (at least 270 uniform marks).

Student recruitment and progression

Pearson follows the Joint Council for Qualifications (JCQ) policy concerning recruitment to our qualifications in 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.

Prior learning and other requirements

Students who would benefit most from studying these qualifications are likely to have a Level 2 qualification such as a GCSE or International GCSE in Biology.

Progression

Students can progress from these qualifications to:

- a range of different, relevant academic or vocational higher education qualifications, for example a degree in biology or in a related subject, including marine biology, natural science and anatomy, or equivalent qualifications such as BTEC Higher Nationals
- employment
- further training.

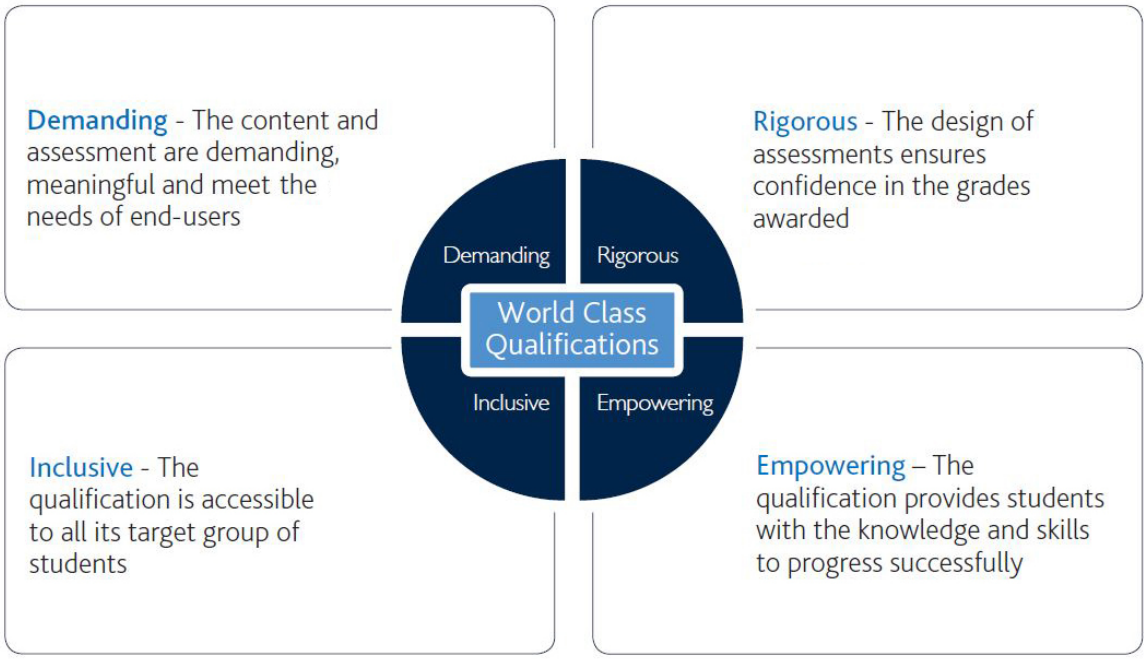
Appendices

Appendix 1: Codes

Type of code	Use of code	Code
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: WBI11/01 Unit 2: WBI12/01 Unit 3: WBI13/01 Unit 4: WBI14/01 Unit 5: WBI15/01 Unit 6: WBI16/01
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.	International Advanced Subsidiary – XBI11 International Advanced Level – YBI11
Entry codes	The entry codes are used to: • enter a student for the assessment of a unit • 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.

Appendix 2: Pearson World Class Qualification design principles

Pearson's World Class Qualification design principles mean that all Edexcel qualifications are developed to be **rigorous, demanding, inclusive and empowering**.



We work collaboratively to gain approval from an external panel of educational thought-leaders and assessment experts from across the globe. This is to ensure that Edexcel qualifications are globally relevant, represent world-class best practice in qualification and assessment design, maintain a consistent standard and support learner progression in today's fast-changing world.

Pearson's Expert Panel for World-Class Qualifications is chaired by Sir Michael Barber, a leading authority on education systems and reform. He is joined by a wide range of key influencers with expertise in education and employability.

"I'm excited to be in a position to work with the global leaders in curriculum and assessment to take a fresh look at what young people need to know and be able to do in the 21st century, and to consider how we can give them the opportunity to access that sort of education." Sir Michael Barber.

Endorsement from Pearson's Expert Panel for World Class Qualifications for the International Advanced Subsidiary (IAS)/International Advanced Level (IAL) development process

December 2015

"We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous world class qualification development process that has included, where appropriate:

- extensive international comparability of subject content against the highest-performing jurisdictions in the world
- benchmarking assessments against UK and overseas providers to ensure that they are at the right level of demand
- establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications.

Importantly, we have worked to ensure that the content and learning is future oriented, and that the design has been guided by Pearson's Efficacy Framework. This is a structured, evidenced process which means that learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education but as a result of our work as a panel we are confident that we have supported the development of Edexcel IAS and IAL qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice."

Sir Michael Barber (Chair)
Chief Education Advisor, Pearson plc

Professor Lee Sing Kong
Dean and Managing Director, National Institute of Education International, Singapore

Dr Peter Hill
Former Chief Executive ACARA

Bahram Bekhradnia
President, Higher Education Policy Institute

Professor Jonathan Osborne
Stanford University

Dame Sally Coates
Director of Academies (South), United Learning Trust

Professor Dr Ursula Renold
Federal Institute of Technology, Switzerland

Professor Bob Schwartz
Harvard Graduate School of Education

Professor Janice Kay
Provost, University of Exeter

Jane Beine
Head of Partner Development, John Lewis Partnership

Jason Holt
CEO, Holts Group

All titles correct as at December 2015.

Appendix 3: Transferable skills

The need for transferable skills

In recent years, higher-education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Cooperation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework [2] as the most evidence-based and robust skills framework, and have used this as a basis for our adapted skills framework.

The framework includes cognitive, intrapersonal skills and interpersonal skills.

The skills have been interpreted for this specification to ensure they are appropriate for the subject. All of the skills listed are evident or accessible in the teaching, learning and/or assessment of the qualifications. Some skills are directly assessed. Pearson materials will support you in identifying these skills and developing these skills in students.

The table overleaf sets out the framework and gives an indication of the skills that can be found in Biology and indicates the interpretation of the skill in this area. A full subject interpretation of each skill, with mapping to show opportunities for student development is given on the subject pages of our website: qualifications.pearson.com

[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)
[2] Koenig, J. A. (2011) *Assessing 21st Century Skills: Summary of a Workshop*, (National Academies Press, 2011)

Cognitive skills	Cognitive processes and strategies	• Critical thinking • Problem solving • Analysis • Reasoning/argumentation • Interpretation • Decision making • Adaptive learning • Executive function
	Creativity	• Creativity • Innovation
Intrapersonal skills	Intellectual openness	• Adaptability • Personal and social responsibility • Continuous learning • Intellectual interest and curiosity
	Work ethic/ conscientiousness	• Initiative • Self-direction • Responsibility • Perseverance • Productivity • Self-regulation (metacognition, forethought, reflection) • Ethics • Integrity
	Positive core self-evaluation	• Self-monitoring/ self-evaluation/ self-reinforcement
Interpersonal skills	Teamwork and collaboration	• Communication • Collaboration • Teamwork • Cooperation • Empathy/perspective taking • Negotiation
	Leadership	• Responsibility • Assertive communication • Self-presentation

Evaluate evidence related to biology and then bring it together to form a conclusion.

Taking responsibility for carrying out practical work in a safe manner, following all safety requirements.

Work with other students in practical work, so that the contribution of every student is encouraged and valued.

Appendix 4: Level 3 Extended Project qualification

What is the Extended Project?

The Extended Project is a stand-alone qualification that can be taken alongside International Advanced Level (IAL) qualifications. It supports the development of independent learning skills and helps to prepare students for their next step – whether that be higher education or employment. The qualification:

- is recognised by higher education for the skills it develops
- is worth half of an International Advanced Level (IAL) qualification at grades A*–E
- carries UCAS points for university entry.

The Extended Project encourages students to develop skills in the following areas: research, critical thinking, extended writing and project management. Students identify and agree a topic area of their choice for in-depth study (which may or may not be related to an IAL subject they are already studying), guided by their teacher.

Students can choose from one of four approaches to produce:

- a dissertation (for example an investigation based on predominately secondary research)
- an investigation/field study (for example a practical experiment)
- a performance (for example in music, drama or sport)
- an artefact (for example creating a sculpture in response to a client brief or solving an engineering problem).

The qualification is non-examination assessment based and students are assessed on the skills of managing, planning and evaluating their project. Students will research their topic, develop skills to review and evaluate the information, and then present the final outcome of their project.

The Extended Project has 120 guided learning hours (GLH) consisting of a 40-GLH taught element that includes teaching the technical skills (for example research skills) and an 80-GLH guided element that includes mentoring students through the project work. The qualification is 100% internally assessed and externally moderated.

How to link the Extended Project with biology

The Extended Project creates the opportunity to develop transferable skills for progression to higher education and to the workplace through the exploration of either an area of personal interest or a topic of interest from within the biology qualification content.

Through the Extended Project, students will develop skills that support their study of biology, including:

- conducting, organising and using research
- independent reading in the subject area
- planning, project management and time management
- stating a proposal to be tested in investigations
- collecting, handling and interpreting data and evidence
- evaluating arguments and processes, including arguments in favour of alternative interpretations of data and evaluation of experimental methodology
- critical thinking.

In the context of the Extended Project, critical thinking refers to the ability to identify and develop arguments for a point of view or hypothesis and to consider and respond to alternative arguments.

Types of Extended Project related to biology

Students may produce a dissertation on any topic that can be researched and argued. A dissertation might involve an investigation such as:

- Is it ethical to use stem cells for medical purposes?
- Should restrictions be placed on research into genetic enhancement?
- Is the use of animal experimentation justifiable?

The dissertation uses secondary research sources to provide a reasoned defence or a point of view, with consideration of counter-arguments.

An alternative might be an investigative project or field study involving the collection of data from primary research, for example:

- Can changing owl behaviour be monitored through pellet studies?
- How has marina development affected local marshland biodiversity?
- Can pollution be effectively monitored by water quality in a local stream?

There is also scope for biology-based artefact Extended Projects. For example, a student might set out to design, make and test an item of apparatus. Extended Projects involving a performance can also be biology based. For example, a social issue relating to biology could be explored through drama.

Using the Extended Project to support breadth and depth

In the Extended Project, students are assessed on the quality of the work they produce and the skills they develop and demonstrate through completing this work. Students should demonstrate that they have extended themselves in some significant way beyond what they have been studying in biology. Students can demonstrate extension in one or more dimensions:

- ***deepening understanding*** – where a student explores a topic in greater depth than in the specification content.
- ***broadening skills*** – where a student learns a new skill. In a biology-based project, this might involve learning to assemble and manipulate an unfamiliar piece of apparatus or learning advanced data-handling techniques.
- ***widening perspectives*** – where the student's project spans different subjects. This might involve discussing historical, philosophical or ethical aspects of a biology-based topic or making links with other subject areas such as chemistry or geography.

A wide range of information to support the delivery and assessment of the Extended Project, including the specification, teacher guidance for all aspects, an editable scheme of work and exemplars for all four approaches, can be found on our website.

Appendix 5: Glossary

Term	Definition
Assessment objectives	The requirements that students need to meet to succeed in the qualification. Each assessment objective has a unique focus, which is then targeted in examinations or coursework. Assessment objectives may be assessed individually or in combination.
External assessment	An examination that is held at the same time and place in a global region.
International Advanced Subsidiary	Abbreviated to IAS.
International Advanced Level	Abbreviated to IAL.
International A2 (IA2)	The additional content required for an IAL.
Modular	Modular qualifications contain units of assessment. These units can be taken during the course of study. The final qualification grade is worked out from the combined unit results.
Raw marks	Raw marks are the actual marks that students achieve when taking an assessment. When calculating an overall grade, raw marks often need to be converted so that it is possible to see the proportionate achievement of a student across all units of study.
Uniform Mark Scale (UMS)	Student actual marks (or raw marks) will be converted into a UMS mark so that it is possible to see the proportionate result of a student. Two units may each be worth 25% of a total qualification. The raw marks for each unit may differ, but the uniform mark will be the same.
Unit	A modular qualification will be divided into a number of units. Each unit will have its own assessment.

Appendix 6: Mathematical skills and exemplifications

In order to be able to develop their skills, knowledge and understanding in biology, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table on the following pages[3].

The assessment of quantitative skills will include at least 10% Level 2 or above mathematical skills. These skills will be applied in the context of biology.

All mathematical content will be assessed within the lifetime of the qualifications.

The following tables illustrate where these mathematical skills may be developed and could be assessed. Those shown in bold type would only be tested in the full International Advanced Level course.

This list of examples is not exhaustive. These skills could be developed in other areas of specification content.

[3] The information in this appendix has been taken directly from the document *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* published by the Department for Education (April 2014).

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(i) A.0 – arithmetic and numerical computation		
A.0.1	Recognise and make use of appropriate units in calculations	Candidates may be tested on their ability to: • convert between units, e.g. mm^3 to cm^3 as part of volumetric calculations • work out the unit for a rate, e.g. breathing rate
A.0.2	Recognise and use expressions in decimal and standard form	Candidates may be tested on their ability to: • use an appropriate number of decimal places in calculations, e.g. for a mean • carry out calculations using numbers in standard and ordinary form, e.g. use of magnification • understand standard form when applied to areas such as size of organelles • convert between numbers in standard and ordinary form • understand that significant figures need retaining when making conversions between standard and ordinary form, e.g. 0.0050 mol dm^{-3} is equivalent to 5.0×10^{-3} mol dm^{-3}
A.0.3	Use ratios, fractions and percentages	Candidates may be tested on their ability to: • calculate percentage yields • calculate surface area to volume ratio • use scales for measuring • represent phenotypic (monohybrid and dihybrid crosses)
A.0.4	Estimate results	Candidates may be tested on their ability to: • estimate results to sense check that the calculated values are appropriate
A.0.5	**Use calculators to find and use power, exponential and logarithmic functions**	**Candidates may be tested on their ability to:** • **estimate the number of bacteria grown over a certain length of time**

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

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

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

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

Appendix 7: Taxonomy

The following table lists the command words used across the IAS/IAL Science qualifications in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to stimulus material given in the question, for example labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included.
Comment on	Requires the synthesis of a number of factors from data/information to form a judgement. More than two factors need to be synthesised.
Compare and contrast	Looking for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete/Record	Requires the completion of a table/diagram/equation.
Criticise	Inspect a set of data, an experimental plan or a scientific statement and consider the elements. Look at the merits and/or faults of the information presented and back judgements made.
Deduce	Draw/reach conclusion(s) from the information provided.
Derive	Combine two or more equations or principles to develop a new equation.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively.
Devise	Plan or invent a procedure from existing principles/ideas.
Discuss	Identify the issue/situation/problem/argument that is being assessed within the question. Explore all aspects of an issue/situation/problem. Investigate the issue/situation/problem etc. by reasoning or argument.
Draw	Produce a diagram either using a ruler or using freehand.

Command word	Definition
Estimate	Give an approximate value for a physical quantity or measurement or uncertainty.
Evaluate	Review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer).
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result or outcome.
Show that	Prove that a numerical figure is as stated in the question. The answer must be to at least 1 more significant figure than the numerical figure in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axes with important features indicated, the axes are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Suggest	Use your knowledge and understanding in an unfamiliar context. May include material or ideas that have not been learnt directly from the specification.
Write	When the questions ask for an equation.

Appendix 8: Use of calculators

Students may use a calculator in the assessments for these qualifications. Centres are responsible for making sure that calculators used by their students meet the requirements given in the table below.

Students must be familiar with the requirements before their assessments for these qualifications.

<table>
<tr><td>Calculators must be:
of a size suitable for use on a desk
either battery or solar powered
free of lids, cases and covers that contain printed instructions or formulae.</td><td rowspan="2">Calculators must not:
be designed or adapted to offer any of these facilities:
language translators
symbolic algebraic manipulation
symbolic differentiation or integration
communication with other machines or the internet
be borrowed from another candidate during an examination for any reason*
have retrievable information stored in them. This includes:
databanks
dictionaries
mathematical formulae
text.</td></tr>
<tr><td>The candidate is responsible for the following:
the calculator’s power supply
the calculator’s working condition
clearing anything stored in the calculator.</td></tr>
</table>

*An invigilator may give a student a calculator.

Further information can be found in the JCQ documents *Instructions for conducting examinations* and *Information for candidates for written examinations*, available at www.jcq.org.uk/exams-office.

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REGISTERED OFFICE: 80 STRAND, LONDON WC2R 0RL
VAT REG NO GB 278 537121

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