OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL AS AND A-LEVEL BIOLOGY

(9610) Specification

For teaching from September 2016 onwards
For International AS exams May/June 2017 onwards
For International A-level exams May/June 2018 onwards
For teaching and examination outside the United Kingdom of Great Britain and Northern Ireland

CONTENTS

ARE YOU USING THE LATEST VERSION OF THIS SPECIFICATION?

- You will always find the most up-to-date version of this specification on our website at **oxfordaqaexams.org.uk/9610**
- We will write to you if there are significant changes to the specification.

1 INTRODUCTION

1.1 WHY CHOOSE OXFORD INTERNATIONAL AQA EXAMINATIONS FOR INTERNATIONAL AS AND A-LEVELS?

Our new international qualifications enable schools that follow a British curriculum to benefit from the best education expertise in the United Kingdom (UK).

Our International AS and A-levels offer the same rigour and high quality as AS and A-levels in the UK and are relevant and appealing to students worldwide. They reflect a deep understanding of the needs of teachers and schools around the globe and are brought to you by Oxford University Press and AQA, the UK's leading awarding body.

Providing valid and reliable assessments, these qualifications are based on over 100 years of experience, academic research and international best practice. They have been independently validated as being to the same standard as the qualifications accredited by the UK examinations regulator, Ofqual. They reflect the latest changes to the British system, enabling students to progress to higher education with up-to-date qualifications.

You can find out about Oxford International AQA Examinations at **oxfordaqaexams.org.uk**

1.2 WHY CHOOSE OUR INTERNATIONAL AS AND A-LEVEL BIOLOGY?

In developing our specifications, we consulted widely with teachers, learned societies and professionals from universities and industry. Our content is designed to stimulate student's interest in, and enthusiasm for, biology and provides an excellent grounding for further study.

Our assessments reward students' knowledge, understanding and application of a wide range of biology topics. These include all of those topics that universities expect students to understand in order to progress to higher education. This specification includes a number of areas, such as discussion of disease, which are particularly relevant to students studying in an international context.

Our International exams include a range of question styles, allowing students to demonstrate a range of skills. Our extensive experience allows us to write exams which are challenging but do not put unhelpful barriers to students. For example, we have a reduced word count in questions, eliminating any information that is not required for students to answer the question. This will particularly help students who speak English as a second language.

Practical work is at the heart of science. Our specification includes ten required practicals that have been designed to give students a broad range of practical experiences. These will be assessed via the written papers, giving more flexibility to schools allowing them to choose how to deliver practical work through their teaching. The required practicals have also been chosen to minimise the use of resources or equipment that could potentially present difficulties in resourcing. This method of assessing practical work ensures all students are given the opportunity to gain key skills without the pressures of coursework or practical exams.

Our clear modular structure allows teachers to plan delivery of the content, and for students to be able to prepare for each exam appropriately. The knowledge and understanding from each module builds on the previous ones, and the skills required for each exam build to allow students to gain confidence in their practical, mathematical and communications skills as they learn.

Helpful resources support this specification. These include schemes of work and a Practical handbook which harmonises the rules for International A-level Biology, Chemistry and Physics. This allows your students to be confident in the knowledge that they are using the same rule in each of their Oxford International AQA Examinations. The Practical handbook also includes example methods for each of the required practicals, allowing you to plan your practical work with confidence.

You can find out about all our International AS and A-level Biology qualifications at **oxfordaqaexams.org.uk/science**

1.3 RECOGNITION

Oxford International AQA Examinations (OxfordAQA Exams) meet the needs of international students. Please refer to the published timetables on the exams administration page of our website (**oxfordaqaexams.org.uk/exams-administration**) for up to date exam timetabling information. They are an international alternative and comparable in standard to the Ofqual regulated qualifications offered in the UK.

Our qualifications have been independently benchmarked by UK NARIC, the UK national agency for providing expert opinion on qualifications worldwide. They have confirmed they can be considered 'comparable to the overall GCE A-level and GCSE standard offered in the UK'. Read their report at **oxfordaqaexams.org.uk/recognition**

To see the latest list of universities who have stated they accept these International qualifications, visit **oxfordaqaexams.org.uk/recognition**

1.4 SUPPORT AND RESOURCES TO HELP YOU TEACH

We know that support and resources are vital for your teaching and that you have limited time to find or develop good quality materials. That's why we've worked with experienced teachers to provide you with resources that will help you confidently plan, teach and prepare for exams.

TEACHING RESOURCES

You will have access to:

- sample schemes of work to help you plan your course with confidence
- teacher guidance notes to give you the essential information you need to deliver the specification
- training courses to help you deliver our qualifications
- student textbooks that have been checked and approved by us
- engaging worksheets and activities developed by teachers, for teachers.

PREPARING FOR EXAMS

You will have access to the support you need to prepare for our exams, including:

- specimen papers and mark schemes
- exemplar student answers with examiner commentaries
- a searchable bank of past AQA exam questions mapped to these new International qualifications.

ANALYSE YOUR STUDENTS' RESULTS WITH ENHANCED RESULTS ANALYSIS (ERA)

After the first examination series, you can use this tool to see which questions were the most challenging, how the results compare to previous years and where your students need to improve. ERA, our free online results analysis tool, will help you see where to focus your teaching.

Information about results, including maintaining standards over time, grade boundaries and our post-results services, will be available on our website in preparation for the first examination series.

HELP AND SUPPORT

Visit our website for information, guidance, support and resources at **oxfordaqaexams.org.uk/9610**

You can contact the subject team directly at **science@oxfordaqaexams.org.uk**

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

2 SPECIFICATION AT A GLANCE

The titles of the qualifications are:

- OxfordAQA International Advanced Subsidiary Biology
- OxfordAQA International Advanced Level Biology.

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level. The International AS can be taken as a stand-alone qualification or can be used to count towards the International A-level. Students can take the International AS in the first year and then take the International A2 in the second year to complete the International A-level or they can take all the units together in the same examination series at the end of the course.

The International AS content will be 50 % of the International A-level content but International AS assessments will contribute 40 % of the total marks for the full International A-level qualification with the remaining 60 % coming from the International A2 assessments.

Candidates may re-sit a unit any number of times within the shelf-life of the specification. The best result for each unit will count towards the final qualification. Exams will be available in January and May/June.

The guided learning hours (GLH) for an OxfordAQA International Advanced Subsidiary is 180.

The guided learning hours (GLH) for an OxfordAQA International Advanced Level is 360.

These figures are for guidance only and may vary according to local practice and the learner's prior experience of the subject.

2.1 SUBJECT CONTENT

INTERNATIONAL AS AND A-LEVEL

Unit 1. The diversity of living organisms

Unit 2. Biological systems and disease

INTERNATIONAL A-LEVEL ONLY

Unit 3. Populations and genes

Unit 4. Control

2.2 INTERNATIONAL AS

ASSESSMENTS

Unit 1: The diversity of living organisms	+	Unit 2: Biological systems and disease
What's assessed Any content in Unit 1 including relevant practical skills.		**What's assessed** Any content from Unit 2 including relevant practical skills. Although questions will not be set on topics from Unit 1, questions may draw on the biological principles specified for Unit 1.
How it's assessed Written exam: 1 hour 30 minutes 75 marks 50 % of the International AS assessment 20 % of the International A-level assessment		**How it's assessed** Written exam: 1 hour 30 minutes 75 marks 50 % of the International AS assessment 20 % of the International A-level assessment
Questions 65 marks: short answer questions. 10 marks: comprehension question.		**Questions** 65 marks: short answer questions. 10 marks: structured question requiring continuous prose.

2.3 INTERNATIONAL A2

ASSESSMENTS

Unit 3: Populations and genes	+	Unit 4: Control	+	Unit 5: Synoptic paper
What's assessed Any content from Unit 3 including relevant practical skills. Although questions will not be set on topics from Units 1 or 2, questions may draw on understanding of the biological principles from these units.		**What's assessed** Any content from Unit 4 including relevant practical skills. Although questions will not be set on topics from Units 1 – 3, questions may draw on understanding of the biological principles from these units.		**What's assessed** Any content from Units 1 – 4.
How it's assessed Written exam: 1 hour 30 minutes 75 marks 20 % of International A-level		**How it's assessed** Written exam: 1 hour 30 minutes 75 marks 20 % of International A-level		**How it's assessed** Written exam: 1 hour 30 minutes 75 marks 20 % of International A-level
Questions 60 marks: a mixture of short and long answer questions. 15 marks: structured question requiring continuous prose.		**Questions** 60 marks: a mixture of short and long answer questions. 15 marks: structured question requiring critical analysis of data.		**Questions** 55 marks: short answer questions based on practical work related to this specification. 20 marks: structured synoptic question requiring an answer in continuous prose.

3 SUBJECT CONTENT

3.1 UNIT 1: THE DIVERSITY OF LIVING ORGANISMS

The variety of life is extensive and is reflected in the similarities and differences in its biochemical basis and cellular organisation. Factors such as size and metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised gas-exchange surfaces.

Classification is based on the concept of a species and is a way of organising the variety of life based on relationships between organisms. Although a species may be defined in terms of similarity, there is frequently considerable intraspecific variation and this is influenced by both genes and the environment. Variation both within and between species contributes to the biodiversity of communities and ecosystems.

3.1.1 BIOLOGICAL MOLECULES

3.1.1.1 Monomers and polymers

Monomers are the smaller units which may be joined together to form polymers.

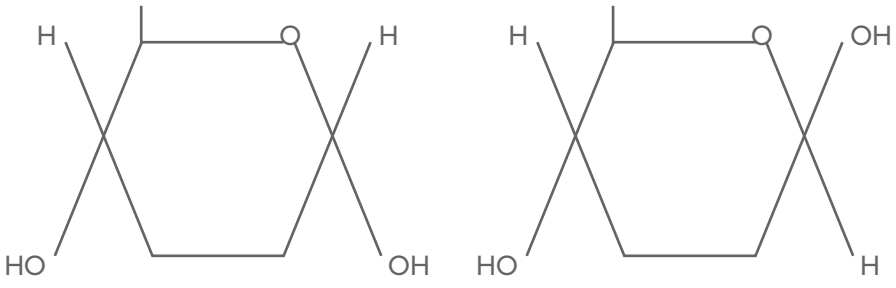
Condensation is the joining together of molecules with a chemical bond and the elimination of a molecule of water.

Hydrolysis is the breaking of the chemical bond between two molecules in a reaction involving a water molecule.

3.1.1.2 Carbohydrates

The monomers from which larger carbohydrates are made are monosaccharides. Common monosaccharides are glucose and fructose.

Glucose exists as two isomers, α-glucose and β-glucose. These isomers have the following chemical structure.



α-glucose β-glucose

Two monosaccharides may join by condensation to form a glycosidic bond. Disaccharides are formed by the condensation of two monosaccharides.

- Maltose is a disaccharide formed from two α-glucose molecules.
- Sucrose is a disaccharide formed from an α-glucose molecule and a fructose molecule.

Many monosaccharides may join by condensation to form a polysaccharide.

- Starches are composed of amylose and amylopectin and formed by the condensation of α-glucose.
- Cellulose is formed by the condensation of β-glucose.

The relationship of the structure of starch and cellulose to their functions in the cells of plants.

Biochemical tests using Benedict's reagent for reducing and non-reducing sugars and iodine/potassium iodide solution for starch.

Students should:

- when provided with the relevant molecular structures or formulae, be able to demonstrate how carbohydrates other than those specified in this section may be joined by condensation or broken down by hydrolysis.

3.1.1.3 Lipids

Triglycerides are formed by the condensation of one glycerol molecule and three fatty acid molecules. Ester bonds are formed as a result.

A fatty acid may be represented by the chemical formula RCOOH. The R-group may be either saturated or unsaturated.

In phospholipids, one of the fatty acids is substituted by a phosphate-containing group.

The different structures of saturated triglycerides, unsaturated triglycerides and phospholipids result in different properties and different functions in living organisms.

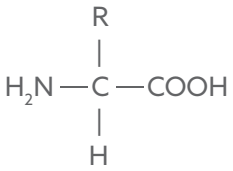
The emulsion test for lipids.

Students should be able to:

- recognise different types of lipid from diagrams and formulae showing molecular structure.

3.1.1.4 Proteins

The monomers from which proteins are made are amino acids. Amino acids have the following general structure.



There are twenty amino acids that are common in all organisms and they differ only in their R-groups.

Amino acids may join by condensation to form a peptide bond. Dipeptides are formed by the condensation of two amino acids. Polypeptides are formed by the condensation of many amino acids.

The role of hydrogen bonds and disulfide bridges in the structure of proteins.

The relationship between primary, secondary, tertiary and quaternary structure and protein function.

The biuret test for proteins.

Students should be able to:

- relate the properties of proteins that are named in this specification to their structure.

3.1.2 CELLS AND CELL STRUCTURE

3.1.2.1 The structure of eukaryotic cells

Microscopes are important tools in the study of cells. The principles and limitations of optical microscopes, transmission electron microscopes and scanning electron microscopes.

The difference between magnification and resolution.

The principles of cell fractionation and ultracentrifugation in the separation of cell components.

The appearance, ultrastructure and function of:

- plasma membranes including the cell-surface membrane
- cell wall
- nucleus
- mitochondria
- chloroplasts
- Golgi apparatus
- lysosomes
- ribosomes
- rough endoplasmic reticulum and smooth endoplasmic reticulum
- cell vacuole.

In complex multicellular organisms, eukaryotic cells have specific functions. Cells are organised into tissues, tissues into organs and organs into systems.

Students should be able to:

- use the formula, magnification = $\frac{\text{size of image}}{\text{size of object}}$
- identify specific organelles from photographs taken using optical or electron microscopes.

3.1.2.2 The structure of prokaryotic cells

Prokaryotic cells are smaller than eukaryotic cells and differ in having:

- cytoplasm lacking in membrane-bounded organelles
- small ribosomes
- no nucleus; their DNA forms a circular molecule that is not associated with proteins and is free in the cytoplasm
- a cell wall containing the glycoprotein murein.

In addition, many prokaryotic cells have:

- one or more plasmids
- a capsule surrounding the cell
- one or more flagella.

3.1.3 BIOCHEMICAL REACTIONS IN CELLS ARE CONTROLLED BY ENZYMES

3.1.3.1 Enzymes and enzyme action

Enzymes are proteins and their properties depend on the tertiary structure of their active sites. They combine with a complementary substrate to form an enzyme-substrate complex.

An enzyme lowers the activation energy of the reaction that it catalyses.

Models of enzyme action have changed over time. This is illustrated by the lock and key and induced fit models of action.

3.1.3.2 The properties of enzymes

Enzymes are catalysts that are specific in their action.

The rate of reaction of an enzyme is related to number of collisions that take place between an enzyme and its substrate. This explains the effect of the following factors on the rate of an enzyme-controlled reaction:

- temperature
- substrate concentration
- enzyme concentration.

The rate of reaction is also related to the ability of the active site to bind with complementary substrate molecules. This explains the effect of the following factors on the rate of an enzyme-controlled reaction:

- temperature
- pH
- competitive and non-competitive inhibitors.

3.1.4 TRANSPORT INTO AND OUT OF CELLS

3.1.4.1 Plasma membranes

The arrangement of phospholipids, proteins and carbohydrates in the fluid-mosaic model of membrane structure. Cholesterol may also be present and restricts the movement of other molecules making up the membrane.

The role of microvilli in increasing the surface area of cell-surface membranes.

3.1.4.2 Diffusion

Diffusion as the passive movement of substances down a concentration gradient. Diffusion across plasma membranes may be limited by the nature of the phospholipid bilayer.

Surface area, difference in concentration and the thickness of the exchange surface affect the rate of diffusion.

Facilitated diffusion involves the use of proteins. These may act as carriers or provide channels.

Osmosis is a special case of diffusion in which water moves from a solution of higher water potential to one of lower water potential through a partially permeable membrane.

3.1.4.3 Active transport

The role of carrier proteins and ATP in the transport of substances against a concentration gradient.

ATP may be synthesised from ADP and phosphate and provides the immediate source of energy for biological processes.

Students should be able to:

- relate the structure and properties of exchange surfaces to their function.

3.1.5 GAS EXCHANGE AND THE TRANSPORT OF OXYGEN IN LIVING ORGANISMS

3.1.5.1 Surface area to volume relationship

The relationship between the size of an organism and its surface area to volume relationship.

Differences in body shape and the development of systems in larger organisms are adaptations that facilitate exchange as the relationship between surface area and volume changes.

In large organisms the efficient supply of materials, such as oxygen, is achieved by mass transport.

3.1.5.2 Gas exchange systems

The adaptations of gas exchange systems as shown by gas exchange:

- across the body surface of a single-celled organism
- in the tracheal system of an insect
- by the leaves of a dicotyledonous plant.

Structural and functional compromises between the opposing needs for efficient gas exchange and the limitation of water loss shown by terrestrial insects and xerophytic plants.

The gross structure of the human gas exchange system, limited to the alveoli, bronchioles, bronchi, trachea and lungs. The essential features of the alveolar epithelium and capillaries as a gas exchange surface. The mechanism of breathing to include the role of the diaphragm and the intercostal muscles in bringing about pressure and volume changes in the thoracic cavity.

Students should be able to:

- use the principles involved in the exchange of gases to identify and explain the adaptations of unfamiliar examples of gas exchange surfaces
- interpret data relating to the effects of lung disease on gas exchange and ventilation.

3.1.5.3 Haemoglobin and the transport of oxygen

The general pattern of blood circulation in a mammal involving arteries, capillaries and veins. Names are required only of the coronary arteries and of vessels entering and leaving the heart and liver.

The role of haemoglobin and red blood cells in the transport of oxygen in relation to the oxygen-haemoglobin dissociation curve. The effect of carbon dioxide on the transport of oxygen by haemoglobin.

The haemoglobins are a group of chemically similar molecules found in many different organisms. They have a similar chemical structure consisting of a number of polypeptide globin chains each of which is associated with an iron-containing haem group. Many animals are adapted to their environments by possessing different types of haemoglobin with different oxygen-transporting properties.

Students should be able to:

- relate the oxygen transporting properties of different types of haemoglobin to the environment and way of life of the organism concerned.

3.1.6 LIVING ORGANISMS VARY

Intraspecific variation is variation between members of a species. Interspecific variation is variation between species.

In investigations of intraspecific variation, the need for random sampling and the importance of chance in contributing to the difference between samples. The importance of appropriate sample size in ensuring that data are representative.

The concept of normal distribution about a mean. Understanding of mean and standard deviation as measures of variation within a sample. Students will **not** be required to calculate standard deviation in questions on written papers.

Similarities and differences between individuals within a species may be the result of genetic factors, differences in environmental factors or a combination of both.

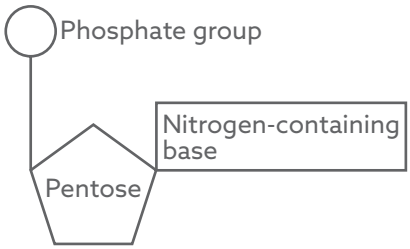
Students should be able to:

- analyse and interpret data referring to intraspecific and interspecific variation.

3.1.7 DNA, GENES AND CHROMOSOMES

3.1.7.1 The structure of nucleic acids

Both DNA and RNA are polymers of nucleotides. Each nucleotide is formed from a pentose, a phosphate group and a nitrogen-containing organic base. Nucleotides have the following general structure.



DNA nucleotides consist of deoxyribose, a phosphate group and one of the bases adenine, cytosine, guanine or thymine.

A molecule of DNA is a double helix with two polynucleotide chains held together by hydrogen bonds formed between complementary base pairs.

RNA nucleotides consist of ribose, a phosphate group and one of the organic bases adenine, cytosine, guanine or uracil

A molecule of RNA is a relatively short polynucleotide chain.

The structure of mRNA and tRNA.

3.1.7.2 DNA, genes and chromosomes

In the nucleus of a eukaryotic cell, DNA is in the form of linear molecules which are associated with proteins. Some of these proteins are the histones that package and order DNA to form a chromosome.

The DNA found in mitochondria and chloroplasts, and in prokaryotic cells is shorter in length, circular and is not associated with proteins.

Most genes occupy fixed positions called loci on particular DNA molecules. A gene is a section of DNA that codes for polypeptides that determine the nature and development of an organism.

In eukaryotes, much of the nuclear DNA does not code for polypeptides. There are non-coding multiple repeats of base sequences between genes. Even within a gene, only some sequences, called exons, code for amino acid sequences. Within the gene, these exons are separated by non-coding sequences called introns.

The concept of the genome as the complete set of genes in a cell.

3.1.7.3 DNA replication

The semi-conservative replication of DNA in terms of:

- the unwinding of the double helix
- breakage of hydrogen bonds between complementary base pairs
- the role of DNA helicase in unwinding DNA and breaking hydrogen bonds
- attraction of new DNA nucleotides to exposed bases on template strands and base pairing
- the role of DNA polymerase in joining DNA nucleotides.

3.1.8 PROTEIN SYNTHESIS

3.1.8.1 The genetic code

The genetic code as base triplets that code for specific amino acids.

The genetic code is universal, non-overlapping and degenerate.

3.1.8.2 Polypeptide synthesis

Transcription as the production of mRNA from DNA. The role of RNA polymerase in joining MRNA nucleotides.

- In prokaryotes, transcription results directly in the production of mRNA from DNA.
- In eukaryotes, transcription results in the production of pre-mRNA. Pre-mRNA is then spliced to form mRNA.

Translation is the production of polypeptides from the sequence of codons on mRNA. The roles of ribosomes, tRNA and ATP.

3.1.8.3 Protein folding

Protein folding as the process by which a polypeptide folds into its characteristic three-dimensional structure.

Protein folding is determined by the amino acid sequence of the polypeptide. Specialised proteins, called chaperones, assist in the folding of other proteins.

Students should be able to:

- relate base sequences of nucleic acids to the amino acid sequence of a polypeptide when provided with suitable information relating to the genetic code.

Students will **not** be required to recall in written papers specific codons and the amino acids for which they code.

3.1.9 GENETIC DIVERSITY MAY ARISE BY MEIOSIS

3.1.9.1 Meiosis

Meiosis results in daughter cells that are genetically different from each other. The process should be studied only in sufficient detail to show how:

- nuclear divisions result in the formation of haploid daughter cells from a single diploid parent cell
- independent segregation of homologous chromosomes results in genetically different daughter cells as a result of different combinations of maternal and paternal chromosomes
- crossing over between homologous chromosomes results in further genetic variation among daughter cells.

Random fertilisation of haploid gametes further increases genetic variation within a species.

Students should be able to:

- describe and explain chromosomal behaviour in appropriate drawings or photographs of meiosis.

3.1.10 SPECIES AND TAXONOMY

3.1.10.1 The concept of a species

Species as the basic unit of biological classification.

A species may defined as the largest group of organisms capable of interbreeding and producing fertile offspring.

Each species is universally identified by a binomial consisting of the name of its genus and species.

Students should be able to:

- recognise the difficulty of defining species and examine critically the definition of a species given above when provided with data relating to specific examples.

3.1.10.2 Biological classification

Biological classification attempts to arrange species in groups that reflect their relationships and may reflect their evolutionary origins. It uses a hierarchy in which smaller groups are placed within larger groups. Each group is called a taxon.

One taxonomic hierarchy comprises the taxa: domain, kingdom, phylum, class, order, family, genus and species.

Students should be able to:

- use given data to show how immunology and genome sequencing help to clarify taxonomic relationships between organisms.

3.1.11 BIODIVERSITY WITHIN A COMMUNITY

3.1.11.1 Genetic diversity

Genetic diversity within, or between, species can be measured by comparing:

- the base sequence of DNA or of mRNA
- the frequency of specific base sequences or alleles in populations
- the amino acid sequence of encoded proteins.

Students should be able to:

- interpret data relating to similarities and differences in base sequences of DNA or in amino acid sequences to suggest relationships between different organisms.

3.1.11.2 Species diversity

Species richness is a measure of the number of different species in a community.

Biodiversity can also be measured by calculating an index. An index of diversity describes the relationship between the number of different species in a community and the number of individuals in each species.

One example of an index of diversity is:

$$d = \frac{N\,(N\text{-}1)}{\sum n\,(n\text{-}1)}$$

where N = total number of organisms of all species and n = total number of organisms of each species.

Many human activities reduce biodiversity.

The balance between human food production and conservation.

Students should be able to:

- recall the formula for the index of diversity and use it to calculate values from given data.

PRACTICAL ACTIVITIES

In the context of Unit 1, students following this course must carry out the practical activities listed below. The International AS written papers will test students' knowledge and understanding of the procedures involved as well as evaluation of the techniques adopted. They may also require students to interpret specimen results.

Required practical 1:
Investigation of the effect of temperature, pH, or substrate concentration on the rate of an enzyme-controlled reaction.

Required practical 2:
Investigation of the effect of solute concentration on the uptake or loss of water from plant tissue.

Required practical 3:
Use of chromatography to investigate the pigments present in leaves.

BIOLOGICAL PRINCIPLES

When they have completed this unit, students will be expected to have an understanding of the following principles.

- Many biological molecules are made up of monomers linked by condensation. The resulting polymers can be broken down to their constituent monomers by hydrolysis.
- Many of the functions of proteins may be explained in terms of molecular structure and shape.
- Enzymes are proteins and the rates of the reactions they catalyse are influenced by a range of factors: temperature, pH, the presence of inhibitors and substrate and enzyme concentrations.
- Substances are exchanged by passive or active transport across exchange surfaces. The structure of plasma membranes enables control of the passage of substances across them.
- Size and the relationship between surface area and volume are of fundamental importance in exchange.
- Genes are sections of DNA that code for the amino acid sequence of proteins.
- Meiosis produces daughter cells that are genetically different from each other.
- A species may be defined in terms of the ability to produce fertile offspring.

An understanding of these principles may be required to develop the knowledge specified in Units 2, 3 and 4. Examiners may draw on this understanding in the Unit 2, 3 or 4 exams although they will not set specific questions based on topics from Unit 1.

3.2 UNIT 2: BIOLOGICAL SYSTEMS AND DISEASE

The digestive system is an example of a system in which an organism exchanges substances with its environment. Mass transport systems ensure efficient movement from exchange surfaces in large organisms. In a mammal, mass transport is by way of the blood system; in a flowering plant, by the xylem and phloem. The systems described in this unit, as well as others in the body, may be affected by disease. Some of these diseases, such as cholera or HIV/AIDS may be caused by microorganisms. Other non-communicable diseases such as those affecting the heart and circulatory system and cancers also have a significant impact on human health. Knowledge of biology allows us not only to explain symptoms but also to interpret data relating to risk factors. The blood has a number of defensive functions, which, together with the use of drugs, helps to limit the spread and effects of disease.

3.2.1 THE CAUSES OF DISEASE: PATHOGENS, LIFESTYLE AND GENES

3.2.1.1 Pathogens

Pathogens are agents of infection and include bacteria and viruses.

Disease can result when pathogens penetrate any of an organism's interfaces with the environment. In a mammal these include the digestive, reproductive and gas-exchange systems.

Pathogens cause disease by damaging the cells of the host and by producing toxins.

3.2.1.2 Lifestyle, coronary heart disease and cancer

Specific risk factors are associated with coronary heart disease and cancer.

Changes in lifestyle may be associated with a reduced risk of contracting these conditions.

Students should be able to:

- analyse, interpret and evaluate data associated with specific risk factors and the incidence of disease.

3.2.2 DIGESTION AND ABSORPTION

3.2.1.1 The human digestive system

The gross structure of the human digestive system limited to oesophagus, stomach, duodenum, ileum, colon and rectum. The glands associated with the system, limited to salivary glands and pancreas.

Digestion is the process in which large molecules are hydrolysed by enzymes to produce smaller molecules. The products of digestion can be absorbed and assimilated. Undigested food is egested as faeces.

3.2.1.2 Digestion

In the human digestive system, digestion of:

- carbohydrates by amylases and membrane-bound disaccharidases
- lipids by lipases
- proteins by endopeptidases, exopeptidases and membrane-bound dipeptidases.

The role of bile salts in facilitating the digestion of lipids.

3.2.1.3 Absorption

The histological structure of the ileum in relation to its absorptive function.

The roles of diffusion, active transport and co-transport involving sodium ions in the absorption of monosaccharides and amino acids.

The role of micelles in the absorption of lipids and their transport as chylomicrons.

3.2.3 CHOLERA

3.2.3.1 Cholera and its symptoms

Cholera bacteria secrete toxins which increase the secretion of chloride ions into the lumen of the intestine. This affects the water potential gradient across the intestinal epithelium and results in severe diarrhoea.

3.2.3.2 Oral rehydration

The use of oral rehydration solutions (ORS) in the treatment of cholera and other diarrhoeal diseases.

Students should be able to:

- discuss the applications and implications of science in developing improved oral rehydration solutions
- discuss the ethical implications of trialling improved oral rehydration solutions on humans.

3.2.4 HIV AS AN EXAMPLE OF A HUMAN DISEASE CAUSED BY A VIRUS

3.2.4.1 The structure of HIV

The structure of a human immunodeficiency virus (HIV) to include:

- genetic material in the form of RNA
- a protein capsid enclosing the genetic material and the enzymes reverse transcriptase, integrase, and protease
- an envelope originating from the host cell plasma membrane and containing glycoproteins.

3.2.4.2 The replication cycle of HIV

HIV binds to receptors on CD4 helper T-cells. These are cells that initiate the body's response to infections.

The contents of the HIV capsid including the RNA and the viral enzymes are released into the host cell.

The viral RNA genome is transcribed into double-strand DNA, which is then integrated into a host cell chromosome.

The viral DNA may be transcribed producing new viral RNA and proteins. These are packaged and released from the cell as new virus particles, completing the replication cycle.

Students should be able to:

- use their knowledge of the structure and replication cycle of HIV to explain the effects of drugs used in treatment of HIV/AIDS when provided with appropriate information.

3.2.5 THE DEFENSIVE FUNCTIONS OF MAMMALIAN BLOOD

3.2.5.1 The principles of immunology

A cell has specific molecules on its surface that identify it. These molecules include proteins and enable the immune system to identify pathogens and toxins, cells from other organisms of the same species and abnormal body cells.

Definition of antigen. The effect of antigen variability on disease and its prevention.

T cells are involved in cell-mediated immunity whereas B cells are primarily responsible for humoral immunity. Humoral immunity involves the production and release of antibodies.

Phagocytosis of pathogens and subsequent digestion by lysosomes.

3.2.5.2 The response of B cells to a foreign antigen

The role of antigen-presenting cells.

Definition of an antibody and its structure.

The formation of an antigen-antibody complex leading to the destruction of the antigen, limited to agglutination and phagocytosis of bacterial cells.

3.2.5.3 Vaccination

The roles of plasma cells and memory cells in producing the primary and secondary immune response.

The use of vaccines to provide protection for individuals and populations against disease. The concept of herd immunity.

The differences between active and passive immunity.

Students should be able to:

- evaluate methodology, evidence and data relating to the trialling and use of vaccines.

3.2.6 THE CIRCULATION OF BLOOD AND THE STRUCTURE OF THE MAMMALIAN HEART

3.2.6.1 The mammalian blood system

The structure of arteries, veins and capillaries in relation to their function.

The structure of capillaries and their importance in metabolic exchange. The formation of tissue fluid and its return to the circulatory system.

3.2.6.2 Heart structure and function

The gross structure of the mammalian heart and its associated blood vessels in relation to function.

Pressure and volume changes and associated movements of the atrioventricular and semilunar valves.

Cardiac output as the product of heart rate and stroke volume.

Students should be able to:

- analyse and interpret data relating to pressure and volume changes during the cardiac cycle.

3.2.7 HEART DISEASE MAY BE ASSOCIATED WITH SPECIFIC RISK FACTORS

3.2.7.1 The biological basis of heart disease

Atheroma as the presence of lipid-containing material within the walls of the arteries. The link between atheroma and the increased risk of aneurysm and thrombosis.

Myocardial infarction and its cause in terms of an interruption of blood flow to cardiac muscle.

3.2.7.2 Risk factors associated with coronary heart disease

Risk factors associated with coronary heart disease: diet, blood cholesterol, cigarette smoking and high blood pressure.

Students should be able to:

- analyse, interpret and evaluate data associated with specific risk factors and the incidence of coronary heart disease.

3.2.8 MASS TRANSPORT SYSTEMS IN PLANTS

3.2.8.1 Xylem and the passage of water and mineral ions through a plant

The structure of a dicotyledonous root in relation to the pathway of water from root hairs, through the cortex and endodermis to the xylem. Apoplastic and symplastic pathways.

The role of root pressure in moving water through the xylem.

Transpiration and the effects of light, temperature, humidity and air movement.

3.2.8.2 Phloem and the passage of organic substances through a plant

The mass flow hypothesis as an explanation of the mechanism of translocation in plants.

Students should be able to:

- analyse and interpret evidence from experiments related to the movement of water through the xylem and organic substances through phloem.

3.2.9 THE ROLE OF APHIDS IN SPREADING PLANT VIRUSES

3.2.9.1 Plant virus diseases

Many important plant diseases are caused by viruses. They are responsible for losses in crop production and quality of produce in all parts of the world.

Infected plants may show a range of symptoms depending on the disease. There may be yellowing of leaves, leaf distortion or abnormalities of other parts of the plant.

As plants are immobile, transmission of viruses usually involves vectors such as aphids.

3.2.9.2 Aphids as feeders on phloem sap

Aphids have sucking mouthparts called stylets. They feed by inserting the stylets into phloem vessels. Once a phloem vessel is punctured, the sap, which is under high pressure, is forced into the aphid's gut.

Some species produce winged females which migrate to start colonies on a new host plant.

3.2.10 CELLS DIVIDE BY BINARY FISSION AND MITOSIS

3.2.10.1 The cell cycle

Eukaryotic cells that retain the ability to divide, show a cell cycle.

The period between mitotic divisions is interphase. Interphase may be divided into three phases.

- In the G_1 phase, a cell increases its protein content and the number of organelles such as mitochondria and ribosomes and grows in size.
- In the S-phase, DNA is replicated.
- In the G_2 phase rapid cell growth and protein synthesis occur.

3.2.10.2 Mitosis

The part of the cell cycle during which a eukaryotic cell divides to produce two daughter cells, each with identical DNA is mitosis.

The behaviour of chromosomes during interphase, prophase, metaphase, anaphase and telophase. The role of spindle fibres attached to centromeres in the separation of chromatids.

Students should be able to:

- recognise interphase and the stages of mitosis from appropriate drawings or photographs.

3.2.10.3 Binary fission

Prokaryotic cells divide by binary fission. During this process:

- the circular DNA and plasmids replicate
- the cytoplasm replicates to produce two daughter cells. Each of these cells has a single copy of the circular DNA but the number of plasmids may vary.

DNA may also be passed from one species of bacterium to another during conjugation. This is horizontal gene transmission.

3.2.11 MUTATION AND CANCER

3.2.11.1 Gene mutations

Gene mutations involve a change in the base sequence of DNA. They arise spontaneously during DNA replication. Mutagens are physical or chemical agents that increase the frequency of mutations.

Base deletion and base substitution as examples of gene mutation.

Because of the degenerative nature of the genetic code, not all mutations result in a change in the sequence of the encoded amino acids.

Students should be able to:

- predict the outcome of specific mutations on amino acid sequences when provided with suitable information relating to the genetic code.

3.2.11.2 Mutations and cancers

The main characteristics of benign and malignant tumours.

The rate of cell division is controlled by proto-oncogenes that stimulate cell division and by tumour suppressor genes that slow cell division.

A mutated proto-oncogene, called an oncogene, stimulates cells to divide too quickly. A mutated tumour suppressor gene is inactivated, allowing the rate of cell division to increase.

Students should be able to:

- analyse, interpret and evaluate data associated with specific risk factors and the incidence of particular cancers
- relate their understanding of the cell cycle to drugs used in the treatment of cancer.

PRACTICAL ACTIVITIES

In the context of Unit 2, students following this course must carry out the practical activities listed below. The International AS written papers will test students' knowledge and understanding of the procedures involved as well as evaluation of the techniques adopted. They may also require students to interpret specimen results.

Required practical 4:
Preparation of stained squashes of root tips and examination of these with a microscope. Observation of the stages of mitosis and calculation of a mitotic index.

Required practical 5:
Investigation of the effect of a specific variable on human heart rate or pulse rate.

Required practical 6:
Investigation of the rate of water uptake by means of a simple potometer.

BIOLOGICAL PRINCIPLES

When they have completed this unit, students will be expected to have an understanding of the following principles.

- In the human digestive system, food is digested by enzymes and the products of digestion across cell membranes.
- Viruses are acellular and non-living. Following injection of their nucleic acid, the infected host cell replicates the virus particles.
- A cell has specific molecules on its surface that identify it. These molecules include proteins and enable the immune system to identify pathogens and toxins, cells from other organisms of the same species and abnormal body cells.
- The blood system contains arteries, veins and capillaries. The structure of these vessels is related to their function.
- Investigations of the epidemiology of disease frequently identify correlations. Correlation between variables does not necessarily mean that there is a causal relationship.
- During mitosis the parent cell divides to produce genetically identical offspring.

An understanding of these principles may be required to develop the knowledge specified in Units 3 and 4. Examiners may draw on this understanding in the remaining Unit 3 or 4 exams although they will not set specific questions based on topics from Unit 2.

3.3 UNIT 3: POPULATIONS AND GENES

Living organisms form structured communities within dynamic but essentially stable ecosystems through which energy is transferred and chemical elements are cycled. Humans are part of the ecological balance and their activities affect it both directly and indirectly. Consideration of these effects is one of the main themes of this unit and should lead to an understanding that sustainability of resources depends on effective management of the conflict between human needs and conservation.

The individuals that comprise a particular species share the same genes but usually have different combinations of alleles of these genes. Individuals inherit alleles from their parents.

A species exists as one or more populations. Genetic variation in populations results from genetic drift and natural selection. Genetic drift may cause changes in allele frequency in small populations. Natural selection occurs when alleles that affect the fitness of individuals that carry them change in frequency. A change in the allele frequency in a population is evolution.

3.3.1 THE EFFECT OF BIOTIC AND ABIOTIC FACTORS ON POPULATIONS

3.3.1.1 Populations, communities and ecosystems

In an ecological context:

- a population is all the organisms of one species in a habitat
- populations of different species form a community
- a community and the non-living components of its environment form an ecosystem.

Within a habitat, a species occupies a niche governed by adaptation to both biotic and abiotic conditions.

3.3.1.2 Variation in population size

Population size may vary as a result of:

- the effect of abiotic factors
- interactions between organisms, including interspecific and intraspecific competition and predation.

Students should be able to:

- analyse and interpret data relating to the numbers and distribution of organisms recognising correlations and causal relationships.

3.3.1.3 Ecological succession

Primary succession from colonisation by pioneer species to climax community.

At each stage in succession, certain species may be recognised that change the environment so that it becomes more suitable for other species with different adaptations. The new species may change the environment in such a way that it becomes less suitable for the previous species.

Changes that organisms produce can result in a less hostile environment and a change in biodiversity.

Conservation of habitats frequently involves management of succession.

3.3.2 PHOTOSYNTHESIS

Life depends on the continuous transfer of energy. Photosynthesis is the main route by which energy enters an ecosystem.

3.3.2.1 The light-dependent reaction

The light-dependent reaction in such detail as to show that:

- chlorophyll absorbs light
- light energy excites electrons in chlorophyll
- energy from these excited electrons generates ATP and reduced NADP
- the production of ATP involves the transfer of electrons down the electron transfer chain and the passage of protons across chloroplast membranes. ATP production is catalysed by ATP synthase embedded in the chloroplast membranes
- photolysis of water produces protons, electrons and oxygen.

3.3.2.2 The light-independent reaction

The light-independent reaction in such detail as to show that:

- carbon dioxide reacts with ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate (GP), a reaction catalysed by the enzyme rubisco
- ATP and reduced NADP from the light-dependent reaction reduce glycerate 3-phosphate to triose phosphate
- some of the triose phosphate is used to regenerate RuBP in the Calvin cycle
- triose phosphate is also converted to useful organic substances.

3.3.2.3 Limiting factors

The principle of limiting factors as applied to the effects of carbon dioxide concentration, light and temperature on the rate of photosynthesis.

3.3.3 RESPIRATION

3.3.3.1 Glycolysis

Glycolysis takes place in the cytoplasm and is common to both aerobic and anaerobic respiratory pathways.

Glycolysis in such detail as to show that:

- glucose is phosphorylated to glucose phosphate using ATP
- triose phosphate is produced and is oxidised to pyruvate with a net gain of ATP and reduced NAD.

3.3.3.2 Anaerobic respiration

In anaerobic respiration, pyruvate is converted to ethanol and carbon dioxide or to lactate using reduced NAD. NAD is regenerated in this way and may be used in further glycolysis.

3.3.3.3 Aerobic respiration

In aerobic respiration, pyruvate from glycolysis enters the mitochondrial matrix by active transport.

Aerobic respiration in such detail as to show that:

- pyruvate is oxidised to acetate, producing reduced NAD
- acetate combines with coenzyme A in the link reaction to produce acetyl coenzyme A
- acetyl coenzyme A reacts with a four-carbon molecule, releasing coenzyme A and producing a six-carbon molecule that enters the Krebs cycle
- in a series of oxidation-reduction reactions, the Krebs cycle generates reduced coenzymes, ATP and carbon dioxide
- synthesis of ATP by oxidative phosphorylation involves the transfer of electrons down the electron transfer chain and the passage of protons across inner mitochondrial membranes. ATP production is catalysed by ATP synthase embedded in the membranes.

3.3.3.4 Respiratory substrates

The breakdown products of lipids and amino acids enter the Krebs cycle and can also be used as respiratory substrates.

The Respiratory Quotient (RQ) may be used to indicate respiratory substrate and is the ratio of carbon dioxide produced to oxygen consumed. The carbon dioxide and oxygen must be given in the same units, and in quantities proportional to the number of molecules involved. Acceptable values may be either moles or volumes of gas.

Students should be able to:

- calculate RQ from appropriate data
- suggest appropriate explanations of RQs in terms of carbohydrate, lipid or protein as a respiratory substrate. They should be able to comment on the tentative nature of any conclusions that are drawn.

3.3.4 ENERGY TRANSFER THROUGH ECOSYSTEMS

3.3.4.1 Energy transfer

Energy is transferred through the trophic levels in food chains and food webs.

The transfer of energy from producers to consumers and between consumers is inefficient. Quantitative consideration of energy transfer between trophic levels.

Pyramids of number, biomass and energy and their relationship to corresponding food chains and webs.

3.3.4.2 Energy and human food production

Gross primary production (*GPP*) is the chemical energy store in plant biomass in a given area or volume, in a given time.

Net primary production (*NPP*) is the chemical energy store in plant biomass after respiratory loss (*R*) has been taken into account.

Net primary production may be calculated from the equation:

$NPP = GPP - R$

The net production of consumers such as mammals may be calculated from the equation

$N = I - (F + U + R)$

where N = net production

I = chemical stored energy in ingested food

F = chemical stored energy in faeces

U = chemical stored energy in urine

R = respiratory loss

Farming practices increase the efficiency of energy transfer by:

- using chemical pesticides, biological agents and integrated systems to reduce energy losses and simplify non-human food webs
- reducing respiratory losses within food chains involving humans.

Students should be able to:

- apply their understanding of ecological principles to provide scientific arguments that explain how specific farming practices affect productivity
- evaluate data considering economic, environmental and ethical issues involved with farming practices that increase productivity.

3.3.5 NUTRIENT CYCLES

3.3.5.1 Principles of nutrient cycling

Different chemical elements are found within organic substances in living organisms.

Decomposers and saprophytic microorganisms play an important role in releasing these elements into the environment in the form of ions or simple inorganic molecules. These are ultimately taken up by producers and incorporated into organic molecules.

Digestion and assimilation result in substances containing these elements being passed along food chains.

3.3.5.2 The carbon cycle

The importance of respiration, photosynthesis and human activity in giving rise to short-term fluctuations and long-term changes in global carbon dioxide concentration.

The roles of carbon dioxide and methane in enhancing the greenhouse effect and bringing about climatic change.

Students should be able to:

- analyse, interpret and evaluate data relating to short-term fluctuations in carbon dioxide concentration
- analyse, interpret and evaluate data relating to the effects of climate change on the yield of crop plants and the life cycles and numbers of insect pests.

3.3.5.3 The nitrogen cycle

The role of bacteria in the nitrogen cycle in sufficient detail as to illustrate the processes of ammonification, nitrification, denitrification and nitrogen fixation.

The use of natural and artificial fertilisers in replacing nutrients lost by harvesting plants and removing livestock.

Leaching and eutrophication arising from the use of fertilisers.

3.3.6 INHERITANCE

3.3.6.1 Principles

The genotype of an organism is its genetic constitution. The phenotype is the expression of this genetic constitution and its interaction with the environment.

There may be many alleles of a single gene. Alleles may be dominant, recessive or codominant. In a diploid organism, the alleles at a specific locus may be either homozygous or heterozygous.

3.3.6.2 Patterns of inheritance

The use of fully labelled genetic diagrams to interpret, or predict, the results of:

- monohybrid and dihybrid crosses involving dominant, recessive and codominant alleles
- crosses involving sex-linkage, autosomal linkage, multiple alleles and epistasis.

Use of the chi-squared (χ^2) test to determine whether there is a significant difference between the expected genetic ratios and the observed ratios.

3.3.7 ALLELE FREQUENCIES IN POPULATIONS

3.3.7.1 Principles and applications

In the study of population genetics, a population may be considered as a group of potentially interbreeding organisms of the same species occupying a particular space at a particular time.

The concept of a gene pool as the complete set of alleles for a gene in a single population.

The concept of allele frequency as the fraction of the genes in the gene pool that is a particular allele.

The influence of selection for high-yielding breeds of domesticated animals and cultivated plants.

Genetic bottlenecks involve severe reductions in population size due to environmental events or human activities which reduces in the gene pool of a population.

Genetic drift results in a change in the frequency of alleles in a population of organisms due to chance. When there are few copies of an allele, the effect of genetic drift is larger.

3.3.7.2 The Hardy-Weinberg principle and the Hardy-Weinberg equation

The Hardy-Weinberg principle provides a mathematical model which predicts that allele frequencies will not change from generation to generation. The conditions under which the principle applies.

The frequency of alleles, genotypes and phenotypes may be calculated using the Hardy-Weinberg equation

$p^2 + 2pq + q^2 = 1$

where p is the frequency of one (usually dominant) allele of the gene

q is the frequency of the other (usually recessive) allele of the gene

Students should be able to:

- use the Hardy-Weinberg equation to calculate allele, genotype and phenotype frequencies from appropriate data.

3.3.8 EVOLUTION MAY LEAD TO SPECIATION

3.3.8.1 The theory of evolution

Evolution is a theory that may be considered as a change in the allele frequencies in a population.

Individuals within a population may show a wide range of phenotypic variation.

Predation, disease and competition for resources result in differential survival and reproduction.

Those organisms with phenotypes providing selective advantages are likely to produce more offspring and pass on their favourable alleles to the next generation. This may affect the frequency of specific alleles within the gene pool.

Students should be able to:

- explain how natural selection may account for changes in allele and phenotype frequency when provided with appropriate data.

3.3.8.2 Selection and speciation

The effects of directional, disruptive and stabilising selection.

Reproductive separation of populations of the same species may result in differences in their gene pools.

New species arise when genetic differences lead to the inability of members of the separated populations to interbreed and produce fertile offspring.

Allopatric and sympatric speciation.

PRACTICAL ACTIVITIES

In the context of Unit 3, students following this course must carry out the practical activities listed below. The International A2 written papers will test students' knowledge and understanding of the procedures involved as well as evaluation of the techniques adopted. They may also require students to interpret specimen results.

Required practical 7:
Investigation of the effect of a specific limiting factor such as light intensity on the rate of photosynthesis.

Required practical 8:
Investigation of a specific variable such as substrate or temperature on the rate of respiration of a suitable organism such as yeast or a locust.

Required practical 9:
A laboratory based investigation of the effect of competition on seedling growth.

BIOLOGICAL PRINCIPLES

When they have completed this unit, students will be expected to have an understanding of the following principles.

- ATP is the immediate source of energy for biological processes. It is resynthesised during respiration.
- Energy is transferred through, and chemical elements recycled in, ecosystems.
- Genetic variation occurs within a species. Selection leads to the accumulation of genetic differences in populations.

An understanding of these principles may be required to develop the knowledge specified in Unit 4. Examiners may draw on this understanding in the Unit 4 exams although they will not set specific questions based on topics from Unit 3.

3.4 UNIT 4: CONTROL

Consideration of control mechanisms underpins the content of this unit. Students who have studied it should develop an understanding of the ways in which organisms and cells control their activities.

Multicellular organisms are able to control the activities of different tissues and organs within their bodies. They do this by detecting stimuli and responding by way of particular effectors; plants rely on specific growth factors; animals use hormones and nerve impulses. By responding to stimuli, animals increase their probability of survival by moving to favourable environments and by maintaining optimal conditions for their metabolism.

Cells are also able to control their metabolic activities by regulating the transcription and translation of their genome. Although the cells within an organism carry the same genetic code, they translate only part of it.

3.4.1 CONTROL SYSTEMS INVOLVE STIMULUS AND RESPONSE

A simple reflex arc involving three neurones. The importance of simple reflexes in avoiding damage to the body.

Taxes and kineses as simple responses that can maintain an organism in a favourable environment, increasing its chance of survival.

3.4.2 RECEPTORS

3.4.2.1 The Pacinian corpuscle

The Pacinian corpuscle should be used as an example of a receptor to illustrate the following:

- receptors respond only to specific stimuli
- stimulation of a receptor leads to the establishment of a generator potential.

The basic structure of a Pacinian corpuscle.

Deformation of stretch-mediated sodium ion channels in a Pacinian corpuscle leads to the establishment of a generator potential.

3.4.2.2 The human retina

The human retina only in sufficient detail as to show how differences in sensitivity to light, colour and visual acuity are explained by differences in the optical pigments of rods and cones and the connections that the rods and cones make in the optical nerve.

3.4.3 NERVE IMPULSES AND SYNAPTIC TRANSMISSION

3.4.3.1 Nerve impulses

The structure of a myelinated motor neurone.

The establishment of a resting potential in terms of differential membrane permeability, electrochemical gradients and the movement of sodium ions and potassium ions.

Changes in membrane permeability lead to depolarisation and subsequent repolarisation. The generation of an action potential and the all-or-nothing principle.

The nature and importance of the refractory period in producing discrete impulses and in limiting the frequency of impulse transmission.

The role of ATP and sodium-potassium pumps in re-establishing the resting potential.

Factors affecting the speed of conduction: myelination and saltatory conduction, axon diameter, temperature.

3.4.3.2 Synaptic transmission

The detailed structure of a cholinergic synapse and of a neuromuscular junction in sufficient detail to explain:

- unidirectionality
- temporal and spacial summation
- inhibition by inhibitory synapses.

Students should be able to:

- use information provided to predict and explain the effects of specific drugs and toxins on synaptic transmission.

3.4.4 SKELETAL MUSCLES AS EFFECTORS

3.4.4.1 The sliding filament theory of muscle contraction

Gross and microscopic structure of skeletal muscle. The ultrastructure of a myofibril.

The roles of actin, myosin, calcium ions, ATP and tropomyosin in the cycle of actomyosin bridge formation and myofibril contraction.

Students should be able to:

- interpret the appearance of diagrams or photographs of myofibrils at different stages of muscle contraction.

3.4.4.2 Muscles as effectors

Muscles act in antagonistic pairs against an incompressible skeleton.

The roles of ATP and phosphocreatine in providing the energy supply during muscle contraction.

The structure, location and general properties of slow and fast skeletal muscle fibres.

3.4.5 CONTROL SYSTEMS IN PLANTS

3.4.5.1 Principles

Plant growth substances are signal molecules that are produced in plants and occur in very low concentrations. They regulate targeted cells near to their site of production or move to other tissues where they regulate a variety of processes including growth in response to directional stimuli, fruit development and closure of stomata as a response to drought.

3.4.5.2 Auxins and tropisms

Tropisms as growth responses to directional stimuli that can maintain the roots and shoots of flowering plants in a favourable environment.

The effects of different concentrations of indoleacetic acid (IAA) on cell elongation in the roots and shoots as an explanation of responses to light and gravity in flowering plants.

3.4.5.3 Ethene and abscisic acid (ABA)

The role of ethene in fruit ripening. Control of ethene allows climacteric fruits such as bananas to be picked green and artificially ripened after shipping.

The role of abscisic acid in closing the stomata when plants are water-stressed and the roots are deficient in water. Abscisic acid stimulates the transport of potassium and chloride ions out of guard cells, raising the water potential in the guard cells and leading to loss of water and shrinkage of the guard cells resulting in stomatal closure.

3.4.6 HOMEOSTASIS AND NEGATIVE FEEDBACK

3.4.6.1 The principles of homeostasis

In mammals, homeostasis involves physiological control systems that maintain the internal environment within restricted limits.

The importance of maintaining a stable core temperature and blood pH in relation to enzyme activity.

3.4.6.2 Feedback

Negative feedback restores systems to their original level.

The possession of separate mechanisms involving negative feedback controlling departures in different directions from the original state gives a greater degree of control.

Positive feedback also occurs and results in greater departures from the original levels.

Positive feedback is often associated with the breakdown of control systems, such as in the control of temperature.

Students should be able to:

- interpret information relating to examples of negative and positive feedback.

3.4.7 HORMONES AND THE CONTROL OF BLOOD GLUCOSE CONCENTRATION

3.4.7.1 Glucose concentration and its control

The importance of maintaining a stable blood glucose concentration in terms of energy transfer and water potential of the blood.

The factors that influence blood glucose concentration.

The role of the liver in glycogenesis, glycogenolysis and gluconeogenesis.

The causes of and risk factors associated with Type 1 and Type 2 diabetes. Control by manipulation of the diet and with insulin.

Students should be able to:

- use their knowledge of biology to explain specific symptoms of diabetes
- analyse, interpret and evaluate data associated with specific risk factors and the incidence of diabetes.

3.4.7.2 The role of insulin

Insulin as a protein hormone that acts by:

- attaching to receptors on the surfaces of target cells
- controlling the uptake of glucose by regulating the inclusion of channel proteins in the surface membranes of target cells
- activating enzymes involved in the conversion of glucose to glycogen.

3.4.7.3 The role of glucagon

Glucagon acts by:

- attaching to receptors on the surfaces of target cells
- activating enzymes involved in the conversion of glycogen to glucose
- activating enzymes involved in the conversion of glycerol and amino acids to glucose.

3.4.7.4 The role of adrenaline

Adrenaline acts by:

- attaching to receptors on the surfaces of target cells
- activating enzymes involved in the conversion of glycogen to glucose.

The second messenger model of adrenaline and glucagon action, involving adenyl cyclase, cyclic AMP (cAMP) and protein kinase.

3.4.8 CONTROL OF HEART RATE

Myogenic stimulation of the heart and transmission of a subsequent wave of electrical activity. Roles of sinoatrial node (SAN), atrioventricular node (AVN) and Purkinje tissue in the bundle of His.

The roles of chemoreceptors and pressure receptors, the autonomic nervous system and effectors in controlling heart rate.

3.4.9 REGULATION OF TRANSCRIPTION AND TRANSLATION

3.4.9.1 Epigenetic control of gene expression

Epigenetic changes result from changes in gene function without alterations in the DNA base sequence. These changes are preserved when cells divide. They may be associated with:

- increased methylation of the DNA
- decreased acetylation of associated histones.

Abnormal methylation of tumour suppressor genes and oncogenes play a role in the development of cancer.

Students should be able to:

- interpret information relating to the way in which an understanding of the roles of oncogenes and tumour suppressor genes could be used in the prevention of and treatment for cancer.

3.4.9.2 RNA interference

MicroRNA (miRNA) and small interfering RNA (siRNA) bind to mRNA produced from target genes and increase or decrease their activity.

3.4.9.3 Most of a cell's DNA is not translated

During development, totipotent cells translate only part of their DNA, resulting in cell specialisation.

Totipotent cells occur only for a limited time in mammalian embryos. Pluripotent, multipotent and unipotent cells are found in mature mammals. They can divide to form a limited number of different cell types.

Students should be able to:

- evaluate the use of stem cells in treating human disorders.

3.4.10 RECOMBINANT DNA TECHNOLOGY

3.4.10.1 Principles

Recombinant DNA technology involves the transfer of fragments of DNA from one organism or species to another. Since the genetic code and the mechanisms of translation and transcription are universal, the transferred DNA can be translated within the cells of the recipient organism.

3.4.10.2 Production of fragments of DNA

Fragments of DNA can be produced by several methods. These include:

- conversion of mRNA to complementary DNA (cDNA) using reverse transcriptase
- using restriction endonucleases to cut a fragment containing the desired gene from the DNA
- artificial gene synthesis.

3.4.10.3 *In vitro* amplification of DNA fragments

The principles of the polymerase chain reaction (PCR) as a method of amplifying DNA fragments.

The polymerase chain reaction may also be used to identify specific DNA fragments.

3.4.10.4 *In vivo* amplification of DNA fragments

DNA fragments may be cultured in transformed host cells. This process includes:

- the addition of promotor and terminator regions to the fragments of DNA
- the use of restriction endonucleases and ligases to insert fragments of DNA into vectors. Transformation of host cells using these vectors
- the use of marker genes to detect genetically modified cells or organisms.

Students should be able to:

- interpret information relating to the use of recombinant DNA technology
- evaluate ethical, financial and social issues associated with the use of recombinant DNA technology.

PRACTICAL ACTIVITIES

In the context of Unit 4, students following this course must carry out the practical activities listed below. The International A2 written papers will test students' knowledge and understanding of the procedures involved as well as evaluation of the techniques adopted. They may also require students to interpret specimen results.

Required practical 10:
Investigation of the effect of a suitable variable on the direction of growth of a root or a shoot.

4 SCHEME OF ASSESSMENT

Find mark schemes, and specimen papers for new courses, on our website at **oxfordaqaexams.org.uk/9610**

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level.

The International AS can be taken as a stand-alone qualification or it can count towards the International A-level. To complete the International A-level, students can take the International AS in their first year and the International A2 in their second year or they can take all the units together in the same examination series at the end of the two year course.

The International AS content will be 50 % of the International A-level content. International AS assessments contribute 40 % of the total marks for the full International A-level qualification. The remaining 60 % comes from the International A2 assessments.

The specification provides an opportunity for students to produce extended responses either in words or using open-ended calculations.

The specification content will be split across units and will include some synoptic assessment. This allows students to draw together different areas of knowledge from across the full course of study.

All materials are available in English only.

Our International AS and A-level exams in Biology include questions that allow students to demonstrate their ability to:

- demonstrate knowledge and understanding of scientific, mathematical and practical techniques, principles and concepts
- apply their knowledge and understanding of scientific, mathematical and practical techniques, principles and concepts.

4.1 AVAILABILITY OF ASSESSMENT UNITS AND CERTIFICATION

Exams and certification for this specification are available as follows:

	Availability of units		Availability of certification	
	International AS	**International A2**	**International AS**	**International A-level**
June 2017	✓		✓	
January 2018	✓		✓	
June 2018	✓	✓	✓	✓
January 2019 onwards	✓	✓	✓	✓
June 2019 onwards	✓	✓	✓	✓

4.2 AIMS

Science is more than facts and information. It is stimulating and helps us to make sense of the world around us in a way that no other subject allows.

Courses based on this specification should encourage students to:

- develop a deep appreciation of, and enjoyment and enthusiasm for, science
- appreciate the breadth of the subject
- prepares for further study in biology
- understand the tentative nature of science and understand the importance of critical thinking
- apply scientific knowledge and understanding in novel contexts
- develop practical, mathematical and communication skills.

4.3 ASSESSMENT OBJECTIVES

The exams will measure how students have achieved the following assessment objectives.

- AO1: Knowledge and understanding of scientific principles and concepts.
- AO2: Application of knowledge and understanding of scientific principles and concepts in both familiar and novel contexts.
- AO3: The ability to describe, analyse, interpret and evaluate scientific information presented in different forms.
- AO4: The ability to select, describe and evaluate scientific procedures.

QUALITY OF WRITTEN COMMUNICATION (QWC)

Students must:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Questions in the papers for this specification do not include specific marks for QWC. However, poor written communication may lead to lower marks due to lack of clarity in answers.

4.3.1 ASSESSMENT OBJECTIVE WEIGHTINGS FOR INTERNATIONAL AS BIOLOGY

Assessment objectives (AOs)	Unit weightings (approx %)		Overall weighting of AOs (approx %)
	Unit 1	Unit 2	
AO1	20	20	40
AO2	7	7	14
AO3	13	13	26
AO4	10	10	20
Overall weighting of units (%)	50	50	100

4.3.2 ASSESSMENT OBJECTIVE WEIGHTINGS FOR INTERNATIONAL A-LEVEL BIOLOGY

Assessment objectives (AOs)	Unit weightings (approx %)					Overall weighting of AOs (approx %)
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	
AO1	8	8	5	5	5	31
AO2	3	3	5	5	3	19
AO3	5	5	8	8	4	30
AO4	4	4	2	2	8	20
Overall weighting of components (%)	20	20	20	20	20	100

4.4 ASSESSMENT WEIGHTINGS

The raw marks awarded on each unit will be transferred to a uniform mark scale (UMS) to meet the weighting of the units and to ensure comparability between units sat in different exam series. Students' final grades will be calculated by adding together the uniform marks for all units. The maximum raw and uniform marks are shown in the table below.

Unit	Maximum raw mark	Percentage weighting International A-level (AS)	Maximum uniform mark
1	75	20 (50)	100
2	75	20 (50)	100
3	75	20	100
4	75	20	100
5	75	20	100
Qualification			
International AS (Unit 1 + Unit 2)	–	40 (100)	200
International A-level (Unit 1 + Unit 2 + Unit 3 + Unit 4 + Unit 5)	–	100	500

For more detail on UMS, see Section 5.3.

5 GENERAL ADMINISTRATION

We are committed to delivering assessments of the highest quality and have developed practices and procedures to support this aim. To ensure all students have a fair experience, we have worked with other awarding bodies in England to develop best practice for maintaining the integrity of exams. This is published through the Joint Council for Qualifications (JCQ). We will maintain the same high standard through their use for OxfordAQA Exams.

More information on all aspects of administration is available at **oxfordaqaexams.org.uk/examsadmin**

For any immediate enquiries please contact **examsadmin@oxfordaqaexams.org.uk**

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

5.1 ENTRIES AND CODES

You should use the following subject award entry codes:

Qualification title	OxfordAQA Exams entry code
OxfordAQA International Advanced Subsidiary Biology	9611
OxfordAQA International Advanced Level Biology	9612

Please check the current version of the Entry Codes book and the latest information about making entries on **oxfordaqaexama.org.uk/examsadmin**

You should use the following unit entry codes:

Unit 1 – BL01

Unit 2 – BL02

Unit 3 – BL03

Unit 4 – BL04

Unit 5 – BL05

A unit entry will not trigger certification. You will also need to make an entry for the overall subject award in the series that certification is required.

Exams will be available May/June and in January.

5.2 OVERLAPS WITH OTHER QUALIFICATIONS

There is overlapping content in the International AS and A-level specifications. This helps you teach the International AS and A-level together.

5.3 AWARDING GRADES AND REPORTING RESULTS

The International AS qualification will be graded on a five-point scale: A, B, C, D and E.

The International A-level qualification will be graded on a six-point scale: A*, A, B, C, D and E. To be awarded an A*, students will need to achieve a grade A on the full A-level qualification and 90% of the maximum uniform mark on the aggregate of the A2 units.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark needed for each grade in each unit when we issue students' results. We will report a student's unit results to schools and colleges in terms of uniform marks and unit grades and we will report qualification results in terms of uniform marks and grades.

The relationship between uniform marks and grades is shown in the table below.

	Uniform mark range per unit and per qualification						
Grade	**Unit 1**	**Unit 2**	**International AS Biology**	**Unit 3**	**Unit 4**	**Unit 5**	**International A-level Biology**
Maximum uniform mark	100	100	200	100	100	100	500
A*							* See note below
A	80–100	80–100	160–200	80–100	80–100	80–100	400–500
B	70–79	70–79	140–159	70–79	70–79	70–79	350–399
C	60–69	60–69	120–139	60–69	60–69	60–69	300–349
D	50–59	50–59	100–119	50–59	50–59	50–59	250–299
E	40–49	40–49	80–99	40–49	40–49	40–49	200–249

* For the award of grade A*, a student must achieve grade A in the full International A-level qualification and a minimum of 270 uniform marks in the aggregate of Units 3, 4 and 5.

5.4 RE-SITS

Unit results remain available to count towards certification, whether or not they have already been used, provided the specification remains valid. Students can re-sit units as many times as they like, as long as they're within the shelf-life of the specification. The best result from each unit will count towards the final qualification grade. Students who wish to repeat a qualification may do so by re-sitting one or more units.

To be awarded a new subject grade, the appropriate subject award entry, as well as the unit entry/entries, must be submitted.

5.5 PREVIOUS LEARNING AND PREREQUISITES

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools and colleges.

5.6 ACCESS TO ASSESSMENT: EQUALITY AND INCLUSION

Our general qualifications are designed to prepare students for a wide range of occupations and further study whilst assessing a wide range of competences.

The subject criteria have been assessed to ensure they test specific competences. The skills or knowledge required do not disadvantage particular groups of students.

Exam access arrangements are available for students with disabilities and special educational needs.

We comply with the *UK Equality Act 2010* to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student. Information about access arrangements is issued to schools or colleges when they become Oxford International AQA Examinations centres.

5.7 WORKING WITH OXFORD US FOR THE FIRST TIME

You will need to apply to become an Oxford International AQA Examinations centre to offer our specifications to your students. Find out how at **oxfordaqaexams.org.uk/centreapprovals**

5.8 PRIVATE CANDIDATES

Centres may accept private candidates for examined units/components only with the prior agreement of OxfordAQA. If you are an approved OxfordAQA centre and wish to accept private candidates, please contact OxfordAQA at: **ExamsAdmin@oxfordaqaexams.org.uk**

As some of the marks in the AS and A-level papers will relate to practical work, students undertaking this specification must carry out the required practical activities in section 6.1 of the specification.

Centres accepting private candidates must ensure they have carried out this minimum requirement. Private candidates may also enter for examined only units via the British Council; please contact your local British Council office for details.

6 PRACTICAL ASSESSMENT

Practical work is at the heart of science and we expect students taking this course to have a rich diet of practical work. This will allow them to appreciate fully the practical nature of science and to understand the methods that scientists use to investigate the world around us.

As schools around the world have very different circumstances, particularly around access to practical equipment, there is no direct assessment of practical work for this qualification. This allows teachers to choose the best ways to introduce practical work to their students. It also allows meaningful discussion of practical work in a way that is separated from the artificial rigors of coursework or other exam board set assessments.

To be able to answer the questions on the papers for this specification, students must have had hands-on experience of the required practicals listed in 6.1. Questions may be set on these practicals directly, or on the skills contained within the practicals.

These skills could include, but are not limited to:

- planning experiments, including identifying and understanding how to control variables
- choosing equipment, or evaluating the use of specified pieces of equipment
- skills required for carrying out experiments such as taking readings or recording data
- choosing, constructing and interpreting appropriate graphical displays for data
- analysing and interpreting data, including carrying out calculations on data
- evaluating experimental procedures.

6.1 REQUIRED PRACTICAL ACTIVITIES

International AS practical activities	International A2 practical activities
Students must carry out the practical activities below. The International AS written papers test knowledge and understanding of procedures, as well as evaluation of the techniques adopted. They may require students to interpret specimen results.	Students must carry out the practical activities below. The International A2 written papers test knowledge and understanding procedures, as well as evaluation of the techniques adopted. They may require students to interpret specimen results.
Practical activity	**Practical activity**
1. Investigation of the effect of temperature, pH, or substrate concentration on the rate of an enzyme-controlled reaction.	**7.** Investigation of the effect of a specific limiting factor such as light intensity on the rate of photosynthesis.
2. Investigation of the effect of solute concentration on the uptake or loss of water from plant tissue.	**8.** Investigation of a specific variable such as substrate or temperature on the rate of respiration of a suitable organisms such as yeast or a locust.
3. Use of chromatography to investigate the pigments present in leaves.	**9.** A laboratory-based investigation into the effect of competition on seedling growth.
4. Preparation of stained squashes of root tips and examination of these with a microscope. Observation of the stages of mitosis and calculation of a mitotic index.	**10.** Investigation into the effect of a suitable variable on the direction of growth of a root or a shoot.
5. Investigation into the effect of a specific variable on the human heart or pulse rate.	
6. Investigate the rate of water uptake by means of a simple potometer.	

Schools and colleges entering students for this specification will be required to submit confirmation that students have had opportunities to complete all of the above required practical activities.

7 MATHEMATICAL REQUIREMENTS

Bold statements will be assessed in International A2 units only.

1. Carry out calculations in decimal and standard form, using an appropriate number of significant figures.
2. Recognise and use appropriate units in calculations.
3. Use fractions, ratios and percentages.
4. Understand the terms 'mean', 'median' and 'mode'.
5. Calculate arithmetic means.
6. Understand and use appropriately the terms 'chance' and 'probability'.
7. Understand the need for random sampling and appropriate sample sizes in ensuring that data are representative.
8. Select, understand and interpret appropriate statistical tests limited to:
   - chi-squared test
   - standard error and 95 % confidence limits
   - spearman rank correlation test.
9. Understand and interpret data involving standard deviation and range.
10. Understand the symbols =, <, >, α and ~
11. Translate information between graphical, numerical and algebraic forms.
12. Manipulate and solve algebraic equations using appropriate units for physical quantities.
13. **Understand the use of logarithms in relation to quantities that range over several orders of magnitude.**
14. Construct and interpret frequency tables and diagrams, pie charts, bar charts and histograms.
15. Construct and use scatter diagrams to identify correlations between variables.
16. Construct and interpret line graphs.
17. Determine values from a graph and calculate rates from curves or sections of curves showing linear relationships.
18. Draw and use the slope of a tangent to a curve as a measure of rate.
19. Calculate the circumferences of circles and rectangles and the volumes of spheres, cylinders and cuboidal prisms.

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