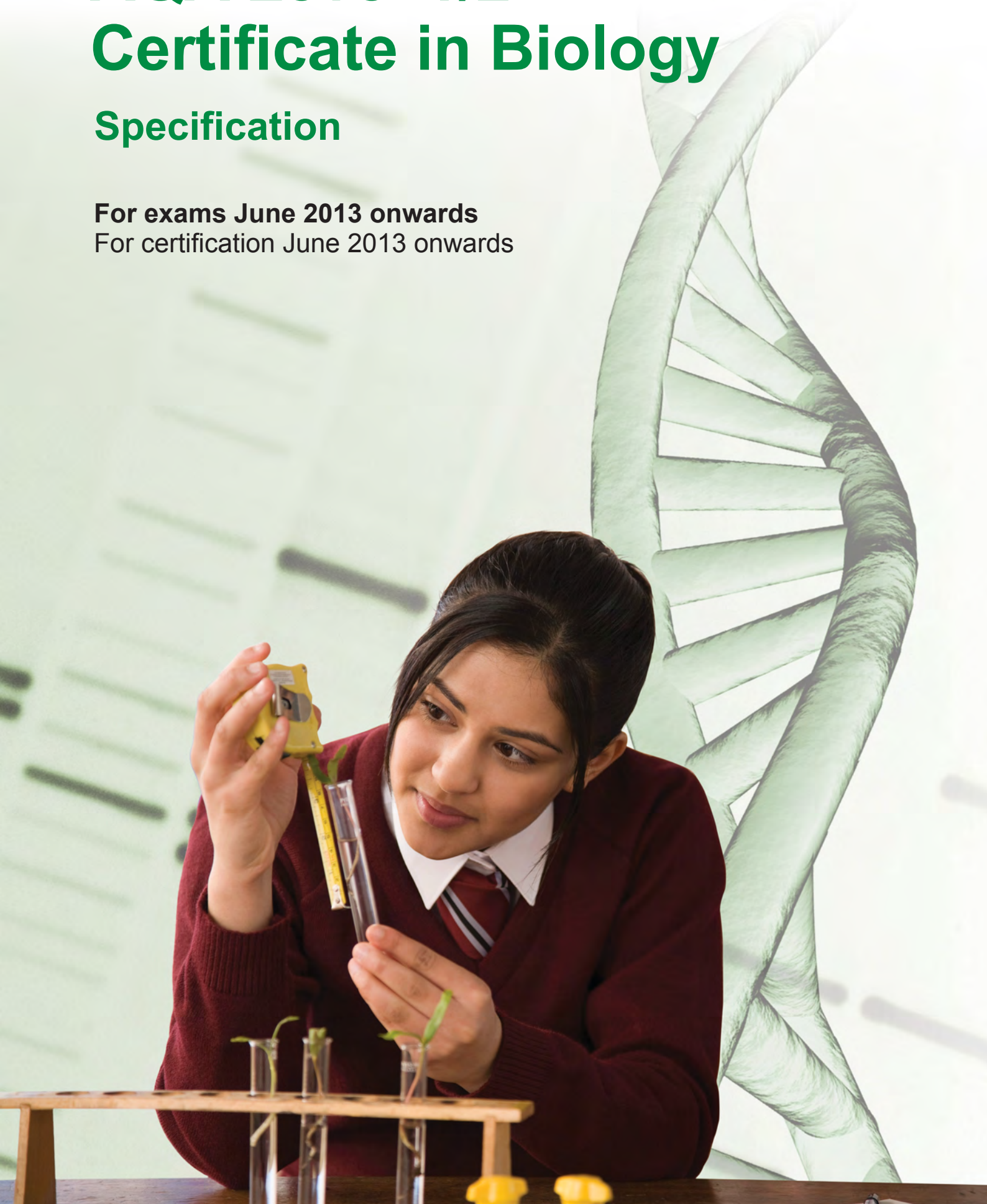
AQA Level 1/2 Certificate in Biology

Specification

For exams June 2013 onwards
For certification June 2013 onwards



Level 1/2
Specification

Certificate in Biology 8401

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Contents

1 Introduction

1a Why choose AQA?

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We understand the different requirements of each subject by working with teachers. Our qualifications:

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If you are already a customer we thank you for your support. If you are thinking of joining us we look forward to welcoming you.

1b Why choose AQA Level 1/2 Certificate in Biology?

In developing this specification we have consulted widely with teachers, science advisers and learned societies to produce content and assessments that will both stimulate students' interest in and enthusiasm for biology and provide an excellent grounding for further study.

The substantive content covers much of, but is not restricted by, the GCSE Programme of Study. This specification thus contains a broad range of biological topics that are designed to engage and stimulate students' interest in biology whilst providing the knowledge and understanding required for progression to Level 3 qualifications. The specification emphasises scientific knowledge, the application of science and the scientific process.

Biology is an enquiry-based discipline involving practical and investigational skills as well as knowledge. Section 3b gives the fundamental ideas behind scientific enquiry that should be delivered through teaching of the content.

This specification has less focus on some of the aspects of How Science Works that are covered in GCSE Biology (for example, there is less sociological, economic and environmental content). This gives time for more detailed study of scientific knowledge and for development of the skills of scientific enquiry essential to this subject. The experimental and investigative skills that will be assessed in this specification are listed in Section 3d.

The terminal assessment model is designed to ensure the maximum amount of time for teaching biology without frequent interruptions for examinations.

The content has a significant overlap with that in the AQA GCSE Biology, thereby enabling co-teaching if required.

1c How do I start using this specification?

You need to register at **aqa.org.uk/askaqa.php** to ensure that you receive regular updates and have access to mark schemes, past question papers, a whole range of teacher support materials and receive details of teacher support meetings.

Once you have decided to enter candidates you need to tell us so we can make sure that you get all the material you need for the examinations. You can let us know by filling in the appropriate *Intention to Enter* and *Estimated Entry* forms.

- If your centre is registered on e-AQA you will receive an e-mail prompting you to submit entry information on-line.
- If you are not e-AQA registered we will send copies to your Examinations Officer. Both forms can be downloaded from our website (**aqa.org.uk/admin/p_entries.php**).

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Speak to your subject team

You can talk directly to the GCSE Sciences subject team about this specification either by e-mailing **science-gcse@aqa.org.uk** or by calling 08442 090 415.

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2 Specification at a Glance

AQA Level 1/2 Certificate in Biology

The scheme of assessment is linear, with two question papers to be taken in the same examination series, as detailed below.

Paper 1

Written paper – 1 hour 30 minutes

90 marks – **50%**

Structured and open questions

PLUS

Paper 2

Written paper – 1 hour 30 minutes

90 marks – **50%**

Structured and open questions

3 Subject Content

3a Introduction

The subject content is presented as a series of topic areas listing the statements of what students need to know and understand, and what they will be assessed on. Expansion of the content and clarification of what may be examined, where necessary, is given in *italics*.

How the specification is assessed

The content is assessed through two 90-minute written papers, each worth 50% of the overall marks for the specification. Assessments will be available twice a year, in January and June.

In both written papers, questions will be set that examine application of the knowledge and understanding gained in discussing, evaluating and suggesting implications of data and evidence in both familiar and unfamiliar situations. All applications will use the knowledge and understanding developed through the substantive content.

Questions may be taken from any part of the substantive content.

Paper 1 is more weighted to assessment of knowledge, understanding and application than Paper 2. Paper 2 will include a higher proportion of questions aimed towards the skills listed in Section 3d than Paper 1.

The importance of scientific literacy

Scientists need to be able to communicate their knowledge and understanding to others in a clear, comprehensive and literate manner. One question in each paper will specifically test students' ability to use good English, organise information clearly and use scientific terms correctly. Each paper will also include some questions that require students to write full descriptions, explanations and/or evaluations in which statements and ideas are clearly and coherently linked.

3b The scientific process

Science attempts to explain the world in which we live. It provides technologies that have had a great impact on our society and the environment. Scientists try to explain phenomena, for example, using hypotheses and models, and to solve problems using evidence.

A scientifically literate person should be equipped to question, and engage in debate on, the evidence used in decision making.

The repeatability and reproducibility of evidence refers to how much we trust the data. The validity of evidence depends on these, as well as on whether the research answers the question. If data is not repeatable or reproducible the research cannot be valid.

To ensure the repeatability, reproducibility, and validity of evidence, scientists consider a range of ideas that relate to:

- how we observe the world
- carrying out investigations so that patterns and relationships between variables may be identified
- making measurements by selecting and using instruments effectively
- presenting and representing data
- identifying patterns and relationships and making suitable conclusions.

These ideas inform decisions and are central to science education. They constitute the scientific process that is a necessary complement to the subject content of biology.

Fundamental ideas

Evidence must be approached with a critical eye. It is necessary to look closely at how measurements have been made and what links have been established. Scientific evidence provides a powerful means of forming opinions. These ideas pervade all of the scientific process.

Observation as a stimulus to investigation

Observation is the link between the real world and scientific ideas. When we observe objects, organisms or events we do so using existing knowledge. Observations may suggest hypotheses that can be tested.

Investigations

An investigation is an attempt to determine whether or not there is a relationship between variables. It is therefore necessary to identify and understand the variables in an investigation. The design of an investigation should be scrutinised when evaluating the validity of the evidence it has produced.

Measurements in investigations

When making measurements we must consider such issues as inherent variation due to variables that have not been controlled, human error and the

characteristics of the instruments used. Evidence should be evaluated with the repeatability and validity of the measurements that have been made in mind.

Presentation of data

To explain the relationship between two or more variables, data may be presented in such a way as to make the patterns more evident. The choice of graphical representation depends upon the type of variable represented.

Using data to draw conclusions

The patterns and relationships observed in data represent the behaviour of the variables in an investigation. However, it is necessary to look at patterns and relationships between variables with the limitations of the data in mind in order to draw conclusions.

Evaluation

In evaluating a whole investigation the repeatability, reproducibility and validity of the data obtained must be considered.

Societal aspects of scientific evidence

A judgement or decision relating to social-scientific issues may be biased, or may not be based on evidence alone, as other societal factors may be relevant.

Limitations of scientific evidence

Science can help us in many ways but it cannot supply all the answers. There are some questions that science cannot answer directly. These tend to be questions where beliefs, opinions and ethics are important.

Investigative skills and practical work

During their study of this course, students should be encouraged to:

- use their knowledge and understanding to pose scientific questions and define scientific problems
- plan and carry out investigative activities, including appropriate risk management, in a range of contexts
- collect, select, process, analyse and interpret both primary and secondary data to provide evidence
- evaluate methodology, evidence and data.

The scientific terms used in this specification are clearly defined by the ASE in *The Language of Measurement: Terminology used in school science investigations* (Association for Science Education, 2010). Teachers should ensure that they, and their students, are familiar with these terms. Definitions of the terms will **not** be required in assessments, but students will be expected to use them correctly.

Further information on how experimental and investigative skills will be assessed in this specification is given in Section 3d.

3c Subject content

Ref	Content
1	**Cell activity**
1.1	**Cell structure**
a)	Most animal cells have the following parts: ■ a nucleus, which controls the activities of the cell ■ cytoplasm, in which most of the chemical reactions take place ■ a cell membrane, which controls the passage of substances into and out of the cell ■ mitochondria, which is where most energy is released in respiration ■ ribosomes, which is where protein synthesis occurs. Most human cells are like most other animal cells.
b)	In addition to the above, plant cells often have: ■ chloroplasts, which absorb light energy to make food ■ a permanent vacuole filled with cell sap. Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell.
c)	A bacterial cell consists of cytoplasm and a membrane surrounded by a cell wall; the genes are not in a distinct nucleus; some of the genes are located in circular structures called plasmids.
d)	Yeast is a single-celled organism. Yeast cells have a nucleus, cytoplasm and a membrane surrounded by a cell wall.
e)	Cells may be specialised to carry out a particular function. *Candidates should be able, when provided with appropriate information, to relate the structure of different types of cell to their function in a tissue, an organ, or the whole organism.*
1.2	**The movement of substances into and out of cells**
a)	Diffusion is the spreading of the particles of any substance in solution, or particles of a gas, resulting in a net movement from a region where they are of a higher concentration to a region with a lower concentration. The greater the difference in concentration, the faster the rate of diffusion.
b)	Dissolved substances can move into and out of cells by diffusion.
c)	Oxygen required for respiration passes through cell membranes by diffusion.
d)	Osmosis is the diffusion of water from a dilute to a more concentrated solution through a partially permeable membrane that allows the passage of water molecules.
e)	Differences in the concentrations of the solutions inside and outside a cell cause water to move into or out of the cell by osmosis. *Candidates should be familiar with experiments related to diffusion and osmosis as well as the terms isotonic, hypotonic, hypertonic, turgor and plasmolysis.*
f)	Substances are sometimes absorbed against a concentration gradient. This requires the use of energy from respiration. The process is called active transport.
g)	Active transport enables plants to absorb ions from very dilute solutions, eg by root hair cells. Similarly, sugar may be absorbed from low concentrations in the intestine and from low concentrations in the kidney tubules.
h)	A single-celled organism has a relatively large surface area to volume ratio. All the necessary exchanges occur via its surface membrane. The size and complexity of an organism increase the difficulty of exchanging materials.

Ref	Content
i)	In multicellular organisms many organ systems are specialised for exchanging materials. The effectiveness of an exchange surface is increased by: ■ having a large surface area that is thin, to provide a short diffusion path ■ (in animals) having an efficient blood supply ■ (in animals, for gaseous exchange) being ventilated. *Candidates should be able to explain how the small intestine and lungs in mammals, and the roots and leaves in plants, are adapted for exchanging materials.*
j)	Gas and solute exchange surfaces in humans and other organisms are adapted to maximise effectiveness. *Candidates should be able, when provided with appropriate information, to explain how gas and solute exchange surfaces are adapted to maximise effectiveness.*
1.3	**Cell division**
a)	The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body. Each chromosome carries a large number of genes.
b)	Many genes have different forms called alleles, which may produce different characteristics.
c)	In body cells the chromosomes are normally found in pairs.
d)	Body cells divide by mitosis to produce additional cells during growth or to produce replacement cells.
e)	When a body cell divides by mitosis: ■ copies of the genetic material are made ■ the cell then divides once to form two genetically identical body cells.
f)	Cells in reproductive organs divide to form gametes.
g)	A cell divides to form gametes by meiosis.
h)	When a cell divides to form gametes: ■ copies of the genetic information are made ■ the cell then divides twice to form four gametes, each with a single set of chromosomes.
i)	Gametes join at fertilisation to form a single body cell with new pairs of chromosomes. This cell repeatedly divides by mitosis to form many cells. As an organism develops, these cells differentiate to form different kinds of cells.
j)	Most types of animal cell differentiate at an early stage whereas many plant cells retain the ability to differentiate throughout life. In mature animals, cell division is mainly restricted to repair and replacement.
k)	Cells from human embryos and adult bone marrow, called stem cells, can be made to differentiate into many different types of human cell, eg nerve cells.
l)	In therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the embryo will not be rejected by the patient's body so they may be used for medical treatment.
m)	Treatment with stem cells may be able to help conditions such as paralysis. *Knowledge and understanding of stem cell techniques is **not** required.* *Candidates should be able, when provided with appropriate information, to make informed judgements about the social and ethical issues concerning the use of stem cells from embryos in medical research and treatments.*
n)	Tumours result from the abnormal, uncontrolled growth of cells. Benign tumours do not invade other tissues. Cells from malignant tumours invade healthy tissue. Some malignant cells may enter the bloodstream and circulate to other parts of the body, forming secondary tumours. Tumours can be caused by chemical carcinogens, eg those found in tobacco smoke and in asbestos, and by ionising radiation, eg UV and X-rays.
	Throughout Section 1.3, candidates should develop an understanding of the relationship from the molecular level upwards between genes, chromosomes, nuclei and cells and to relate these to tissues, organs and systems.

Ref	Content
2	**Tissues, organs and organ systems**
2.1	**Organisation**
a)	Large multicellular organisms develop systems for exchanging materials. During the development of a multicellular organism, cells differentiate so that they can perform different functions.
b)	A tissue is a group of cells with similar structure and function.
c)	Organs are made of tissues. One organ may contain several tissues.
d)	Organ systems are groups of organs that perform a particular function. *Candidates should develop an understanding of size and scale in relation to cells, tissues, organs and systems.*
2.2	**Animal tissues, organs and systems**
a)	Examples of animal tissues include: ■ muscular tissue, which can contract to bring about movement ■ glandular tissue, which can produce substances such as enzymes and hormones ■ epithelial tissue, which covers some parts of the body.
b)	An example of an animal organ is the stomach, which contains: ■ muscular tissue, to allow contents to move through the digestive system ■ glandular tissue, to produce digestive juices ■ epithelial tissue, to cover the outside and the inside of the stomach.
c)	An example of an animal organ system is the digestive system, a system in which humans and other mammals exchange substances with the environment. The digestive system includes: ■ glands, such as the pancreas and salivary glands, which produce digestive juices ■ the stomach and small intestine, where digestion occurs ■ the liver, which produces bile ■ the small intestine, where the absorption of soluble food occurs ■ the large intestine, where water is absorbed from the undigested food, producing faeces.
2.3	**Plant tissues, organs and systems**
a)	Examples of plant tissues include: ■ epidermal tissues, which cover the plant ■ palisade mesophyll, which carries out photosynthesis ■ spongy mesophyll, which has air spaces to facilitate diffusion of gases ■ xylem and phloem, which transport substances around the plant.
b)	Plant organs include stems, roots and leaves. *Details of the internal structure of these organs are limited to the leaf and to the position of the xylem and phloem in a dicotyledonous primary root and primary stem.*

Ref	Content

3 Carbohydrates, lipids, proteins and enzymes

3.1 Carbohydrates, lipids and proteins

a) All carbohydrates are made up of units of sugar.

- Carbohydrates that contain only one sugar unit, eg glucose, or two sugar units, eg sucrose, are referred to as simple sugars.
- Complex carbohydrates, eg starch and cellulose, are long chains of simple sugar units bonded together.

b) Lipids are molecules consisting of three molecules of fatty acids joined to a molecule of glycerol.

c) Protein molecules are made up of long chains of amino acids. These long chains are folded to produce a specific shape that enables other molecules to fit into the protein. Proteins act as:

- structural components of tissues such as muscles
- hormones
- antibodies
- enzymes.

3.2 Enzymes

a) Enzymes are biological catalysts. Catalysts increase the rate of chemical reactions.

b) The shape of an enzyme is vital for the enzyme's function. High temperatures denature the enzyme, changing the shape of the active site.

c) Different enzymes work best at different pH values.

d) Some enzymes work outside the body cells. The digestive enzymes are produced by specialised cells in glands and in the lining of the gut. The enzymes then pass out of the cells into the gut, where they come into contact with food molecules. They catalyse the breakdown of large molecules into smaller molecules.

e) Some microorganisms produce enzymes that pass out of the cells. These enzymes have many uses in the home and in industry.

f) In the home:

- biological detergents may contain protein-digesting and fat-digesting enzymes (proteases and lipases)
- biological detergents are more effective at low temperatures than other types of detergents.

g) In industry:

- proteases are used to ‘pre-digest’ the protein in some baby foods
- carbohydrases are used to convert starch into sugar syrup
- isomerase is used to convert glucose syrup into fructose syrup, which is much sweeter than glucose and therefore can be used in smaller quantities in slimming foods.

Ref	Content
	4 Human biology
	4.1 Breathing
a)	The respiratory (breathing) system takes air into and out of the body so that oxygen from the air can diffuse into the bloodstream and carbon dioxide can diffuse out of the bloodstream into the air. The lungs are in the upper part of the body (thorax), protected by the ribcage and separated from the lower part of the body (abdomen) by the diaphragm. *Candidates should be able to recognise the following on a diagram of the respiratory system: ribs, intercostal muscles, diaphragm, lungs, trachea, bronchi, bronchioles, alveoli.*
b)	To inhale: ■ the intercostal muscles contract, pulling the ribcage upwards ■ at the same time the diaphragm muscles contract, causing the diaphragm to flatten ■ these two movements cause an increase in the volume of the thorax ■ the consequent decrease in pressure to below that of the air surrounding the body results in atmospheric air entering the lungs. To exhale: ■ the intercostal muscles relax, allowing the rib cage to move downwards ■ at the same time the diaphragm muscles relax, allowing the diaphragm to resume its domed shape ■ these two movements cause a reduction in the volume of the thorax ■ the consequent increase in pressure results in air leaving the lungs.
c)	The alveoli provide a very large surface area, richly supplied with blood capillaries, so that gases can readily diffuse into and out of the blood.
d)	A healthy person breathes automatically twenty four hours each day. However, spontaneous breathing may stop due to disease or injury. If this happens the patient can be helped to breathe by using a mechanical ventilator. There are two main types of mechanical ventilator: ■ negative pressure ventilators, which cause air to be 'drawn' into the lungs ■ positive pressure ventilators, which force air into the lungs.
	4.2 Respiration
a)	Respiration in cells can take place aerobically (using oxygen) or anaerobically (without oxygen), to release energy.
b)	During aerobic respiration chemical reactions occur that use glucose (a sugar) and oxygen and release energy.
c)	Aerobic respiration is summarised by the equations: glucose + oxygen $\longrightarrow$ carbon dioxide + water (+ energy) $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ (+ energy)
d)	Aerobic respiration takes place continuously in both plants and animals.
e)	Most of the reactions in aerobic respiration take place inside mitochondria.
f)	The energy that is released during respiration may be used by the organism in a variety of ways: ■ to build larger molecules from smaller ones ■ in animals, to enable muscles to contract ■ in mammals and birds, to maintain a steady body temperature in colder surroundings ■ in plants, to build up sugars, nitrates and other nutrients into amino acids, which are then built up into proteins.

Ref	Content
g)	During exercise the human body needs to react to the increased demand for energy. A number of changes take place: ■ the heart rate increases, increasing blood flow to the muscles ■ the rate and depth of breathing increase ■ glycogen stored in the muscles is converted back to glucose.
h)	These changes increase the supply of glucose and oxygen to, and increase the rate of removal of carbon dioxide from, the muscles.
i)	If insufficient oxygen is reaching the muscles, energy is produced by anaerobic respiration. glucose ⟶ lactic acid (+ energy) $C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$ (+ energy)
j)	Anaerobic respiration in muscles is the incomplete breakdown of glucose, which causes a build-up of lactic acid. An oxygen debt needs to be repaid to oxidise the lactic acid to carbon dioxide and water.
k)	Because the breakdown of glucose is incomplete, much less energy is released in anaerobic respiration than during aerobic respiration.
l)	During long periods of vigorous activity muscles become fatigued and stop contracting efficiently. One cause of muscle fatigue is the build-up of lactic acid in the muscles. Blood flowing through the muscles eventually removes the lactic acid. *Candidates will be expected to interpret data relating to the effects of exercise on the human body.*
m)	Anaerobic respiration in plant cells and in some microorganisms results in the production of ethanol and carbon dioxide.

4.3 Circulation

a)	Substances are transported from where they enter the body to the cells, or from the cells to where they are removed from the body, by the circulatory system (the heart, the blood vessels and the blood).
b)	The heart is an organ that pumps blood around the body. Much of the wall of the heart is made from muscle tissue.
c)	The heart has four main chambers (right and left atria and right and left ventricles).
d)	The natural resting heart rate is controlled by a group of cells that act as a pacemaker, located in the right atrium. Artificial pacemakers are electrical devices used to correct irregularities in the heart rate.
e)	In coronary heart disease layers of fatty material build up inside the coronary arteries, narrowing them. This reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle. Stents are used to keep the coronary arteries open.
f)	In some people heart valves may become faulty. There are two main faults – the heart valve tissue might stiffen, preventing the valve from opening fully, or the heart valve might develop a leak. Faulty heart valves can be replaced using: ■ biological valves – valves from humans or other mammals ■ mechanical valves.
g)	Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest as an aid to recovery.
h)	Blood enters the atria of the heart. The atria contract and force blood into the ventricles. The ventricles contract and force blood out of the heart. Valves in the heart ensure that blood flows in the correct direction. *Knowledge of the names of the heart valves is **not** required.*

Ref	Content
i)	Blood flows from the heart to the organs through arteries and returns through veins. There are two separate circulation systems, one for the lungs and one for all other organs of the body. Knowledge of the blood vessels associated with the heart is limited to aorta, vena cava, pulmonary artery, pulmonary vein and coronary arteries.
j)	Arteries have thick walls containing muscle and elastic fibres. Veins have thinner walls and often have valves to prevent back-flow of blood.
k)	In the organs, blood flows through very narrow, thin-walled blood vessels called capillaries. Substances needed by the cells in body tissues pass out of the blood and substances produced by the cells pass into the blood, through the walls of the capillaries.
l)	Blood is a tissue consisting of a fluid called plasma, in which the white blood cells, platelets and red blood cells are suspended.
m)	Blood plasma transports: ■ carbon dioxide from the organs to the lungs ■ soluble products of digestion from the small intestine to other organs ■ urea from the liver to the kidneys.
n)	Red blood cells have no nucleus. They are packed with a red pigment called haemoglobin. Red blood cells transport oxygen from the lungs to the organs. In the lungs haemoglobin combines with oxygen to form oxyhaemoglobin. In other organs oxyhaemoglobin splits up into haemoglobin and oxygen.
o)	White blood cells have a nucleus. They form part of the body's defence system against microorganisms.
p)	Platelets are small fragments of cells. They have no nucleus. Platelets help blood to clot at the site of a wound.
q)	Blood clotting is a series of enzyme-controlled reactions, resulting in the change of fibrinogen to fibrin, which forms a network of fibres trapping blood cells and forming a clot.
r)	Antigens are proteins on the surface of cells.
s)	In organ transplants a diseased organ is replaced with a healthy one from a donor. The recipient's antibodies may attack the antigens on the donor organ as they do not recognise them as part of the recipient's body. To prevent rejection of the transplanted organ: ■ a donor organ with a 'tissue-type' similar to that of the recipient is used ■ the recipient is treated with drugs that suppress their immune system. *Candidates should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of treating organ failure by mechanical devices or transplant.*
t)	There are four main types of human blood: O, A, B and AB. Blood group O is the universal donor. *Candidates should understand:* ■ *the need for blood typing* ■ *the ABO compatibility table.*

4.4 Digestion

a)	Starch (a carbohydrate), proteins and fats are insoluble. They are broken down into soluble substances so that they can be absorbed into the bloodstream in the wall of the small intestine. In the large intestine much of the water mixed with the food is absorbed into the bloodstream. The indigestible food which remains makes up the bulk of the faeces. Faeces leave the body via the anus. *Candidates should be able to recognise the following on a diagram of the digestive system: salivary glands, oesophagus, stomach, liver, gall bladder, pancreas, duodenum, small intestine, large intestine, anus.*
b)	The enzyme amylase is produced in the salivary glands, the pancreas and the small intestine. Amylase catalyses the breakdown of starch into sugars in the mouth and small intestine.

Ref	Content
c)	Protease enzymes are produced by the stomach, the pancreas and the small intestine. These enzymes catalyse the breakdown of proteins into amino acids in the stomach and the small intestine.
d)	Lipase enzymes are produced by the pancreas and small intestine. These enzymes catalyse the breakdown of lipids into fatty acids and glycerol in the small intestine.
e)	The stomach also produces hydrochloric acid. The enzymes in the stomach work most effectively in acid conditions.
f)	The liver produces bile, which is stored in the gall bladder before being released into the small intestine. Bile neutralises the acid that was added to food in the stomach. This provides alkaline conditions in which enzymes in the small intestine work most effectively. Bile also emulsifies fats (breaks large drops of fats into smaller droplets). This increases the surface area of fats for lipase enzymes to act upon.

4.5 The nervous system

a)	The nervous system enables humans to react to their surroundings and to coordinate their behaviour.
b)	Information from receptors passes along cells (neurones) as impulses to the central nervous system (the brain or the spinal cord). The brain coordinates the response.
c)	The brain controls complex behaviour. It is made of billions of interconnected neurones and has different regions that carry out different functions: ■ the cerebral cortex is concerned with consciousness, intelligence, memory and language ■ the cerebellum is concerned mainly with the coordination of muscular activity ■ the medulla is concerned with unconscious activities such as heartbeat and breathing.
d)	Scientists have been able to map the regions of the brain to particular functions by studying patients with brain damage, electrically stimulating different parts of the brain and using MRI scanning techniques.
e)	Reflex actions are automatic and rapid. They often involve sensory, relay and motor neurones.
f)	In a simple reflex action such as a pain-withdrawal reflex: ■ impulses from a receptor pass along a sensory neurone to the central nervous system ■ at a junction (synapse) between a sensory neurone and a relay neurone in the central nervous system, a chemical is released that causes an impulse to be sent along a relay neurone ■ a chemical is then released at the synapse between a relay neurone and motor neurone in the central nervous system, causing impulses to be sent along a motor neurone to the effector ■ the effector is either a muscle or a gland: a muscle responds by contracting and a gland responds by releasing (secreting) chemical substances.
g)	Effectors include muscles and glands. *Candidates should be able, when provided with appropriate information, to analyse a particular given example of behaviour in terms of:* *stimulus* ⟶ *receptor* ⟶ *co-ordinator* ⟶ *effector* ⟶ *response*

Ref	Content
4.6	**Homeostasis**
4.6.1	**Principles of homeostasis**
a)	Automatic control systems in the body keep conditions inside the body relatively constant.
b)	Control systems include: ■ cells called receptors, which detect stimuli (changes in the environment) ■ coordination centres that receive and process information from receptors ■ effectors, which bring about responses.
c)	Receptors are found in many organs, including: ■ the eyes – sensitive to light ■ the ears – sensitive to sound, and to changes in position (which enables us to keep our balance) ■ the tongue and in the nose – sensitive to chemicals (enable us to taste and to smell) ■ the skin – sensitive to touch, pressure, pain and to temperature changes ■ the brain – sensitive to blood temperature and the concentration of water in the blood ■ the pancreas – sensitive to the concentration of glucose in the blood. *Knowledge and understanding of the structure and functions of sense organs such as the eye and the ear is **not** required.*
d)	Coordination centres include the brain and spinal cord and the pancreas. Many processes are coordinated by chemical substances called hormones. Hormones are secreted by glands and are usually transported to their target organs by the bloodstream.
e)	Internal conditions that are controlled include: ■ temperature ■ the water content of the body ■ the ion content of the body ■ blood glucose levels.
4.6.2	**Control of water and ion content of the body**
a)	Water leaves the body via the lungs when we breathe out and the skin when we sweat. Excess water is removed via the kidneys in the urine.
b)	Urea and ions are lost via the skin when we sweat. Excess ions are removed via the kidneys in the urine.
c)	In the liver: ■ excess amino acids are deaminated to form ammonia, which is converted into urea for excretion ■ poisonous substances are detoxified, and the breakdown products excreted in the urine via the kidneys ■ old blood cells are broken down and the iron is stored.
d)	In a healthy kidney: ■ the blood is filtered ■ all the glucose is reabsorbed ■ the dissolved ions needed by the body are reabsorbed ■ as much water as the body needs is reabsorbed ■ urea, excess ions and excess water are released as urine. *Knowledge of other parts of the urinary system, the structure of the kidney and the structure of a nephron is **not** required.*

Ref	Content
e)	If the water content of the blood is too low, the pituitary gland releases a hormone called ADH into the blood. This causes the kidneys to reabsorb more water and results in a more concentrated urine.
f)	If the water content of the blood is too high, less ADH is released into the blood. Less water is reabsorbed in the kidneys, resulting in a more dilute urine.
g)	People who suffer from kidney failure may be treated by organ transplant or by using kidney dialysis, which restores the concentrations of dissolved substances in the blood to normal levels. Dialysis has to be carried out at regular intervals. In a dialysis machine a person's blood flows between partially permeable membranes. The dialysis fluid contains the same concentration of useful substances as the blood of a person without kidney disease. This ensures that glucose and useful mineral ions are not lost but that harmful substances such as urea pass out from the blood into dialysis fluid. *Candidates should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of treating organ failure by mechanical devices or transplant.*

3

4.6.3 Temperature control

a)	Body temperature is monitored and controlled by the thermoregulatory centre in the brain. This centre has receptors sensitive to the temperature of the blood flowing through the brain. *The name of the centre in the brain (hypothalamus) is **not** required.*
b)	Temperature receptors in the skin send impulses to the thermoregulatory centre, giving information about skin temperature.
c)	If the core body temperature is too high: ■ blood vessels supplying the skin capillaries dilate so that more blood flows through the capillaries and more heat is lost ■ sweat glands release more sweat, which cools the body as it evaporates.
d)	Sweating helps to cool the body. More water is lost when it is hot, and more fluid has to be taken through drink or food to balance this loss.
e)	If the core body temperature is too low: ■ blood vessels supplying the skin capillaries constrict to reduce the flow of blood through the capillaries ■ muscles may 'shiver' – their contraction needs respiration, which releases some energy to warm the body.

4.6.4 Control of blood glucose

a)	The blood glucose concentration is monitored and controlled by the pancreas. Much of the glucose is stored as glycogen in the liver and muscles. When these stores are full, excess glucose is stored as lipid.
b)	If blood glucose levels are too high, the pancreas produces the hormone insulin, which allows the glucose to move from the blood into the cells.
c)	When blood glucose levels fall, the pancreas produces a second hormone, glucagon. This causes glycogen to be converted into glucose and released into the blood.
d)	In Type 1 diabetes a person's blood glucose level may be too high because the pancreas does not produce enough of the hormone insulin. Type 1 diabetes may be controlled by careful diet, exercise, and by injecting insulin.
e)	Type 2 diabetes develops when the body does not respond to its own insulin. Obesity is a significant factor in the development of Type 2 diabetes. Type 2 diabetes can be controlled by careful diet, exercise and by drugs that help the cells to respond to insulin.

Ref	Content
	5 Defending ourselves against infectious disease
a)	Microorganisms that cause infectious disease are called pathogens.
b)	Bacteria and viruses may reproduce rapidly inside the body. Bacteria may produce poisons (toxins) that make us feel ill. Viruses live and reproduce inside cells, causing damage. *Knowledge of the structure of viruses is **not** required.*
c)	White blood cells help to defend against pathogens by: ▪ ingesting pathogens ▪ producing antibodies, which destroy particular bacteria or viruses ▪ producing antitoxins, which counteract the toxins released by the pathogens.
d)	The immune system of the body produces specific antibodies to kill a particular pathogen. This leads to immunity from that pathogen. In some cases, dead or inactivated pathogens stimulate antibody production. If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced.
e)	People can be immunised against a disease by introducing small quantities of dead or inactive forms of the pathogen into the body (vaccination). Vaccines stimulate the white blood cells to produce antibodies that destroy the pathogen. This makes the person immune to future infections by the microorganism, because the body can respond by rapidly making the correct antibody, in the same way as if the person had previously had the disease. The MMR vaccine is used to protect children against measles, mumps and rubella. *Details of vaccination schedules and side effects associated with specific vaccines are **not** required.* *Candidates should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of being vaccinated against a particular disease.*
f)	Some medicines, including painkillers, help to relieve the symptoms of infectious disease, but do not kill the pathogens.
g)	Antibiotics, such as penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases.
h)	Antibiotics cannot kill viral pathogens. *Candidates should be aware that it is difficult to develop drugs that kill viruses without also damaging the body's tissues.*
i)	Mutations of pathogens produce new strains. Antibiotics kill individual pathogens of the non-resistant strain but individual resistant pathogens survive and reproduce, so the population of the resistant strain rises. Antibiotics and vaccinations may no longer be effective against a new resistant strain of the pathogen. The new strain will then spread rapidly because people are not immune to it and there is no effective treatment. *Knowledge of development of resistance in bacteria is limited to the fact that pathogens mutate, producing resistant strains.*
j)	Many strains of bacteria, including MRSA, have developed resistance to antibiotics. Overuse and inappropriate use of antibiotics has increased the rate of development of antibiotic-resistant strains of bacteria. Antibiotics are not currently used to treat non-serious infections such as mild throat infections, in order to slow down the rate of development of resistant strains.
k)	The development of antibiotic-resistant strains of bacteria necessitates the development of new antibiotics.

Ref	Content
l)	Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics. For this: ■ Petri dishes and culture media must be sterilised before use to kill unwanted microorganisms ■ inoculating loops used to transfer microorganisms to the media must be sterilised by passing them through a flame ■ the lid of the Petri dish should be secured with adhesive tape to prevent microorganisms from the air contaminating the culture, and stored upside down to stop bacteria falling onto the agar surface.
m)	In school and college laboratories, cultures should be incubated at a maximum temperature of 25 °C, which greatly reduces the likelihood of the growth of pathogens that might be harmful to humans.
n)	In industrial conditions higher temperatures can produce more rapid growth.

3

6 Plants as organisms

6.1 Photosynthesis

a)	Photosynthesis is summarised by the equations: $\text{carbon dioxide + water} \xrightarrow{\text{light energy}} \text{glucose + oxygen}$ $6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$
b)	During photosynthesis: ■ light energy is absorbed by a green substance called chlorophyll, which is found in chloroplasts in some plant cells and in algae ■ this energy is used to convert carbon dioxide (from the air) and water (from the soil) into sugar (glucose) ■ oxygen is released as a by-product.
c)	The rate of photosynthesis may be limited by: ■ low temperature ■ shortage of carbon dioxide ■ shortage of light. These factors interact and any one of them may be the factor that limits photosynthesis. *Candidates should be able to relate the principle of limiting factors to the economics of enhancing the following conditions in greenhouses:* ■ *temperature* ■ *carbon dioxide concentration* ■ *light intensity.*
d)	The glucose produced in photosynthesis may be: ■ used for respiration ■ converted into insoluble starch for storage ■ used to produce fat or oil for storage ■ used to produce cellulose, which strengthens the cell wall ■ used to produce proteins.
e)	To produce proteins, plants also use nitrate ions that are absorbed from the soil.
f)	Carnivorous plants such as the Venus Fly Trap are adapted to live in nutrient-poor soil as they obtain most of their nutrients from the animals, such as insects, that they catch.

Ref	Content
6.2	**Exchange and transport**
a)	In flowering plants: ■ carbon dioxide enters leaves by diffusion through the stomata ■ most of the water and mineral ions are absorbed by roots.
b)	The surface area of roots is increased by root hairs, and the surface area of leaves is increased by the flattened shape and internal air spaces.
c)	Plants have stomata to obtain carbon dioxide from the atmosphere and to remove oxygen produced in photosynthesis.
d)	Plants mainly lose water vapour from their leaves. Most of the loss of water vapour takes place through the stomata. ■ Evaporation is more rapid in hot, dry and windy conditions. ■ If plants lose water faster than it is replaced by the roots, the stomata can close to prevent wilting.
e)	The size of stomata is controlled by guard cells, which surround them.
f)	Flowering plants have separate transport systems: ■ xylem tissue transports water and mineral ions from the roots to the stem and leaves ■ the movement of water from the roots through the xylem and out of the leaves is called the transpiration stream ■ phloem tissue carries dissolved sugars from the leaves to the rest of the plant, including the growing regions and the storage organs. This process is called translocation.
6.3	**Plant responses**
a)	Plants are sensitive to light (phototropism), moisture (hydrotropism) and gravity (gravitropism): ■ their shoots grow towards light and against the force of gravity ■ their roots grow towards moisture and in the direction of the force of gravity.
b)	Plants produce hormones to coordinate and control growth. The hormone auxin controls phototropism and gravitropism (geotropism).
c)	The responses of plant roots and shoots to light, gravity and moisture are the result of unequal distribution of auxin, causing unequal growth rates.
d)	Plant growth hormones are used in agriculture and horticulture as weed killers and as rooting hormones. *Names of specific weed killers and rooting hormones are **not** required.*
6.4	**Sexual reproduction in plants**
a)	Sexual reproduction in flowering plants involves: ■ the production of male and female gametes ■ the transfer of the male gametes to the female ovules in a process called pollination ■ fertilisation, after which ovules grow into seeds within a fruit.
b)	The processes involved in sexual reproduction include: ■ the anther produces the male gametes in pollen grains ■ the pollen grains attach to the stigma on top of a carpel, in which the female gametes (ovules) are located ■ a pollen tube grows through the carpel's style into the ovule ■ the nuclei from the pollen grain migrate into the ovule to fertilise the egg cell nucleus and endosperm nuclei ■ the resulting zygote develops into an embryo ■ the endosperm and the female tissues of the ovule give rise to seed ■ the ovary then grows into a fruit, which surrounds the seed(s). *Candidates should be able to recognise the structures listed above on a diagram.*

Ref	Content
	7 Variation and inheritance
	7.1 Genetic variation
a)	Differences in the characteristics of individuals of the same kind may be due to differences in: ■ the genes they have inherited (genetic causes) ■ the conditions in which they have developed (environmental causes) ■ a combination of the above.
b)	The information that results in plants and animals having similar characteristics to their parents is carried by genes, which are passed on in the sex cells (gametes) from which the offspring develop.
c)	The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body. Chromosomes are normally found in pairs.
d)	In human body cells, one of the 23 pairs of chromosomes carries the genes that determine sex. In females the sex chromosomes are the same (XX); in males the sex chromosomes are different (XY).
e)	Different genes control the development of different characteristics of an organism. Some characteristics are controlled by a single gene. Each gene may have different forms called alleles. *Candidates should understand that genes operate at a molecular level to develop characteristics that can be seen.*
f)	If both chromosomes in a pair contain the same allele of a gene, the individual is homozygous for that gene. If the chromosomes in a pair contain different alleles of a gene, the individual is heterozygous for that gene.
g)	An allele that controls the development of a characteristic when it is present on only one of the chromosomes is called a dominant allele. An allele that controls the development of a characteristic only if the dominant allele is not present is called a recessive allele. *Candidates should be familiar with principles used by Mendel in investigating monohybrid inheritance in peas. They should understand that Mendel's work preceded the work by other scientists which linked Mendel's 'inherited factors' with chromosomes.* *Candidates should be able to construct genetic diagrams of monohybrid crosses and to predict the outcomes of monohybrid crosses. They should be able to use the terms homozygous, heterozygous, phenotype and genotype.* *Candidates should understand that genetic diagrams are biological models which can be used to predict the outcomes of crosses.* *Candidates should be able to interpret genetic diagrams, including family trees.*
h)	There are two forms of reproduction: ■ sexual reproduction – the joining (fusion) of male and female gametes. The mixture of the genetic information from two parents leads to variety in the offspring ■ asexual reproduction – no fusion of gametes and only one individual is needed as the parent. There is no mixing of genetic information and so no genetic variation in the offspring. These genetically identical individuals are known as clones.
i)	Chromosomes are made up of large molecules of DNA (deoxyribonucleic acid). DNA contains the coded information that determines inherited characteristics.
j)	A gene is a small section of DNA. Each gene codes for a particular combination of amino acids, to make a specific protein.
k)	DNA is made of very long strands, twisted to form a double helix, which contain four different compounds, called bases. *Candidates are **not** expected to know the names of the four bases or how complementary pairs of bases enable DNA replication to take place.*
l)	A sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein.

Ref	Content
7.2	**Genetic disorders**
	Attention is drawn to the potential sensitivity needed in teaching about inherited disorders.
a)	Some disorders are inherited.
b)	Polydactyly (having extra fingers or toes) is caused by a dominant allele and can therefore be passed on by only one parent who has the disorder.
c)	Cystic fibrosis (a disorder of cell membranes) is caused by a recessive allele and must therefore be inherited from both parents. It can be passed on by parents who may be carriers of the disorder without actually having the disorder themselves.
d)	Sickle-cell anaemia (a disorder affecting red blood cells) is caused by a recessive allele. People who are heterozygous for the sickle-cell anaemia gene are less likely to get malaria than people who are homozygous for the dominant gene.
e)	Some inherited conditions are caused by inheritance of abnormal numbers of chromosomes, eg Down's Syndrome is caused by the presence of an extra chromosome.
f)	Embryos can be screened for the alleles that cause many genetic disorders: ■ DNA is isolated from embryo cells ■ a gene probe that will bind onto the gene for a specific disorder is produced. The probe usually has a fluorescent chemical attached to it ■ the probe is added to a mixture containing the DNA sample from the embryo ■ UV light is used to detect the probe attached to the gene for the disorder.
g)	Concerns about embryo screening include: ■ the risk of miscarriages ■ the reliability of the information from the screening procedure ■ decisions about terminating pregnancy. *Candidates should be able, when provided with appropriate information, to evaluate and make informed judgements about issues concerning embryo screening.*
7.3	**Genetic manipulation**
a)	Modern cloning techniques include: ■ tissue culture – using small groups of cells from part of a plant ■ embryo transplants – splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers ■ adult cell cloning – the nucleus is removed from an unfertilised egg cell and the nucleus from an adult body cell, eg a skin cell, is inserted into the egg cell. An electric shock then acts as the catalyst for the egg cell to begin to divide to form embryo cells. These embryo cells contain the same genetic information as the adult skin cell. When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.
b)	In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms: ■ enzymes are used to isolate the required gene ■ this gene is inserted into a vector, usually a bacterial plasmid or a virus ■ the vector is used to insert the gene into the required cells.
c)	Genes can also be transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics. Crops that have had their genes modified in this way are called genetically modified crops (GM crops). Genetically modified crops include ones that are resistant to insect attack or to herbicides. Genetically modified crops generally show increased yields.

Ref	Content
d)	Concerns about GM crops include the effect on populations of wild flowers and insects, and uncertainty about the effects of eating GM crops on human health.
	Candidates should be able, when provided with appropriate information, to interpret information about cloning techniques and genetic engineering techniques and to make informed judgements about issues concerning cloning and genetic engineering, including GM crops.

8 Adaptation and interdependence

8.1 Adaptation

a)	To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there.
b)	Plants often compete with each other for light and space, and for water and nutrients from the soil.
c)	Animals often compete with each other for food, mates and territory.
d)	Organisms, including microorganisms, have features (adaptations) that enable them to survive in the conditions in which they normally live.
e)	Some organisms live in environments that are very extreme, containing high levels of salt, high temperatures or high pressures. These organisms are called extremophiles.
f)	Adaptations include: ■ structural adaptations, eg the ways in which organisms are shaped, or coloured ■ behavioural adaptations, eg migration ■ functional adaptations, related to processes such as reproduction and metabolism.
g)	Parasites are adapted for living on or inside their hosts. ■ Fleas live amongst the hair of mammals. They have sharp mouthparts to enable them to suck blood. The body is flattened so that the flea is not easily dislodged. It has a hard body that is not damaged when the mammal scratches. Its long hind legs enable the flea to jump from host to host. ■ Tapeworms live inside the intestines of mammals and many other groups of animals. They have both suckers and hooks to fix themselves to the wall of the intestine. The body consists of flattened segments whose main function is to produce large numbers of eggs. Tapeworms have no gut; their flattened shape provides a large surface area for the absorption of soluble food from the host gut. A thick outer cuticle protects the tapeworm from the host's digestive enzymes. ■ Malaria parasites are single-celled organisms that cause malaria in humans. The organism has different forms. Each form is specialised for living in a different place in the host: – *gametocytes* that infect mosquitoes and reproduce sexually. When the mosquito has sucked blood containing gametocytes, these pass into the salivary glands of the mosquito, where they develop into a new form, the sporozoite – *sporozoites* are passed on to humans when the mosquito bites, injecting its saliva into blood vessels. The sporozoites travel with the blood to the liver and enter the liver cells. In the liver some of the sporozoites divide and become thousands of merozoites – *merozoites* are released from the liver into the blood, where they enter the red blood cells. Some of these turn into schizonts – *schizonts* burst the red blood cells, releasing more merozoites. This release coincides with the fever attacks seen when a person has malaria – some merozoites in the blood cells enter a sexual phase of reproduction and produce female gametocytes, which can be transferred to the mosquito when it bites.
	Throughout Section 8.1, candidates should be able, when provided with appropriate information: ■ *to suggest how organisms are adapted to the conditions in which they live* ■ *to suggest the factors for which organisms are competing in a given habitat.*

Ref	Content
8.2	**Environmental change and distribution of organisms**
a)	Living organisms form communities and we need to understand the relationships within and between these communities.
b)	Changes in the environment affect the distribution of living organisms. *Examples might include the changing distribution of some bird species and the disappearance of pollinating insects, including bees.*
c)	Environmental factors that may affect organisms include living or non-living factors such as: ■ change in numbers or types of competitor organism ■ temperature ■ availability of nutrients ■ amount of light ■ availability of water ■ availability of oxygen and carbon dioxide ■ availability of nesting sites, shelter and appropriate habitats.
d)	Living organisms can be used as indicators of environmental change: ■ lichens can be used as air pollution indicators, particularly of the concentration of sulfur dioxide in the atmosphere ■ invertebrate animals can be used as water pollution indicators and are used to indicate the concentration of dissolved oxygen in water.
e)	Environmental changes can be measured using non-living indicators such as oxygen levels, temperature and rainfall. *Candidates should understand the advantages and disadvantages of using equipment to measure oxygen levels, temperature and rainfall.*
f)	Quantitative data on the distribution of organisms can be obtained by: ■ random sampling with quadrats ■ sampling along a transect. *Candidates should understand:* ■ *the terms mean, median and mode* ■ *that sample size is related to validity, reproducibility and repeatability.* *Candidates should be able, when provided with appropriate information:* ■ *to suggest reasons for the distribution of living organisms in a particular habitat* ■ *to evaluate methods used to collect environmental data, and consider the validity, reproducibility and repeatability as evidence for environmental change.*

Ref	Content
8.3	**Humans and their effects on the environment**
a)	Rapid growth in the human population and an increase in the standard of living mean that increasingly more waste is produced. Unless waste is properly handled, more pollution will be caused.
b)	Waste may pollute: ■ water, with sewage, fertiliser or toxic chemicals ■ air, with smoke and gases such as sulfur dioxide, which contributes to acid rain ■ land, with toxic chemicals such as pesticides and herbicides, which may be washed from land into water ■ sewage and fertilisers may cause eutrophication: – an increase in the concentration of mineral ions in the water stimulates the growth of algae and/or plants – eventually the growth of the algae and/or plants results in some of these being unable to receive sufficient light for photosynthesis and these organisms die – there is a large increase in the population of microorganisms that feed on these dead organisms – the respiration of the microorganisms depletes the oxygen concentration in the water, leading to the death of aerobic organisms.
c)	Humans reduce the amount of land available for other animals and plants by building, quarrying, farming and dumping waste.
d)	Large-scale deforestation in tropical areas has occurred so that: ■ there can be increases in cattle and in rice fields to provide more food. These organisms produce methane and this has led to increases in methane in the atmosphere ■ crops can be grown from which biofuels, based on ethanol, can be produced.
e)	Large-scale deforestation in tropical areas has: ■ increased the release of carbon dioxide into the atmosphere (because of burning and the activities of microorganisms) ■ reduced the rate at which carbon dioxide is removed from the atmosphere and 'locked up' for hundreds of years as wood.
f)	Loss of forest leads to reduction in biodiversity.
g)	The destruction of peat bogs, and other areas of peat, releases carbon dioxide into the atmosphere. *Candidates should understand why 'peat free' composts are of increasing importance.*
h)	Levels of carbon dioxide and methane in the atmosphere are increasing, and contribute to 'global warming'. An increase in the Earth's temperature of only a few degrees Celsius may: ■ cause big changes in the Earth's climate ■ cause a rise in sea level ■ cause changes in migration patterns, eg in birds ■ result in changes in the distribution of species.
i)	Carbon dioxide can be sequestered in oceans, lakes and ponds, and this is an important factor in removing carbon dioxide from the atmosphere.
	Throughout Section 8.3, candidates should be able, when provided with appropriate information: ■ *to analyse and interpret scientific data concerning environmental issues* ■ *to evaluate methods used to collect environmental data and consider their validity and reliability as evidence for environmental change.*

Ref	Content
9	**Evolution**
9.1	**Natural selection**
a)	Darwin's theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago. *A study of creationism is **not** required.*
b)	The theory of evolution by natural selection was only gradually accepted because: ■ the theory challenged the idea that God made all the animals and plants that live on Earth ■ there was insufficient evidence at the time the theory was published to convince many scientists ■ the mechanism of inheritance and variation was not known until 50 years after the theory was published.
c)	Other theories, including that of Lamarck, are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited. We now know that in the vast majority of cases this type of inheritance cannot occur.
d)	Studying the similarities and differences between organisms allows us to classify living organisms into animals, plants and microorganisms, and helps us to understand evolutionary and ecological relationships. Models allow us to suggest relationships between organisms. *Candidates should understand how evolutionary trees (models) are used to represent the relationships between organisms.*
e)	Evolution occurs via natural selection. ■ Individual organisms within a particular species may show a wide range of variation because of differences in their genes. ■ Individuals with characteristics most suited to the environment are more likely to survive to breed successfully. ■ The genes that have enabled these individuals to survive are then passed on to the next generation. *Candidates should develop an understanding of the timescales involved in evolution.*
9.2	**Speciation**
a)	Evidence of early forms of life comes from fossils.
b)	Fossils are the 'remains' of organisms from hundreds of thousands of years ago, which are found in rocks. Fossils may be formed in various ways: ■ from parts of organisms that have not decayed because one or more of the conditions needed for decay are absent ■ when parts of the organism are replaced by other materials as they decay ■ as preserved traces of organisms, eg footprints, burrows and rootlet traces.
c)	Many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity. This is why scientists cannot be certain about how life began on Earth.
d)	We can learn from fossils how much or how little different organisms have changed as life developed on Earth.
e)	Extinction may be caused by: ■ changes to the environment over geological time ■ new predators ■ new diseases ■ new, more successful, competitors ■ a single catastrophic event, eg massive volcanic eruptions or collisions with asteroids.

Ref	Content
f)	New species arise as a result of: ■ isolation: two populations of a species become separated, eg geographically ■ genetic variation: each population has a wide range of alleles that control their characteristics ■ natural selection: in each population, the alleles that control the characteristics which help the organism to survive are selected ■ speciation: the populations become so different that successful interbreeding is no longer possible.

10 Energy and biomass in food chains

a)	Radiation from the Sun is the source of energy for most communities of living organisms. Green plants and algae absorb a small amount of the light that reaches them. The transfer from light energy to chemical energy occurs during photosynthesis. This energy is stored in the substances that make up the cells of the plants.
b)	The mass of living material (biomass) at each stage in a food chain is less than it was at the previous stage because: ■ some materials and energy are always lost in the organisms' waste materials ■ respiration supplies all the energy needs for living processes, including movement. Much of this energy is eventually transferred to the surroundings. *Construction of food webs and chains, and of pyramids of numbers, is **not** required. An understanding of pyramids of numbers is **not** required.*
c)	The biomass at each stage can be drawn to scale and shown as a pyramid of biomass. *Candidates should be able to interpret pyramids of biomass and construct them from appropriate information.*
d)	The efficiency of food production can be improved by reducing the number of stages in a food chain.
e)	The efficiency of food production can also be improved by restricting energy loss from food animals by limiting their movement and by controlling the temperature of their surroundings.
f)	Fish stocks in the oceans are declining. It is important to maintain fish stocks at a level where breeding continues, otherwise certain species may disappear altogether in some areas. Net size and fishing quotas play an important role in the conservation of fish stocks.
	Throughout Section 10, candidates should be able, when provided with appropriate information, to evaluate the positive and negative effects of managing food production and distribution, and be able to recognise that practical solutions for human needs may require compromise between competing priorities, including: ■ *the differences in efficiency between producing food from animals and plants* ■ *the issues associated with factory farming of animals* ■ *the implications of 'food miles'.*

11 Decay and the carbon cycle

a)	Living organisms remove materials from the environment for growth and other processes. These materials are returned to the environment either in waste materials or when living things die and decay.
b)	Materials decay because they are broken down (digested) by microorganisms. Microorganisms are more active and digest materials faster in warm, moist, aerobic conditions.
c)	The decay process releases substances that plants need to grow.
d)	In a stable community, the processes that remove materials are balanced by processes that return materials. The materials are part of a constant cycle.

Ref	Content
e)	The constant cycling of carbon is called the carbon cycle. In the carbon cycle: ■ carbon dioxide is removed from the environment by green plants and algae during photosynthesis ■ the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the body of plants and algae ■ when green plants and algae respire, some of this carbon becomes carbon dioxide and is released into the atmosphere ■ when green plants and algae are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins that make up their bodies ■ when animals respire, some of this carbon becomes carbon dioxide and is released into the atmosphere ■ when plants, algae and animals die, some animals and microorganisms feed on their bodies ■ carbon is released into the atmosphere as carbon dioxide when microorganisms respire ■ by the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally absorbed by green plants and algae has been transferred ■ combustion of wood and fossil fuels releases carbon dioxide into the atmosphere.

3d Experimental and investigative skills

During this course, students should be encouraged to develop their understanding of the scientific process and the skills associated with scientific enquiry. In Paper 2, students will be assessed on aspects of the skills listed below, and may be required to read and interpret information from scales given in diagrams and charts, present data in appropriate formats, design investigations and evaluate information that is presented to them.

a) Design a practical procedure to answer a question, solve a problem or test a hypothesis.

b) Comment on/evaluate plans for practical procedures.

c) Select suitable apparatus for carrying out experiments accurately and safely.

d) Appreciate that, unless certain variables are controlled, experimental results may not be valid.

e) Recognise the need to choose appropriate sample sizes, and study control groups where necessary.

f) Identify possible hazards in practical situations, the risks associated with these hazards, and methods of minimising the risks.

g) Make and record observations and measurements with appropriate precision and record data collected in an appropriate format (such as a table, chart or graph).

h) Recognise and identify the cause of anomalous results and suggest what should be done about them.

i) Appreciate when it is appropriate to calculate a mean, calculate a mean from a set of at least three results and recognise when it is appropriate to ignore anomalous results in calculating a mean.

j) Recognise and identify the causes of random errors and systematic errors.

k) Recognise patterns in data, form hypotheses and deduce relationships.

l) Use and interpret tabular and graphical representations of data.

m) Draw conclusions that are consistent with the evidence obtained and support them with scientific explanations.

n) Evaluate data, considering its repeatability, reproducibility and validity in presenting and justifying conclusions.

o) Evaluate methods of data collection and appreciate that the evidence obtained may not allow a conclusion to be made with confidence.

p) Suggest ways of improving an investigation or practical procedure to obtain extra evidence to allow a conclusion to be made.

3e Mathematical and other requirements

Mathematical requirements

This specification provides learners with the opportunity to develop their skills in communication, mathematics and the use of technology in scientific contexts. In order to deliver the mathematical element of this outcome, assessment materials for this specification contain opportunities for candidates to demonstrate scientific knowledge using appropriate mathematical skills.

The areas of mathematics that arise naturally from the science content are listed below. This is not a checklist for each question paper, but assessments reflect these mathematical requirements, covering the full range of mathematical skills over a reasonable period of time.

Candidates are permitted to use calculators in all assessments.

Candidates are expected to use units appropriately. However, not all questions reward the appropriate use of units.

All candidates should be able to:

1 Understand number size and scale and the quantitative relationship between units.

2 Understand when and how to use estimation.

3 Carry out calculations involving +, –, ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers.

4 Provide answers to calculations to an appropriate number of significant figures.

5 Understand and use the symbols =, <, >, ~.

6 Understand and use direct proportion and simple ratios.

7 Calculate arithmetic means.

8 Understand and use common measures and simple compound measures such as speed.

9 Plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes.

10 Substitute numerical values into simple formulae and equations using appropriate units.

11 Translate information between graphical and numeric form.

12 Extract and interpret information from charts, graphs and tables.

13 Understand the idea of probability.

14 Calculate area, perimeters and volumes of simple shapes.

15 Interpret order and calculate with numbers written in standard form.

16 Carry out calculations involving negative powers (only –1 for rate).

17 Change the subject of an equation.

18 Understand and use inverse proportion.

19 Understand and use percentiles and deciles.

Units, symbols and nomenclature

Units, symbols and nomenclature used in examination papers will normally conform to the recommendations contained in the following:

- *The Language of Measurement: Terminology used in school science investigations.* Association for Science Education (ASE), 2010. ISBN 978 0 86357 424 5.
- *Signs, Symbols and Systematics – the ASE companion to 16–19 Science.* Association for Science Education (ASE), 2000. ISBN 978 0 86357 312 5.
- *Signs, Symbols and Systematics – the ASE companion to 5–16 Science.* Association for Science Education (ASE), 1995. ISBN 0 86357 232 4.

4 Scheme of Assessment

This specification is designed to be taken over a one- or two-year course of study with all assessment at the end of the course.

Examinations and certification for this specification are available for the first time in June 2013 and then every January and June thereafter throughout the life of the specification.

4a Aims and learning outcomes

The AQA Level 1/2 Certificate in Biology should encourage students to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. It should encourage students to develop their curiosity about the living world, enable students to engage with biology in their everyday lives and to make informed choices about further study in biology and related disciplines.

The AQA Level 1/2 Certificate in Biology should enable students to:

- develop their knowledge and understanding of biology
- develop and apply their knowledge and understanding of the scientific process
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop and apply their observational, practical, modelling, enquiry and problem-solving skills, and their understanding in laboratory, field and other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions both qualitatively and quantitatively
- develop their skills in reporting and presenting information clearly and logically in different formats
- develop their skills in communication, mathematics and the use of technology in scientific contexts.

4b Assessment Objectives (AOs)

The examination papers will assess the following assessment objectives in the context of the content and skills set out in Section 3 (Subject Content).

AO1:

Recall, select and communicate their knowledge and understanding of biology

AO2:

Apply skills, knowledge and understanding of biology in practical and other contexts

AO3:

Analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence

Weighting of Assessment Objectives

The table below shows approximate weighting of each of the Assessment Objectives in the AQA Level 1/2 Certificate in Biology assessments.

Assessment Objectives	Paper weightings (%)		Overall weighting of AOs (%)
	Paper 1	Paper 2	
AO1	27.5	15.0	**42.5**
AO2	19.5	15.5	**35.0**
AO3	3.0	19.5	**22.5**
Overall weighting of papers (%)	**50**	**50**	**100**

4c National criteria

This specification is in line with the following.

- The Code of Practice
- The Arrangements for the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland: Common Criteria
- The requirements for qualifications to provide access to Levels 1 and 2 of the National Qualification Framework

4d Previous learning requirements

There are no prior learning requirements.

However, any requirements set for entry to a course based on this specification are at your centre's discretion.

4e Access to assessment: diversity and inclusion

This qualification and subject criteria were reviewed to see whether any of the skills or knowledge needed by the subject presented a possible difficulty to any candidates, whatever their ethnic background, religion, sex, age, disability or sexuality. If there were difficulties, the situation was reviewed again to make sure that such tests of specific competences were only included if they were important to the subject.

Arrangements are made for candidates with special needs to help them access the assessments as long as the competences being tested are not changed. Because of this, most candidates will be able to access any part of the assessment. More details are given in Section 5d.

5 Administration

5a Availability of assessment components and certification

Examinations and certification for this specification are available for the first time in June 2013, and then each January and June thereafter.

5b Entries

Please check the current version of **Entry Procedures and Codes** for up-to-date entry procedures. You should use the following entry codes for the components and for certification.

AQA Level 1/2 Certificate in Biology – 8401

A single entry is all that is needed for both examination papers and certification.

5c Private candidates

This specification is available to private candidates. Private candidates should write to us for a copy of Supplementary Guidance for Private Candidates (for specifications without controlled assessment).

5d Access arrangements, reasonable adjustments and special consideration

We have taken note of the equality and discrimination legislation and the interests of minority groups in developing and administering this specification.

We follow guidelines in the Joint Council for Qualifications (JCQ) document: *Access Arrangements, Reasonable Adjustments and Special Consideration: General and Vocational Qualifications.* This is published on the JCQ website **jcq.org.uk** or you can follow the link from our website **aqa.org.uk**

Access arrangements

We can arrange for candidates with special needs to access an assessment. These arrangements must be made **before** the examination. For example, we can produce a Braille paper for a candidate with sight problems.

Reasonable adjustments

An access arrangement which meets the needs of a particular disabled candidate would be a reasonable adjustment for that candidate. For example, a Braille paper would be a reasonable adjustment for a Braille reader but not for a candidate who did not read Braille. The Equality Act requires us to make reasonable adjustments to remove or lessen any disadvantage affecting a disabled candidate. Further detailed information is available in the JCQ regulations *Access arrangements, reasonable adjustments and special consideration*. The needs of individual candidates covered by the Equality Act will vary considerably. For queries relating to individual candidate's needs and what reasonable adjustments may be approved you can contact our Access Arrangements team for specialist advice.

Special consideration

We can give special consideration to candidates who have had a temporary illness, injury or serious problem such as the death of a relative, at the time of the examination. We can only do this **after** the examination.

The Examinations Officer at the centre should apply online for access arrangements and special consideration by following the e-AQA link from our website **aqa.org.uk**

5e Examination language

We only provide components for this specification in English.

5f Qualification title

The qualification based on this specification is:

- AQA Level 1/2 Certificate in Biology

5g Awarding grades and reporting results

This qualification will be graded on an eight-grade scale: A*, A, B, C, D, E, F, G. Candidates who fail to reach the minimum standard for grade G will be recorded as 'U' (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark for each grade, for each paper and for the overall qualification, when we issue candidates' results. We will report a candidate's results to your centre in terms of uniform marks and qualification results in terms of uniform marks and grades. A candidate's grade is determined solely by their overall mark. There is no requirement to achieve the grade boundary in each paper in order to achieve a particular grade overall. Hence, a strong performance in one paper can compensate for a weaker performance in the other.

For each paper, the uniform mark corresponds to a grade as follows:

Grade	Uniform Mark Range
A*	90 – 100
A	80 – 89
B	70 – 79
C	60 – 69
D	50 – 59
E	40 – 49
F	30 – 39
G	20 – 29
U	0 – 19

We calculate a candidate's total uniform mark by adding together the uniform marks for the papers. We convert this total uniform mark into a grade as follows.

AQA Level 1/2 Certificate in Biology
(maximum uniform mark = 200)

Grade	Uniform Mark Range
A*	180 – 200
A	160 – 179
B	140 – 159
C	120 – 139
D	100 – 119
E	80 – 99
F	60 – 79
G	40 – 59
U	0 – 39

5h Re-sits

This is a traditional linear specification and, as such, individual components may not be retaken, neither can results for individual examination papers be carried forward or re-used.

Candidates can re-sit the whole qualification as many times as they wish. Candidates' grades are based on the work they submit for assessment.

Appendices

A Grade Descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates who were awarded particular grades. The descriptions should be considered in relation to the content outlined in the specification – they are not designed to define that content. The grade awarded will depend on how well the candidate has met the assessment objectives (see Section 4b). If a candidate has performed less well in some areas this may be balanced by better performance in others.

Grade	Description
A	■ Candidates recall, select and communicate precise knowledge and detailed understanding of biology. ■ They demonstrate a comprehensive understanding of biological principles and applications. ■ They use scientific and technical knowledge, terminology and conventions appropriately and consistently. ■ They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of contexts. ■ They are confident with a wide range of appropriate methods, sources of information and data, consistently applying relevant skills to address scientific questions, solve problems and recognise appropriate hypotheses. ■ They analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. ■ They evaluate information systematically to develop arguments and explanations, taking account of the limitations of the available evidence. ■ They make reasoned judgements consistently and draw detailed, evidence-based conclusions.
C	■ Candidates recall, select and communicate secure knowledge and understanding of biology. ■ They demonstrate understanding of biological principles and applications. ■ They use scientific and technical knowledge, terminology and conventions appropriately. ■ They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of contexts. ■ They are familiar with a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and usually recognise appropriate hypotheses. ■ They analyse, interpret and evaluate a range of quantitative and qualitative data and information. ■ They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. ■ They make judgements and draw conclusions based on the available evidence.

F

- Candidates recall, select and communicate limited knowledge and understanding of biology.
- They demonstrate some understanding of biological principles and applications.
- They use limited scientific and technical knowledge, terminology and conventions.
- They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in some contexts.
- They are familiar with a limited range of methods, sources of information and data to address straightforward scientific questions and problems.
- They interpret limited quantitative and qualitative data and information from a narrow range of sources.
- They have some understanding of the limitations of evidence.
- They can draw elementary conclusions having collected limited evidence.

B Spiritual, Moral, Ethical, Social, Legislative, Sustainable Development, Economic and Cultural Issues, and Health and Safety Considerations

We have taken great care to make sure that any wider issues (for example, spiritual, moral, ethical, social, legal, sustainable development, economic and cultural issues), including those relevant to the education of students at Key Stage 4, have been taken into account when preparing this specification.

They will only form part of the assessment requirements where they are relevant to the specific content of the specification and have been identified in Section 3: Subject Content.

European Dimension

We have taken the 1988 Resolution of the Council of the European Community into account when preparing this specification and associated specimen components.

Environmental Education

We have taken the 1988 Resolution of the Council of the European Community and the Report *Environmental Responsibility: An Agenda for Further and Higher Education* (1993) into account when preparing this specification and associated specimen components.

Avoiding bias

We have taken great care to avoid bias of any kind when preparing this specification and specimen components.

C Overlaps with other qualifications

Much of the content in the AQA Level 1/2 Certificate in Biology is contained in the AQA Level 1/2 Certificate in Science: Double Award.

D The replacement of Key Skills with Functional Skills

The Key Skills qualifications have been replaced by the Functional Skills. However, centres may claim proxies for Key Skills components and/or certification in the following series: January, March and June 2012. The **Administration Handbook for the Key Skills Standards 2012** has further details. All Examination Officers in centres offering AQA Key Skills and Wider Key Skills have been sent a letter outlining the details of the end dates of these subjects. Copies of the letters have also been sent to the Head of Centre and Key Skills coordinator. This is a brief outline of that information. It is correct as at August 2011 and replaces the information on the same subject found in other documents on the AQA website:

Key Skills Levels 1, 2 and 3 Test and Portfolio

The final opportunity for candidates to enter for a level 1, 2 or 3 Key Skills test or portfolio was June 2011 with last certification in 2012.

Key Skills Level 4

The last series available to candidates entering for the Key Skills Level 4 test and portfolio was June 2010 with the last certification in the June series 2012.

Wider Key Skills

The AQA Wider Key Skills qualifications are no longer available. The last portfolio moderation took place in June 2010.

Further updates to this information will be posted on the website as it becomes available:

http://web.aqa.org.uk/qual/keyskills/wider_noticeboard.php

AQA Level 1/2 Certificate in Biology from 2012 onwards

Qualification Accreditation Number: 600/4024/5

For updates and further information on any of our specifications, to find answers or ask us a question, register with

Ask AQA at:
aqa.org.uk/askaqa

Download a copy of this specification from our website at:
aqa.org.uk/igcse-science

Free launch meetings are available in 2012 followed by further support meetings through the life of the specification.

Further information is available at:
http://events.aqa.org.uk/ebooking

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