AQA
Realising potential

GCSE
BIOLOGY
(8461)

Specification
For teaching from September 2016 onwards
For exams in 2018 onwards

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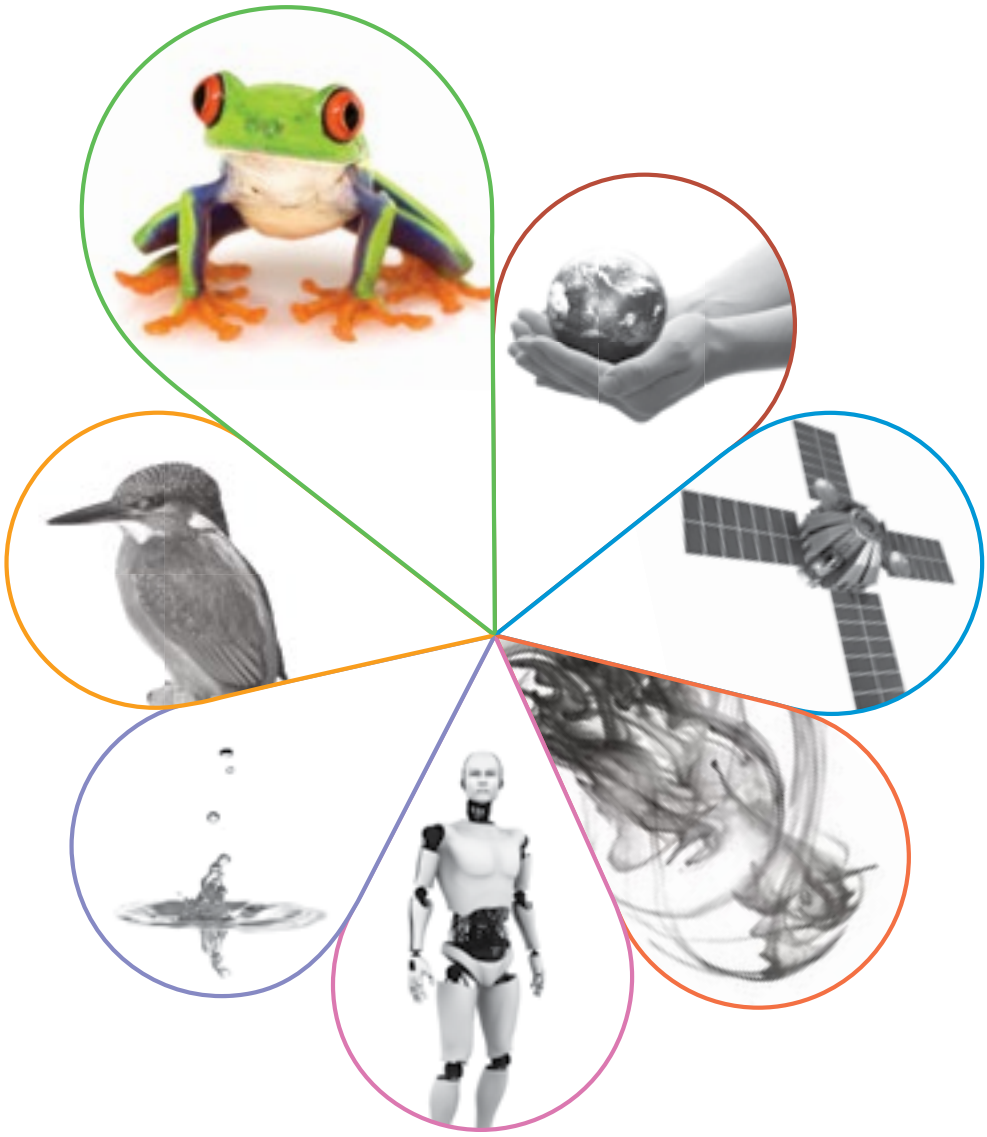


2 Specification at a glance

This qualification is linear. Linear means that students will sit all their exams at the end of the course.

2.1 Subject content

2.2 Assessments

Paper 1	+	Paper 2
What's assessed Topics 1–4: Cell biology; Organisation; Infection and response; and Bioenergetics.		**What's assessed** Topics 5–7: Homeostasis and response; Inheritance, variation and evolution; and Ecology.
How it's assessed • Written exam: 1 hour 45 minutes • Foundation and Higher Tier • 100 marks • 50 % of GCSE		**How it's assessed** • Written exam: 1 hour 45 minutes • Foundation and Higher Tier • 100 marks • 50 % of GCSE
Questions Multiple choice, structured, closed short answer and open response.		**Questions** Multiple choice, structured, closed short answer and open response.

4.5 Homeostasis and response

Cells in the body can only survive within narrow physical and chemical limits. They require a constant temperature and pH as well as a constant supply of dissolved food and water. In order to do this the body requires control systems that constantly monitor and adjust the composition of the blood and tissues. These control systems include receptors which sense changes and effectors that bring about changes.

In this section we will explore the structure and function of the nervous system and how it can bring about fast responses. We will also explore the hormonal system which usually brings about much slower changes. Hormonal coordination is particularly important in reproduction since it controls the menstrual cycle. An understanding of the role of hormones in reproduction has allowed scientists to develop not only contraceptive drugs but also drugs which can increase fertility.

4.5.1 Homeostasis

Content	Key opportunities for skills development
Students should be able to explain that homeostasis is the regulation of the internal conditions of a cell or organism to maintain optimum conditions for function in response to internal and external changes. Homeostasis maintains optimal conditions for enzyme action and all cell functions. In the human body, these include control of: • blood glucose concentration • body temperature • water levels. These automatic control systems may involve nervous responses or chemical responses. All control systems include: • cells called receptors, which detect stimuli (changes in the environment) • coordination centres (such as the brain, spinal cord and pancreas) that receive and process information from receptors • effectors, muscles or glands, which bring about responses which restore optimum levels.	

4.5.2 The human nervous system

4.5.2.1 Structure and function

Content	Key opportunities for skills development
Students should be able to explain how the structure of the nervous system is adapted to its functions. The nervous system enables humans to react to their surroundings and to coordinate their behaviour. Information from receptors passes along cells (neurones) as electrical impulses to the central nervous system (CNS). The CNS is the brain and spinal cord. The CNS coordinates the response of effectors which may be muscles contracting or glands secreting hormones. stimulus → receptor → coordinator → effector → response Students should be able to explain how the various structures in a reflex arc – including the sensory neurone, synapse, relay neurone and motor neurone – relate to their function. Students should understand why reflex actions are important. Reflex actions are automatic and rapid; they do not involve the conscious part of the brain.	
Students should be able to extract and interpret data from graphs, charts and tables, about the functioning of the nervous system.	MS 2c
Students should be able to translate information about reaction times between numerical and graphical forms.	MS 4a

Required practical activity 7: plan and carry out an investigation into the effect of a factor on human reaction time.

AT skills covered by this practical activity: AT 1, 3 and 4.

This practical activity also provides opportunities to develop WS and MS. Details of all skills are given in Key opportunities for skills development.

4.5.2.2 The brain (biology only)

Content	Key opportunities for skills development
The brain controls complex behaviour. It is made of billions of interconnected neurones and has different regions that carry out different functions. Students should be able to identify the cerebral cortex, cerebellum and medulla on a diagram of the brain, and describe their functions.	
(HT only) Students should be able to explain some of the difficulties of investigating brain function and treating brain damage and disease. (HT only) Neuroscientists 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. The complexity and delicacy of the brain makes investigating and treating brain disorders very difficult.	(HT only) WS 1.5 Evaluate the benefits and risks of procedures carried out on the brain and nervous system.

4.5.2.3 The eye (biology only)

Content	Key opportunities for skills development
Students should be able to relate the structures of the eye to their functions. This includes: • accommodation to focus on near or distant objects • adaptation to dim light. The eye is a sense organ containing receptors sensitive to light intensity and colour.	

Content	Key opportunities for skills development
Students should be able to identify the following structures on a diagram of the eye and explain how their structure is related to their function: • retina • optic nerve • sclera • cornea • iris • ciliary muscles • suspensory ligaments. Accommodation is the process of changing the shape of the lens to focus on near or distant objects. To focus on a near object: • the ciliary muscles contract • the suspensory ligaments loosen • the lens is then thicker and refracts light rays strongly. To focus on a distant object: • the ciliary muscles relax • the suspensory ligaments are pulled tight • the lens is then pulled thin and only slightly refracts light rays. Two common defects of the eyes are myopia (short sightedness) and hyperopia (long sightedness) in which rays of light do not focus on the retina. • Generally these defects are treated with spectacle lenses which refract the light rays so that they do focus on the retina. • New technologies now include hard and soft contact lenses, laser surgery to change the shape of the cornea and a replacement lens in the eye.	WS 1.2
Students should be able to interpret ray diagrams, showing these two common defects of the eye and demonstrate how spectacle lenses correct them.	WS 1.2, 1.4

4.5.2.4 Control of body temperature (biology only)

Content	Key opportunities for skills development
Body temperature is monitored and controlled by the thermoregulatory centre in the brain. The thermoregulatory centre contains receptors sensitive to the temperature of the blood. The skin contains temperature receptors and sends nervous impulses to the thermoregulatory centre. If the body temperature is too high, blood vessels dilate (vasodilation) and sweat is produced from the sweat glands. Both these mechanisms cause a transfer of energy from the skin to the environment. If the body temperature is too low, blood vessels constrict (vasoconstriction), sweating stops and skeletal muscles contract (shiver).	
(HT only) Students should be able to explain how these mechanisms lower or raise body temperature in a given context.	

4.5.3 Hormonal coordination in humans

4.5.3.1 Human endocrine system

Content	Key opportunities for skills development
Students should be able to describe the principles of hormonal coordination and control by the human endocrine system. The endocrine system is composed of glands which secrete chemicals called hormones directly into the bloodstream. The blood carries the hormone to a target organ where it produces an effect. Compared to the nervous system the effects are slower but act for longer. The pituitary gland in the brain is a 'master gland' which secretes several hormones into the blood in response to body conditions. These hormones in turn act on other glands to stimulate other hormones to be released to bring about effects. Students should be able to identify the position of the following on a diagram of the human body: • pituitary gland • pancreas • thyroid • adrenal gland • ovary • testes.	

4.5.3.2 Control of blood glucose concentration

Content	Key opportunities for skills development
Blood glucose concentration is monitored and controlled by the pancreas. If the blood glucose concentration is too high, the pancreas produces the hormone insulin that causes glucose to move from the blood into the cells. In liver and muscle cells excess glucose is converted to glycogen for storage. Students should be able to explain how insulin controls blood glucose (sugar) levels in the body. Type 1 diabetes is a disorder in which the pancreas fails to produce sufficient insulin. It is characterised by uncontrolled high blood glucose levels and is normally treated with insulin injections. In Type 2 diabetes the body cells no longer respond to insulin produced by the pancreas. A carbohydrate controlled diet and an exercise regime are common treatments. Obesity is a risk factor for Type 2 diabetes. Students should be able to compare Type 1 and Type 2 diabetes and explain how they can be treated.	WS 1.3 Evaluate information around the relationship between obesity and diabetes, and make recommendations taking into account social and ethical issues.
Students should be able to extract information and interpret data from graphs that show the effect of insulin in blood glucose levels in both people with diabetes and people without diabetes.	MS 2c
(HT only) If the blood glucose concentration is too low, the pancreas produces the hormone glucagon that causes glycogen to be converted into glucose and released into the blood. (HT only) Students should be able to explain how glucagon interacts with insulin in a negative feedback cycle to control blood glucose (sugar) levels in the body.	

4.5.3.3 Maintaining water and nitrogen balance in the body (biology only)

Content	Key opportunities for skills development
Students should be able to explain the effect on cells of osmotic changes in body fluids. Water leaves the body via the lungs during exhalation. Water, ions and urea are lost from the skin in sweat. There is no control over water, ion or urea loss by the lungs or skin. Excess water, ions and urea are removed via the kidneys in the urine. If body cells lose or gain too much water by osmosis they do not function efficiently.	
(HT only) The digestion of proteins from the diet results in excess amino acids which need to be excreted safely. In the liver these amino acids are deaminated to form ammonia. Ammonia is toxic and so it is immediately converted to urea for safe excretion.	
Students should be able to describe the function of kidneys in maintaining the water balance of the body. The kidneys produce urine by filtration of the blood and selective reabsorption of useful substances such as glucose, some ions and water. Knowledge of other parts of the urinary system, the structure of the kidney and the structure of a nephron is not required.	
Students should be able to translate tables and bar charts of glucose, ions and urea before and after filtration.	MS 4a
(HT only) Students should be able to describe the effect of ADH on the permeability of the kidney tubules. (HT only) The water level in the body is controlled by the hormone ADH which acts on the kidney tubules. ADH is released by the pituitary gland when the blood is too concentrated and it causes more water to be reabsorbed back into the blood from the kidney tubules. This is controlled by negative feedback.	
People who suffer from kidney failure may be treated by organ transplant or by using kidney dialysis. Students should know the basic principles of dialysis.	WS 1.4 Students should be able to describe how kidney dialysis works. WS 1.5 Evaluate the advantages and disadvantages of treating organ failure by mechanical device or transplant.

4.5.3.4 Hormones in human reproduction

Content	Key opportunities for skills development
Students should be able to describe the roles of hormones in human reproduction, including the menstrual cycle. During puberty reproductive hormones cause secondary sex characteristics to develop. Oestrogen is the main female reproductive hormone produced in the ovary. At puberty eggs begin to mature and one is released approximately every 28 days. This is called ovulation. Testosterone is the main male reproductive hormone produced by the testes and it stimulates sperm production. Several hormones are involved in the menstrual cycle of a woman. • Follicle stimulating hormone (FSH) causes maturation of an egg in the ovary. • Luteinising hormone (LH) stimulates the release of the egg. • Oestrogen and progesterone are involved in maintaining the uterus lining.	
(HT only) Students should be able to explain the interactions of FSH, oestrogen, LH and progesterone, in the control of the menstrual cycle.	
(HT only) Students should be able to extract and interpret data from graphs showing hormone levels during the menstrual cycle.	MS 2c

4.5.3.5 Contraception

Content	Key opportunities for skills development
Students should be able to evaluate the different hormonal and non-hormonal methods of contraception. Fertility can be controlled by a variety of hormonal and non-hormonal methods of contraception. These include: • oral contraceptives that contain hormones to inhibit FSH production so that no eggs mature • injection, implant or skin patch of slow release progesterone to inhibit the maturation and release of eggs for a number of months or years • barrier methods such as condoms and diaphragms which prevent the sperm reaching an egg • intrauterine devices which prevent the implantation of an embryo or release a hormone • spermicidal agents which kill or disable sperm • abstaining from intercourse when an egg may be in the oviduct • surgical methods of male and female sterilisation.	WS 1.3 Show why issues around contraception cannot be answered by science alone. WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.

4.5.3.6 The use of hormones to treat infertility (HT only)

Content	Key opportunities for skills development
Students should be able to explain the use of hormones in modern reproductive technologies to treat infertility. This includes giving FSH and LH in a 'fertility drug' to a woman. She may then become pregnant in the normal way. In Vitro Fertilisation (IVF) treatment. • IVF involves giving a mother FSH and LH to stimulate the maturation of several eggs. • The eggs are collected from the mother and fertilised by sperm from the father in the laboratory. • The fertilised eggs develop into embryos. • At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb).	WS 1.1 Developments of microscopy techniques have enabled IVF treatments to develop. WS 1.3 Understand social and ethical issues associated with IVF treatments.
Although fertility treatment gives a woman the chance to have a baby of her own: • it is very emotionally and physically stressful • the success rates are not high • it can lead to multiple births which are a risk to both the babies and the mother.	WS 1.4 Evaluate from the perspective of patients and doctors the methods of treating infertility.

4.5.3.7 Negative feedback (HT only)

Content	Key opportunities for skills development
Students should be able to explain the roles of thyroxine and adrenaline in the body. Adrenaline is produced by the adrenal glands in times of fear or stress. It increases the heart rate and boosts the delivery of oxygen and glucose to the brain and muscles, preparing the body for 'flight or fight'. Thyroxine from the thyroid gland stimulates the basal metabolic rate. It plays an important role in growth and development.	
Thyroxine levels are controlled by negative feedback.	WS 1.2, MS 2c Interpret and explain simple diagrams of negative feedback control.

4.5.4 Plant hormones (biology only)

4.5.4.1 Control and coordination

Content	Key opportunities for skills development
Plants produce hormones to coordinate and control growth and responses to light (phototropism) and gravity (gravitropism or geotropism). Unequal distributions of auxin cause unequal growth rates in plant roots and shoots.	
(HT only) Gibberellins are important in initiating seed germination. (HT only) Ethene controls cell division and ripening of fruits. (HT only) The mechanisms of how gibberellins and ethene work are not required.	

Required practical activity 8: investigate the effect of light or gravity on the growth of newly germinated seedlings.

Record results as both length measurements and as careful, labelled biological drawings to show the effects.

AT skills covered by this practical activity: AT 1, 3, 4 and 7.

This practical activity also provides opportunities to develop WS and MS. Details of all skills are given in Key opportunities for skills development.

4.5.4.2 Use of plant hormones (HT only)

Content	Key opportunities for skills development
Students should be able to describe the effects of some plant hormones and the different ways people use them to control plant growth. Plant growth hormones are used in agriculture and horticulture. Auxins are used: • as weed killers • as rooting powders • for promoting growth in tissue culture. Ethene is used in the food industry to control ripening of fruit during storage and transport. Gibberellins can be used to: • end seed dormancy • promote flowering • increase fruit size.	WS 1.3, 1.4 Understand how the everyday use of hormones as weed killers has an effect on biodiversity.

4.6 Inheritance, variation and evolution

In this section we will discover how the number of chromosomes are halved during meiosis and then combined with new genes from the sexual partner to produce unique offspring. Gene mutations occur continuously and on rare occasions can affect the functioning of the animal or plant. These mutations may be damaging and lead to a number of genetic disorders or death. Very rarely a new mutation can be beneficial and consequently, lead to increased fitness in the individual. Variation generated by mutations and sexual reproduction is the basis for natural selection; this is how species evolve.

An understanding of these processes has allowed scientists to intervene through selective breeding to produce livestock with favoured characteristics. Once new varieties of plants or animals have been produced it is possible to clone individuals to produce larger numbers of identical individuals all carrying the favourable characteristic.

Scientists have now discovered how to take genes from one species and introduce them in to the genome of another by a process called genetic engineering. In spite of the huge potential benefits that this technology can offer, genetic modification still remains highly controversial.

4.6.1 Reproduction

4.6.1.1 Sexual and asexual reproduction

Content	Key opportunities for skills development
Students should understand that meiosis leads to non-identical cells being formed while mitosis leads to identical cells being formed. Sexual reproduction involves the joining (fusion) of male and female gametes: • sperm and egg cells in animals • pollen and egg cells in flowering plants. In sexual reproduction there is mixing of genetic information which leads to variety in the offspring. The formation of gametes involves meiosis. Asexual reproduction involves only one parent and no fusion of gametes. There is no mixing of genetic information. This leads to genetically identical offspring (clones). Only mitosis is involved.	There are links with this content to Mitosis and the cell cycle.

4.6.1.2 Meiosis

Content	Key opportunities for skills development
Students should be able to explain how meiosis halves the number of chromosomes in gametes and fertilisation restores the full number of chromosomes. Cells in reproductive organs divide by meiosis to form gametes. When a cell divides to form gametes: • copies of the genetic information are made • the cell divides twice to form four gametes, each with a single set of chromosomes • all gametes are genetically different from each other. Gametes join at fertilisation to restore the normal number of chromosomes. The new cell divides by mitosis. The number of cells increases. As the embryo develops cells differentiate. Knowledge of the stages of meiosis is not required.	WS 1.2 Modelling behaviour of chromosomes during meiosis.

4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction (biology only)

Content	Key opportunities for skills development
Advantages of sexual reproduction: • produces variation in the offspring • if the environment changes variation gives a survival advantage by natural selection • natural selection can be speeded up by humans in selective breeding to increase food production. Advantages of asexual reproduction: • only one parent needed • more time and energy efficient as do not need to find a mate • faster than sexual reproduction • many identical offspring can be produced when conditions are favourable.	There are links with this content to Animal and plant cells and Cloning (biology only).
Some organisms reproduce by both methods depending on the circumstances. • Malarial parasites reproduce asexually in the human host, but sexually in the mosquito. • Many fungi reproduce asexually by spores but also reproduce sexually to give variation. • Many plants produce seeds sexually, but also reproduce asexually by runners such as strawberry plants, or bulb division such as daffodils. Knowledge of reproduction in organisms is restricted to those mentioned. Students are expected to be able to explain the advantages and disadvantages of asexual and sexual reproduction for any organism if given appropriate information.	WS 1.1 Historical developments of our understanding of the causes and prevention of malaria.

4.6.1.4 DNA and the genome

Content	Key opportunities for skills development
Students should be able to describe the structure of DNA and define genome. The genetic material in the nucleus of a cell is composed of a chemical called DNA. DNA is a polymer made up of two strands forming a double helix. The DNA is contained in structures called chromosomes. A gene is a small section of DNA on a chromosome. Each gene codes for a particular sequence of amino acids, to make a specific protein. The genome of an organism is the entire genetic material of that organism. The whole human genome has now been studied and this will have great importance for medicine in the future.	
Students should be able to discuss the importance of understanding the human genome. This is limited to the: • search for genes linked to different types of disease • understanding and treatment of inherited disorders • use in tracing human migration patterns from the past.	WS 1.1, 1.4

4.6.1.5 DNA structure (biology only)

Content	Key opportunities for skills development
Students should be able to describe DNA as a polymer made from four different nucleotides. Each nucleotide consists of a common sugar and phosphate group with one of four different bases attached to the sugar. DNA contains four bases, A, C, G and T. 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.	
The long strands of DNA consist of alternating sugar and phosphate sections. Attached to each sugar is one of the four bases. The DNA polymer is made up of repeating nucleotide units.	WS 1.2 Interpret a diagram of DNA structure but will not be required to reproduce it.

Content	Key opportunities for skills development
(HT only) Students should be able to: • recall a simple description of protein synthesis • explain simply how the structure of DNA affects the protein made • describe how genetic variants may influence phenotype: a) in coding DNA by altering the activity of a protein: and b) in non-coding DNA by altering how genes are expressed. (HT only) In the complementary strands a C is always linked to a G on the opposite strand and a T to an A. (HT only) Students are not expected to know or understand the structure of mRNA, tRNA, or the detailed structure of amino acids or proteins. (HT only) Students should be able to explain how a change in DNA structure may result in a change in the protein synthesised by a gene. (HT only) Proteins are synthesised on ribosomes, according to a template. Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order. (HT only) When the protein chain is complete it folds up to form a unique shape. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.	
(HT only) Mutations occur continuously. Most do not alter the protein, or only alter it slightly so that its appearance or function is not changed. (HT only) A few mutations code for an altered protein with a different shape. An enzyme may no longer fit the substrate binding site or a structural protein may lose its strength. (HT only) Not all parts of DNA code for proteins. Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.	WS 1.2 Modelling insertions and deletions in chromosomes to illustrate mutations.

4.6.1.6 Genetic inheritance

Content	Key opportunities for skills development
Students should be able to explain the terms: • gamete • chromosome • gene • allele • dominant • recessive • homozygous • heterozygous • genotype • phenotype. Some characteristics are controlled by a single gene, such as: fur colour in mice; and red-green colour blindness in humans. Each gene may have different forms called alleles. The alleles present, or genotype, operate at a molecular level to develop characteristics that can be expressed as a phenotype. A dominant allele is always expressed, even if only one copy is present. A recessive allele is only expressed if two copies are present (therefore no dominant allele present). If the two alleles present are the same the organism is homozygous for that trait, but if the alleles are different they are heterozygous. Most characteristics are a result of multiple genes interacting, rather than a single gene.	
Students should be able to understand the concept of probability in predicting the results of a single gene cross, but recall that most phenotype features are the result of multiple genes rather than single gene inheritance.	MS 2e
Students should be able to use direct proportion and simple ratios to express the outcome of a genetic cross.	MS 1c, 3a
Students should be able to complete a Punnett square diagram and extract and interpret information from genetic crosses and family trees.	MS 2c, 4a
(HT only) Students should be able to construct a genetic cross by Punnett square diagram and use it to make predictions using the theory of probability.	MS 2e, WS 1.2

4.6.1.7 Inherited disorders

Content	Key opportunities for skills development
Some disorders are inherited. These disorders are caused by the inheritance of certain alleles. • Polydactyly (having extra fingers or toes) is caused by a dominant allele. • Cystic fibrosis (a disorder of cell membranes) is caused by a recessive allele. Students should make informed judgements about the economic, social and ethical issues concerning embryo screening, given appropriate information.	WS 1.3 Appreciate that embryo screening and gene therapy may alleviate suffering but consider the ethical issues which arise.

4.6.1.8 Sex determination

Content	Key opportunities for skills development
Ordinary human body cells contain 23 pairs of chromosomes. 22 pairs control characteristics only, but one of the pairs carries the genes that determine sex. • In females the sex chromosomes are the same (XX). • In males the chromosomes are different (XY).	
Students should be able to carry out a genetic cross to show sex inheritance. Students should understand and use direct proportion and simple ratios in genetic crosses.	MS 1c, 3a

4.6.2 Variation and evolution

4.6.2.1 Variation

Content	Key opportunities for skills development
Students should be able to describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism. Differences in the characteristics of individuals in a population is called variation and 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 genes and the environment.	
Students should be able to: • state that there is usually extensive genetic variation within a population of a species • recall that all variants arise from mutations and that: most have no effect on the phenotype; some influence phenotype; very few determine phenotype. Mutations occur continuously. Very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.	There are links with this content to Speciation (biology only).

4.6.2.2 Evolution

Content	Key opportunities for skills development
Students should be able to describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species. The 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. Students should be able to explain how evolution occurs through natural selection of variants that give rise to phenotypes best suited to their environment. If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species.	WS 1.2 Use the theory of evolution by natural selection in an explanation.

4.6.2.3 Selective breeding

Content	Key opportunities for skills development
Students should be able to explain the impact of selective breeding of food plants and domesticated animals. Selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics. Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals. Selective breeding involves choosing parents with the desired characteristic from a mixed population. They are bred together. From the offspring those with the desired characteristic are bred together. This continues over many generations until all the offspring show the desired characteristic. The characteristic can be chosen for usefulness or appearance: • Disease resistance in food crops. • Animals which produce more meat or milk. • Domestic dogs with a gentle nature. • Large or unusual flowers. Selective breeding can lead to 'inbreeding' where some breeds are particularly prone to disease or inherited defects.	WS 1.3, 1.4 Explain the benefits and risks of selective breeding given appropriate information and consider related ethical issues.

4.6.2.4 Genetic engineering

Content	Key opportunities for skills development
Students should be able to describe genetic engineering as a process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic. Plant crops have been genetically engineered to be resistant to diseases or to produce bigger better fruits.	
Bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.	There are links with this content to Role of biotechnology (biology only).
Students should be able to explain the potential benefits and risks of genetic engineering in agriculture and in medicine and that some people have objections. In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms. Crops that have had their genes modified in this way are called genetically modified (GM) crops. GM crops include ones that are resistant to insect attack or to herbicides. GM crops generally show increased yields. Concerns about GM crops include the effect on populations of wild flowers and insects. Some people feel the effects of eating GM crops on human health have not been fully explored. Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.	WS 1.3, 1.4
(HT only) Students should be able to describe the main steps in the process of genetic engineering. (HT only) In genetic engineering: • 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 • genes are transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.	(HT only) WS 1.4 Interpret information about genetic engineering techniques and to make informed judgements about issues concerning cloning and genetic engineering, including GM crops.

4.6.2.5 Cloning (biology only)

Content	Key opportunities for skills development
Tissue culture: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries. Cuttings: an older, but simple, method used by gardeners to produce many identical new plants from a parent 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. • The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell. • An electric shock stimulates the egg cell to divide to form an embryo. • 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.	WS 1.3, 1.4 Explain the potential benefits and risks of cloning in agriculture and in medicine and that some people have ethical objections. There are links with this content to Advantages and disadvantages of sexual and asexual reproduction (biology only) and Selective breeding.

4.6.3 The development of understanding of genetics and evolution

4.6.3.1 Theory of evolution (biology only)

Content	Key opportunities for skills development
Charles Darwin, as a result of observations on a round the world expedition, backed by years of experimentation and discussion and linked to developing knowledge of geology and fossils, proposed the theory of evolution by natural selection. • Individual organisms within a particular species show a wide range of variation for a characteristic. • Individuals with characteristics most suited to the environment are more likely to survive to breed successfully. • The characteristics that have enabled these individuals to survive are then passed on to the next generation. Darwin published his ideas in *On the Origin of Species* (1859). There was much controversy surrounding these revolutionary new ideas. 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. Other theories, including that of Jean-Baptiste 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. A study of creationism is not required.	WS 1.1, 1.3 Students should appreciate that the theory of evolution by natural selection developed over time and from information gathered by many scientists.

4.6.3.2 Speciation (biology only)

Content	Key opportunities for skills development
Students should be able to: • describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection • explain the impact of these ideas on biology. Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published joint writings with Darwin in 1858 which prompted Darwin to publish *On the Origin of Species* (1859) the following year. Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on warning colouration in animals and his theory of speciation. Alfred Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of speciation. Students should be able to describe the steps which give rise to new species.	There are links with this content to Evolution. WS 1.1 The theory of speciation has developed over time.

4.6.3.3 The understanding of genetics (biology only)

Content	Key opportunities for skills development
Students should be able to: • describe the development of our understanding of genetics including the work of Mendel • understand why the importance of Mendel's discovery was not recognised until after his death. In the mid-19th century Gregor Mendel carried out breeding experiments on plants. One of his observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged. In the late 19th century behaviour of chromosomes during cell division was observed.	WS 1.1 Our current understanding of genetics has developed over time.
In the early 20th century it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units', now called genes, were located on chromosomes. In the mid-20th century the structure of DNA was determined and the mechanism of gene function worked out. This scientific work by many scientists led to the gene theory being developed.	There are links with this content to Genetic inheritance. WS 1.1

4.6.3.4 Evidence for evolution

Content	Key opportunities for skills development
Students should be able to describe the evidence for evolution including fossils and antibiotic resistance in bacteria. The theory of evolution by natural selection is now widely accepted. Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in genes. There is further evidence in the fossil record and the knowledge of how resistance to antibiotics evolves in bacteria.	WS 1.3 Data is now available to support the theory of evolution.

4.6.3.5 Fossils

Content	Key opportunities for skills development
Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks. Fossils may be formed: • 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 minerals as they decay • as preserved traces of organisms, such as footprints, burrows and rootlet traces.	MS 2c, 4a Extract and interpret information from charts, graphs and tables.
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.	WS 1.3 Appreciate why the fossil record is incomplete.
We can learn from fossils how much or how little different organisms have changed as life developed on Earth.	WS 1.1 Understand how scientific methods and theories develop over time.
Students should be able to extract and interpret information from charts, graphs and tables such as evolutionary trees.	MS 2c, 4a

4.6.3.6 Extinction

Content	Key opportunities for skills development
Extinctions occur when there are no remaining individuals of a species still alive. Students should be able to describe factors which may contribute to the extinction of a species.	

4.6.3.7 Resistant bacteria

Content	Key opportunities for skills development
Bacteria can evolve rapidly because they reproduce at a fast rate. Mutations of bacterial pathogens produce new strains. Some strains might be resistant to antibiotics, and so are not killed. They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment.	
MRSA is resistant to antibiotics. To reduce the rate of development of antibiotic resistant strains: • doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections • patients should complete their course of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains • the agricultural use of antibiotics should be restricted. The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.	There are links with this content to Antibiotics and painkillers.

4.6.4 Classification of living organisms

Content	Key opportunities for skills development
Traditionally living things have been classified into groups depending on their structure and characteristics in a system developed by Carl Linnaeus. Linnaeus classified living things into kingdom, phylum, class, order, family, genus and species. Organisms are named by the binomial system of genus and species.	
Students should be able to use information given to show understanding of the Linnaean system. Students should be able to describe the impact of developments in biology on classification systems. As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed. Due to evidence available from chemical analysis there is now a 'three-domain system' developed by Carl Woese. In this system organisms are divided into: • archaea (primitive bacteria usually living in extreme environments) • bacteria (true bacteria) • eukaryota (which includes protists, fungi, plants and animals).	WS 1.1 Understand how scientific methods and theories develop over time.
Evolutionary trees are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.	WS 1.2 Interpret evolutionary trees.

4.7 Ecology

The Sun is a source of energy that passes through ecosystems. Materials including carbon and water are continually recycled by the living world, being released through respiration of animals, plants and decomposing microorganisms and taken up by plants in photosynthesis.

All species live in ecosystems composed of complex communities of animals and plants dependent on each other and that are adapted to particular conditions, both abiotic and biotic. These ecosystems provide essential services that support human life and continued development.

In order to continue to benefit from these services humans need to engage with the environment in a sustainable way. In this section we will explore how humans are threatening biodiversity as well as the natural systems that support it. We will also consider some actions we need to take to ensure our future health, prosperity and well-being.

4.7.1 Adaptations, interdependence and competition

4.7.1.1 Communities

Content	Key opportunities for skills development
Students should be able to describe: • different levels of organisation in an ecosystem from individual organisms to the whole ecosystem • the importance of interdependence and competition in a community. Students should be able to, when provided with appropriate information: • suggest the factors for which organisms are competing in a given habitat • suggest how organisms are adapted to the conditions in which they live. An ecosystem is the interaction of a community of living organisms (biotic) with the non-living (abiotic) parts of their environment. To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there. Plants in a community or habitat often compete with each other for light and space, and for water and mineral ions from the soil. Animals often compete with each other for food, mates and territory. Within a community each species depends on other species for food, shelter, pollination, seed dispersal etc. If one species is removed it can affect the whole community. This is called interdependence. A stable community is one where all the species and environmental factors are in balance so that population sizes remain fairly constant.	WS 2.6 Recording first-hand observations of organisms.
Students should be able to extract and interpret information from charts, graphs and tables relating to the interaction of organisms within a community.	MS 2c, 4a Extract and interpret information from charts, graphs and tables.

4.7.1.2 Abiotic factors

Content	Key opportunities for skills development
Students should be able to explain how a change in an abiotic factor would affect a given community given appropriate data or context. Abiotic (non-living) factors which can affect a community are: • light intensity • temperature • moisture levels • soil pH and mineral content • wind intensity and direction • carbon dioxide levels for plants • oxygen levels for aquatic animals.	WS 1.2
Students should be able to extract and interpret information from charts, graphs and tables relating to the effect of abiotic factors on organisms within a community.	MS 2c, 4a Extract and interpret information from charts, graphs and tables.

4.7.1.3 Biotic factors

Content	Key opportunities for skills development
Students should be able to explain how a change in a biotic factor might affect a given community given appropriate data or context. Biotic (living) factors which can affect a community are: • availability of food • new predators arriving • new pathogens • one species outcompeting another so the numbers are no longer sufficient to breed.	WS 1.2
Students should be able to extract and interpret information from charts, graphs and tables relating to the effect of biotic factors on organisms within a community.	MS 2c, 4a Extract and interpret information from charts, graphs and tables.

4.7.1.4 Adaptations

Content	Key opportunities for skills development
Students should be able to explain how organisms are adapted to live in their natural environment, given appropriate information. Organisms have features (adaptations) that enable them to survive in the conditions in which they normally live. These adaptations may be structural, behavioural or functional.	
Some organisms live in environments that are very extreme, such as at high temperature, pressure, or salt concentration. These organisms are called extremophiles. Bacteria living in deep sea vents are extremophiles.	

4.7.2 Organisation of an ecosystem

4.7.2.1 Levels of organisation

Content	Key opportunities for skills development
Students should understand that photosynthetic organisms are the producers of biomass for life on Earth. Feeding relationships within a community can be represented by food chains. All food chains begin with a producer which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis. A range of experimental methods using transects and quadrats are used by ecologists to determine the distribution and abundance of species in an ecosystem.	
In relation to abundance of organisms students should be able to: • understand the terms mean, mode and median • calculate arithmetic means • plot and draw appropriate graphs selecting appropriate scales for the axes.	MS 2b, 2f, 4a, 4c
Producers are eaten by primary consumers, which in turn may be eaten by secondary consumers and then tertiary consumers.	
Consumers that kill and eat other animals are predators, and those eaten are prey. In a stable community the numbers of predators and prey rise and fall in cycles.	WS 1.2 Interpret graphs used to model predator-prey cycles.
Students should be able to interpret graphs used to model these cycles.	MS 4a

Required practical activity 9: measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.

AT skills covered by this practical activity: AT 1, 3, 4, 6 and 8.

This practical activity also provides opportunities to develop WS and MS. Details of all skills are given in Key opportunities for skills development.

4.7.2.2 How materials are cycled

Content	Key opportunities for skills development
Students should: • recall that many different materials cycle through the abiotic and biotic components of an ecosystem • explain the importance of the carbon and water cycles to living organisms. All materials in the living world are recycled to provide the building blocks for future organisms. The carbon cycle returns carbon from organisms to the atmosphere as carbon dioxide to be used by plants in photosynthesis. The water cycle provides fresh water for plants and animals on land before draining into the seas. Water is continuously evaporated and precipitated. Students are not expected to study the nitrogen cycle. Students should be able to explain the role of microorganisms in cycling materials through an ecosystem by returning carbon to the atmosphere as carbon dioxide and mineral ions to the soil.	WS 1.2 Interpret and explain the processes in diagrams of the carbon cycle, the water cycle. There are links with the water cycle to GCSE Chemistry 4.9.1.2 The Earth's early atmosphere.

4.7.2.3 Decomposition (biology only)

Content	Key opportunities for skills development
Students should be able to explain how temperature, water and availability of oxygen affect the rate of decay of biological material.	
Students should be able to: • calculate rate changes in the decay of biological material • translate information between numerical and graphical form • plot and draw appropriate graphs selecting appropriate scales for the axes.	MS 1c, 4a, 4c
Gardeners and farmers try to provide optimum conditions for rapid decay of waste biological material. The compost produced is used as a natural fertiliser for growing garden plants or crops. Anaerobic decay produces methane gas. Biogas generators can be used to produce methane gas as a fuel.	

Required practical activity 10: investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.

AT skills covered by this practical activity: AT 1, 3, 4 and 5.

This practical activity also provides opportunities to develop WS and MS. Details of all skills are given in Key opportunities for skills development.

4.7.2.4 Impact of environmental change (biology only) (HT only)

Content	Key opportunities for skills development
Students should be able to evaluate the impact of environmental changes on the distribution of species in an ecosystem given appropriate information. Environmental changes affect the distribution of species in an ecosystem. These changes include: • temperature • availability of water • composition of atmospheric gases. The changes may be seasonal, geographic or caused by human interaction.	WS 1.4 There are links with this content to Biodiversity and the effect of human interaction on ecosystems.

4.7.3 Biodiversity and the effect of human interaction on ecosystems

4.7.3.1 Biodiversity

Content	Key opportunities for skills development
Biodiversity is the variety of all the different species of organisms on earth, or within an ecosystem. A great biodiversity ensures the stability of ecosystems by reducing the dependence of one species on another for food, shelter and the maintenance of the physical environment. The future of the human species on Earth relies on us maintaining a good level of biodiversity. Many human activities are reducing biodiversity and only recently have measures been taken to try to stop this reduction.	WS 1.4 Explain how waste, deforestation and global warming have an impact on biodiversity.

4.7.3.2 Waste management

Content	Key opportunities for skills development
Rapid growth in the human population and an increase in the standard of living mean that increasingly more resources are used and more waste is produced. Unless waste and chemical materials are properly handled, more pollution will be caused. Pollution can occur: • in water, from sewage, fertiliser or toxic chemicals • in air, from smoke and acidic gases • on land, from landfill and from toxic chemicals. Pollution kills plants and animals which can reduce biodiversity.	There are links with this content to GCSE Chemistry 4.9.3.1 Atmospheric pollutants from fuels.

4.7.3.3 Land use

Content	Key opportunities for skills development
Humans reduce the amount of land available for other animals and plants by building, quarrying, farming and dumping waste.	
The destruction of peat bogs, and other areas of peat to produce garden compost, reduces the area of this habitat and thus the variety of different plant, animal and microorganism species that live there (biodiversity). The decay or burning of the peat releases carbon dioxide into the atmosphere.	WS 1.4, 1.5 Understand the conflict between the need for cheap available compost to increase food production and the need to conserve peat bogs and peatlands as habitats for biodiversity and to reduce carbon dioxide emissions. There are links within this section to Global warming. There are links within this section to Factors affecting food security (biology only).

4.7.3.4 Deforestation

Content	Key opportunities for skills development
Large-scale deforestation in tropical areas has occurred to: • provide land for cattle and rice fields • grow crops for biofuels.	WS 1.4 Evaluate the environmental implications of deforestation.

4.7.3.5 Global warming

Content	Key opportunities for skills development
Students should be able to describe some of the biological consequences of global warming. Levels of carbon dioxide and methane in the atmosphere are increasing, and contribute to 'global warming'.	WS 1.6 Understand that the scientific consensus about global warming and climate change is based on systematic reviews of thousands of peer reviewed publications. WS 1.3 Explain why evidence is uncertain or incomplete in a complex context.

4.7.3.6 Maintaining biodiversity

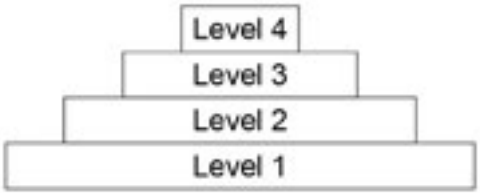
Content	Key opportunities for skills development
Students should be able to describe both positive and negative human interactions in an ecosystem and explain their impact on biodiversity. Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity. These include: • breeding programmes for endangered species • protection and regeneration of rare habitats • reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop • reduction of deforestation and carbon dioxide emissions by some governments • recycling resources rather than dumping waste in landfill.	WS 1.4, 1.5 Evaluate given information about methods that can be used to tackle problems caused by human impacts on the environment. Explain and evaluate the conflicting pressures on maintaining biodiversity given appropriate information.

4.7.4 Trophic levels in an ecosystem (biology only)

4.7.4.1 Trophic levels

Content	Key opportunities for skills development
Students should be able to describe the differences between the trophic levels of organisms within an ecosystem. Trophic levels can be represented by numbers, starting at level 1 with plants and algae. Further trophic levels are numbered subsequently according to how far the organism is along the food chain. Level 1: Plants and algae make their own food and are called producers. Level 2: Herbivores eat plants/algae and are called primary consumers. Level 3: Carnivores that eat herbivores are called secondary consumers. Level 4: Carnivores that eat other carnivores are called tertiary consumers. Apex predators are carnivores with no predators. Decomposers break down dead plant and animal matter by secreting enzymes into the environment. Small soluble food molecules then diffuse into the microorganism.	

4.7.4.2 Pyramids of biomass

Content	Key opportunities for skills development
Pyramids of biomass can be constructed to represent the relative amount of biomass in each level of a food chain. Trophic level 1 is at the bottom of the pyramid.  	WS 1.2
Students should be able to construct accurate pyramids of biomass from appropriate data.	MS 2c

4.7.4.3 Transfer of biomass

Content	Key opportunities for skills development
Students should be able to: • describe pyramids of biomass • explain how biomass is lost between the different trophic levels. Producers are mostly plants and algae which transfer about 1 % of the incident energy from light for photosynthesis.	
Only approximately 10 % of the biomass from each trophic level is transferred to the level above it. Losses of biomass are due to: • not all the ingested material is absorbed, some is egested as faeces • some absorbed material is lost as waste, such as carbon dioxide and water in respiration and water and urea in urine. Large amounts of glucose are used in respiration.	MS 1c Calculate the efficiency of biomass transfer between trophic levels.
Students should be able to calculate the efficiency of biomass transfers between trophic levels by percentages or fractions of mass. Students should be able to explain how this affects the number of organisms at each trophic level.	MS 1c

4.7.5 Food production (biology only)

4.7.5.1 Factors affecting food security

Content	Key opportunities for skills development
Students should be able to describe some of the biological factors affecting levels of food security. Food security is having enough food to feed a population. Biological factors which are threatening food security include: • the increasing birth rate has threatened food security in some countries • changing diets in developed countries means scarce food resources are transported around the world • new pests and pathogens that affect farming • environmental changes that affect food production, such as widespread famine occurring in some countries if rains fail • the cost of agricultural inputs • conflicts that have arisen in some parts of the world which affect the availability of water or food. Sustainable methods must be found to feed all people on Earth.	WS 1.4 Interpret population and food production statistics to evaluate food security.

4.7.5.2 Farming techniques

Content	Key opportunities for skills development
The efficiency of food production can be improved by restricting energy transfer from food animals to the environment. This can be done by limiting their movement and by controlling the temperature of their surroundings. Some animals are fed high protein foods to increase growth.	WS 1.3 Understand that some people have ethical objections to some modern intensive farming methods. WS 1.4 Evaluate the advantages and disadvantages of modern farming techniques.

4.7.5.3 Sustainable fisheries

Content	Key opportunities for skills development
Fish stocks in the oceans are declining. It is important to maintain fish stocks at a level where breeding continues or certain species may disappear altogether in some areas. Control of net size and the introduction of fishing quotas play important roles in conservation of fish stocks at a sustainable level.	WS 1.4 Understand how application of different fishing techniques promotes recovery of fish stocks.

4.7.5.4 Role of biotechnology

Content	Key opportunities for skills development
Students should be able to describe and explain some possible biotechnical and agricultural solutions, including genetic modification, to the demands of the growing human population. Modern biotechnology techniques enable large quantities of microorganisms to be cultured for food. The fungus *Fusarium* is useful for producing mycoprotein, a protein-rich food suitable for vegetarians. The fungus is grown on glucose syrup, in aerobic conditions, and the biomass is harvested and purified. A genetically modified bacterium produces human insulin. When harvested and purified this is used to treat people with diabetes. GM crops could provide more food or food with an improved nutritional value such as golden rice.	There are links with this content to Genetic engineering.

4.8 Key ideas

The complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas in biology.

These key ideas are of universal application, and we have embedded them throughout the subject content. They underpin many aspects of the science assessment.

These ideas include:

- life processes depend on molecules whose structure is related to their function
- the fundamental units of living organisms are cells, which may be part of highly adapted structures including tissues, organs and organ systems, enabling living processes to be performed effectively
- living organisms may form populations of single species, communities of many species and ecosystems, interacting with each other, with the environment and with humans in many different ways
- living organisms are interdependent and show adaptations to their environment
- life on Earth is dependent on photosynthesis in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen
- organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life
- the chemicals in ecosystems are continually cycling through the natural world
- the characteristics of a living organism are influenced by its genome and its interaction with the environment
- evolution occurs by a process of natural selection and accounts both for biodiversity and how organisms are all related to varying degrees.

AT 1 – 7 are common with combined science. AT 8 is biology only.

	Apparatus and techniques
AT 1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH (links to A-level AT a).
AT 2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater (links to A-level AT a).
AT 3	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes.
AT 4	Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment (links to A-level AT h).
AT 5	Measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator.
AT 6	Application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field (links to A-level AT k).
AT 7	Use of appropriate apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings (links to A-level AT d and e).
AT 8 (Biology only)	Use of appropriate techniques and qualitative reagents to identify biological molecules and processes in more complex and problem-solving contexts including continuous sampling in an investigation (links to A-level AT f).

8.2 Required practical activities

The following practical activities must be carried out by all students taking GCSE Biology.

Following any revision by the Secretary of State of the apparatus or techniques specified, we will review and revise the required practical activities as appropriate.

Schools and colleges will be informed of any changes in a timely manner and the amended specification will be published, highlighting the changes accordingly.

Teachers are encouraged to vary their approach to these practical activities. Some are more suitable for highly structured approaches that develop key techniques while others allow opportunities for students to develop investigative approaches.

This list is not designed to limit the practical activities carried out by students. A rich practical experience will include more than the ten required practical activities. The explicit teaching of practical skills will build students' competence. Many teachers will also use practical approaches to introduce content knowledge in the course of their normal teaching.

Schools and colleges are required to provide a practical science statement to AQA, that is true and accurate written statement, which confirms that it has taken reasonable steps to secure that each student has:

- completed the required practical activities detailed in this specification
- made a contemporaneous record of such work undertaken during the activities and the knowledge, skills and understanding derived from those activities.

We will provide a form for the head of centre to sign. You must submit the form to us by the date published at aqa.org.uk/science. We will contact schools and colleges directly with the deadline date and timely reminders if the form is not received. Failure to send this form counts as malpractice/maladministration, and may result in formal action or warning for the school or college.

Practicals 1, 3, 4, 5, 6, 7, and 9 are common with GCSE Combined Science: Trilogy and GCSE Combined Science: Synergy. Practicals 2, 8 and 10 are GCSE Biology only.

8.2.1 Required practical activity 1

Use a light microscope to observe, draw and label a selection of plant and animal cells.

A magnification scale must be included.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record length and area.

AT 7 – use a microscope to make observations of biological specimens and produce labelled scientific drawings.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

MS 1d, 3a – use estimations to judge the relative size or area of sub-cellular structures.

8.2.2 Required practical activity 2 (biology only)

Investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record length and area.

AT 3 – use appropriate apparatus and techniques to observe and measure the process of bacterial growth.

AT 4 – safe and ethical use of bacteria to measure physiological function and response to antibiotics and antiseptics in the environment.

AT 8 – the use of appropriate techniques and qualitative reagents in problem-solving contexts to find the best antibiotic to use or the best concentration of antiseptic to use.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – develop hypotheses about the effectiveness of the antibiotics or antiseptics to be used.

WS 2.2 – plan experiments to make observations, test hypotheses and explore phenomena.

WS 2.4 – have due regard for accuracy of measurements, and health and safety when using bacterial cultures.

MS 5c – calculate cross-sectional areas of bacterial cultures and clear agar jelly using πr^2.

8.2.3 Required practical activity 3

Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record mass and time.

AT 3 – use appropriate apparatus and techniques to observe and measure the process of osmosis.

AT 5 – measure the rate of osmosis by water uptake.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – use the theory of osmosis to create hypotheses on plant tissue.

WS 2.2 – plan experiments to test hypotheses.

WS 2.4 – have due regard for accuracy of measurements and health and safety.

WS 2.6 – make and record observations and measurements of mass.

WS 2.7 – evaluate the method and suggest possible improvements and further investigations.

WS 3.1 – present observations and other data in graphical form.

WS 3.2 – translate mass data into graphical form.

MS 1a, 1c – use simple compound measures of rate of water uptake.

MS 1c – use percentages and calculate percentage gain and loss of mass of plant tissue.

MS 2b – find mean mass of plant tissue.

MS 4a, 4b, 4c, 4d – plot, draw and interpret appropriate graphs.

8.2.4 Required practical activity 4

Use qualitative reagents to test for a range of carbohydrates, lipids and proteins.

To include: Benedict's test for sugars; iodine test for starch; and Biuret reagent for protein.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 2 – safe use of a Bunsen burner and a boiling water bath.

AT 8 – use of qualitative reagents to identify biological molecules.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.4 – carry out experiments appropriately having due regard for the correct manipulation of apparatus, and health and safety considerations.

8.2.5 Required practical activity 5

Investigate the effect of pH on the rate of reaction of amylase enzyme.

Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is to be used to test for starch every 30 seconds. Temperature must be controlled by use of a water bath or electric heater.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record the volumes of liquids, time and pH.

AT 2 – safe use of a water bath or electric heater.

AT 5 – measure the rate of reaction by the colour change of iodine indicator.

AT 8 – use of qualitative iodine reagent to identify starch by continuous sampling.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – use scientific theories and explanations and hypothesis on how pH affects amylase activity.

WS 2.4 – carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements, and health and safety.

WS 2.5 – describe the appropriate sampling technique to ensure samples are representative.

WS 2.6 – make and record observations and measurements of time.

WS 3.1 – present a graph of amylase activity against pH.

WS 3.2 – translate numeric data into graphical form.

MS 1a, 1c – carry out rate calculations for chemical reactions.

8.2.6 Required practical activity 6

Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record the rate of production of oxygen gas produced; and to measure and control the temperature of water in a large beaker that acts as a ‘heat shield’.

AT 2 – use a thermometer to measure and control temperature of water bath.

AT 3 – use appropriate apparatus and techniques to observe and measure the process of oxygen gas production.

AT 4 – safe and ethical use and disposal of living pondweed to measure physiological functions and responses to light.

AT 5 – measuring rate of reaction by oxygen gas production.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – use scientific theories and explanations to develop hypotheses on how light intensity affects the rate of photosynthesis.

WS 2.2 – plan experiments to test hypotheses.

WS 2.5 – recognise that multiple samples will be needed at each light intensity.

WS 2.6 – make and record observations of gas production.

WS 3.1 – present a graph of light intensity against rate of photosynthesis.

WS 3.2 – translate numeric data into graphical form.

MS 1a, 1c – measure and understand the rate of photosynthesis reactions.

MS 4a, 4c – plot and draw appropriate graphs of rate of photosynthesis against light intensity selecting appropriate scale for axes.

MS 3a, 3d (HT) – understand and use inverse proportion: the inverse square law and light intensity in the context of photosynthesis.

8.2.7 Required practical activity 7

Plan and carry out an investigation into the effect of a factor on human reaction time.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record time.

AT 3 – selecting appropriate apparatus and techniques to measure the process of reaction time.

AT 4 – safe and ethical use of humans to measure physiological function of reaction time and responses to a chosen factor.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

MS 4a – translate information between numerical and graphical forms.

8.2.8 Required practical activity 8 (biology only)

Investigate the effect of light or gravity on the growth of newly germinated seedlings.

Record results both as length measurements and as accurate, labelled biological drawings to show the effects.

Apparatus and techniques

In doing this practical students should cover these parts of the Apparatus and Techniques requirements.

AT 1 – use appropriate apparatus to record length and time.

AT 3 – selecting appropriate apparatus and techniques to measure the growth of shoots or roots.

AT 4 – safe and ethical use of plants to measure physiological function of growth in response to light or gravity.

AT 7 – observations of biological specimens to produce labelled scientific drawings.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.2 – plan experiments to make observations to explore the phenomena of plant responses.

WS 2.3 – apply knowledge of a range of techniques, apparatus and materials appropriate to the experiment.

WS 2.6 – make and record observations and measurements using length and biological drawings.

WS 2.7 – suggest improvements and further investigations.

WS 3.1 – present observations as tables, graphs or drawings.

8.2.9 Required practical activity 9

Measure the population size of a common species in a habitat.

Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record length and area.

AT 3 – use transect lines and quadrats to measure distribution of a species.

AT 4 – safe and ethical use of organisms and response to a factor in the environment.

AT 6 – application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field.

AT 8 – use of appropriate techniques in more complex contexts including continuous sampling in an investigation.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – develop hypotheses regarding distribution of a species as a consequence of a factor.

WS 2.2 – plan experiments to test hypotheses on distribution.

WS 2.3 – apply a range of techniques, including the use of transects and quadrats, and the measurement of an abiotic factor.

MS 1d, 3a – estimates of population size based on sampling.

MS 2b – calculate arithmetic means.

MS 2d – understand principles of sampling.

MS 2f – understand the terms mean, mode and median as applied to ecological data.

MS 4c – plot and draw appropriate graphs selecting appropriate scales for the axes.

8.2.10 Required practical activity 10 (biology only)

Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.

Apparatus and techniques

In doing this practical students should cover these parts of the apparatus and techniques requirements.

AT 1 – use appropriate apparatus to record temperature and pH.

AT 3 – the use of appropriate apparatus to measure anaerobic decay.

AT 4 – safe use of microorganisms.

AT 5 – measurement of rate of decay by pH change.

Key opportunities for skills development

In doing this practical there are key opportunities for students to develop the following skills.

WS 2.1 – use scientific theories to make a hypothesis about the effect of temperature on rate of decay.

WS 2.4 – carry out experiments with due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

WS 2.6 – make and record observations and measurements.

WS 2.7 – evaluate method and identify possible improvements.

MS 1c – calculate rate changes in the decay of biological material.

MS 4a – translate information between numerical and graphical form.

MS 4c – plot and draw appropriate graphs selecting appropriate scales for the axes.