

Biology

Co-teaching Combined Science and Biology

April 2016

Area		Spec reference		Combined and Biology	Biology Only
		Combined	Biology		
4.1 Cell Biology	4.1.1 Cell Structure	4.1.1.1	4.1.1.1	Eukaryotes and prokaryotes	
		4.1.1.2	4.1.1.2	Animal cells and plant cells	
		4.1.1.3	4.1.1.3	Cell specialisation	
		4.1.1.4	4.1.1.4	Cell differentiation	
		4.1.1.5	4.1.1.5	Microscopy	
			4.1.1.6		Culturing microorganisms
	4.1.2 Cell division	4.1.2.1	4.1.2.1	Chromosomes	
		4.1.2.2	4.1.2.2	Mitosis and the cell cycle	
		4.1.2.3	4.1.2.3	Stem cells	
	4.1.3 Transport in cells	4.1.3.1	4.1.3.1	Diffusion	
		4.1.3.2	4.1.3.2	Osmosis	
		4.1.3.3	4.1.3.3	Active transport	
4.2 Organisation	4.2.1 Principles of organisation	4.2.1.1	4.2.1.1	Principals of organisation	
	4.2.2 Animal tissue, organs and organ system	4.2.2.1	4.2.2.1	The human digestive system	
		4.2.2.2	4.2.2.2	The heart and blood vessels	
		4.2.2.3	4.2.2.3	Blood	
		4.2.2.4	4.2.2.4	Coronary heart disease: a non-communicable disease	

		4.2.2.5	4.2.2.5	Health issues	
		4.2.2.6	4.2.2.6	The effect of lifestyle on some non-communicable diseases	
		4.2.2.7	4.2.2.7	Cancer	
	4.2.3 Plant tissue, organs and systems	4.2.3.1	4.2.3.1	Plant tissues	
		4.2.3.2	4.2.3.2	Plant organ system	
4.3 Infection and response	4.3.1 Communicable diseases	4.3.1.1	4.3.1.1	Communicable (infectious) disease	
		4.3.1.2	4.3.1.2	Viral diseases	
		4.3.1.3	4.3.1.3	Bacterial diseases	
		4.3.1.4	4.3.1.4	Fungal diseases	
		4.3.1.5	4.3.1.5	Protist diseases	
		4.3.1.6	4.3.1.6	Human defence systems	
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		4.3.1.8	4.3.1.8	Antibiotics and painkillers	
		4.3.1.9	4.3.1.9	Discovery and development of drugs	
	4.3.2 Monoclonal antibodies		4.3.2.1		Producing monoclonal antibodies (HT)
			4.3.2.2		Uses of monoclonal antibodies (HT)
	4.3.3 Plant disease		4.3.3.1		Detection and identification of plant diseases
			4.3.3.2		Plant defence responses
4.4 Bioenergetics	4.4.1 Photosynthesis	4.4.1.1	4.4.1.1	Photosynthetic reaction	
		4.4.1.2	4.4.1.2	Rate of Photosynthesis	

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	4.4.2 Respiration	4.4.2.1	4.4.2.1	Aerobic and anaerobic respiration	
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4.5 Homeostasis and response	4.5.1 Homeostasis	4.5.1.1	4.5.1.1	Homeostasis	
	4.5.2 The human nervous system	4.5.2	4.5.2.1	Structure and function ('The human nervous system' for combined)	
			4.5.2.2		The brain
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			4.5.2.4		Control of body temperature
	4.5.3 Hormonal coordination in humans	4.5.3.1	4.5.3.1	Human endocrine system	
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			4.5.3.3		Maintaining water and nitrogen balance in the body
		4.5.3.3	4.5.3.4	Hormones in human reproduction	
		4.5.3.4	4.5.3.5	Contraception	
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	4.5.4 Plant Hormones		4.5.4.1		Control and coordination
			4.5.4.2		Use of plant hormones

					(HTonly)
4.6 Inheritance , variation and evolution	4.6.1 Reproduction	4.6.1.1	4.6.1.1	Sexual and asexual reproduction	
		4.6.1.2	4.6.1.2	Meiosis	
			4.6.1.3		Advantages and disadvantages of sexual and asexual reproduction
		4.6.1.3	4.6.1.4	DNA and the genome	
			4.6.1.5		DNA structure
		4.6.1.4	4.6.1.6	Genetic inheritance	
		4.6.1.5	4.6.1.7	Inherited disorders	
		4.6.1.6	4.6.1.8	Sex determination	
	4.6.2 Variation and evolution	4.6.2.1	4.6.2.1	Variation	
		4.6.2.2	4.6.2.2	Evolution	
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		4.6.2.4	4.6.2.4	Genetic engineering	
			4.6.2.5		Cloning
	4.6.3 The development of understanding of genetics and evolution		4.6.3.1		Theory of evolution
			4.6.3.2		Speciation
			4.6.3.3		The understanding of genetics
		4.6.3.1	4.6.3.4	Evidence for evolution	
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		4.6.3.3	4.6.3.6	Extinction	
		4.6.3.4	4.6.3.7	Resistant bacteria	
	4.6.4 Classification of living organisms	4.6.4	4.6.4	Classification of living organisms	

4.7 Ecology	4.7.1 Adaptions , interdependence and competition	4.7.1.1	4.7.1.1	Communities	
		4.7.1.2	4.7.1.2	Abiotic factors	
		4.7.1.3	4.7.1.3	Biotic factors	
		4.7.1.4	4.7.1.4	Adaptations	
	4.7.2 Organisation of an ecosystem	4.7.2.1	4.7.2.1	Levels of organisation	
		4.7.2.2	4.7.2.2	How materials are cycled	
			4.7.2.3		Decomposition
			4.7.2.4		Impact of environmental change (HT only)
	4.7.3 Biodiversity and the effect of human interaction on ecosystems	4.7.3.1	4.7.3.1	Biodiversity	
		4.7.3.2	4.7.3.2	Waste management	
		4.7.3.3	4.7.3.3	Land use	
		4.7.3.4	4.7.3.4	Deforestation	
		4.7.3.5	4.7.3.5	Global warming	
		4.7.3.6	4.7.3.6	Maintaining biodiversity	
	4.7.4 Trophic levels in an ecosystem		4.7.4.1		Trophic levels
			4.7.4.2		Pyramids of biomass
			4.7.4.3		Transfer of biomass
	4.7.5 Food production		4.7.5.1		Factors affecting food security
			4.7.5.2		Farming techniques
			4.7.5.3		Sustainable fisheries
		4.7.5.4		Role of biotechnology	

Biology only content

4.1.1.6 Culturing microorganisms (biology only)

Content	Key opportunities for skills development
<p>Bacteria multiply by simple cell division (binary fission) as often as once every 20 minutes if they have enough nutrients and a suitable temperature.</p> <p>Bacteria can be grown in a nutrient broth solution or as colonies on an agar gel plate.</p> <p>Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.</p>	<p>MS 1a, 1b, 1d, 2a, 2h</p> <p>Calculate the number of bacteria in a population after a certain time if given the mean division time.</p> <p>MS 5c</p> <p>Calculate cross-sectional areas of colonies or clear areas around colonies using πr^2.</p>
<p>Students should be able to describe how to prepare an uncontaminated culture using aseptic technique.</p> <p>They should be able to explain why:</p> <ul style="list-style-type: none"> • Petri dishes and culture media must be sterilised before use • 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 and stored upside down • in school and college laboratories, cultures should be incubated at a maximum temperature of 25°C. 	<p>WS 2.2, 2.4</p>
<p>Students should be able to calculate cross-sectional areas of colonies or clear areas around colonies using πr^2.</p>	<p>MS 5c</p>
<p>Students should be able to calculate the number of bacteria in a population after a certain time if given the mean division time.</p>	<p>MS 1a, 2a, 2h</p>
<p>(HT only) Students should be able to express the answer in standard form.</p>	<p>MS 1b</p>

Required practical activity 2: investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.

AT skills covered by this practical activity: AT 1, 3, 4 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](#) (page 96).

There are links with this practical to [Antibiotics and painkillers](#) (page 36).

4.3.2 Monoclonal antibodies (biology only) (HT only)

4.3.2.1 Producing monoclonal antibodies

Content	Key opportunities for skills development
<p>Students should be able to describe how monoclonal antibodies are produced.</p> <p>Monoclonal antibodies are produced from a single clone of cells. The antibodies are specific to one binding site on one protein antigen and so are able to target a specific chemical or specific cells in the body.</p> <p>They are produced by stimulating mouse lymphocytes to make a particular antibody. The lymphocytes are combined with a particular kind of tumour cell to make a cell called a hybridoma cell. The hybridoma cell can both divide and make the antibody. Single hybridoma cells are cloned to produce many identical cells that all produce the same antibody. A large amount of the antibody can be collected and purified.</p>	

4.3.2.2 Uses of monoclonal antibodies

Content	Key opportunities for skills development
<p>Students should be able to describe some of the ways in which monoclonal antibodies can be used.</p> <p>Some examples include:</p> <ul style="list-style-type: none"> • For diagnosis such as in pregnancy tests. • In laboratories to measure the levels of hormones and other chemicals in blood, or to detect pathogens. • In research to locate or identify specific molecules in a cell or tissue by binding to them with a fluorescent dye. • To treat some diseases: for cancer the monoclonal antibody can be bound to a radioactive substance, a toxic drug or a chemical which stops cells growing and dividing. It delivers the substance to the cancer cells without harming other cells in the body. <p>Students are not expected to recall any specific tests or treatments but given appropriate information they should be able to explain how they work.</p>	<p>WS 1.3 Appreciate the power of monoclonal antibodies and consider any ethical issues.</p>
<p>Monoclonal antibodies create more side effects than expected. They are not yet as widely used as everyone hoped when they were first developed.</p>	<p>WS 1.5 Evaluate the advantages and disadvantages of monoclonal antibodies.</p>

4.3.3 Plant disease (biology only)

4.3.3.1 Detection and identification of plant diseases

Content	Key opportunities for skills development
<p>(HT only) Plant diseases can be detected by:</p> <ul style="list-style-type: none"> • stunted growth • spots on leaves • areas of decay (rot) • growths • malformed stems or leaves • discolouration • the presence of pests. <p>(HT only) Identification can be made by:</p> <ul style="list-style-type: none"> • reference to a gardening manual or website • taking infected plants to a laboratory to identify the pathogen • using testing kits that contain monoclonal antibodies. 	<p>WS 1.4</p> <p>The everyday application of scientific knowledge to detect and identify plant disease.</p>
<p>Plants can be infected by a range of viral, bacterial and fungal pathogens as well as by insects.</p> <p>Knowledge of plant diseases is restricted to tobacco mosaic virus as a viral disease, black spot as a fungal disease and aphids as insects.</p> <p>Plants can be damaged by a range of ion deficiency conditions:</p> <ul style="list-style-type: none"> • stunted growth caused by nitrate deficiency • chlorosis caused by magnesium deficiency. <p>Knowledge of ions is limited to nitrate ions needed for protein synthesis and therefore growth, and magnesium ions needed to make chlorophyll.</p>	<p>WS 1.4</p> <p>The understanding of ion deficiencies allows horticulturists to provide optimum conditions for plants.</p>

4.3.3.2 Plant defence responses

Content	Key opportunities for skills development
<p>Students should be able to describe physical and chemical plant defence responses.</p> <p>Physical defence responses to resist invasion of microorganisms.</p> <ul style="list-style-type: none"> • Cellulose cell walls. • Tough waxy cuticle on leaves. • Layers of dead cells around stems (bark on trees) which fall off. <p>Chemical plant defence responses.</p> <ul style="list-style-type: none"> • Antibacterial chemicals. • Poisons to deter herbivores. 	<p>There are links with this content to Adaptations (page 73).</p>

Mechanical adaptations.

- Thorns and hairs deter animals.
- Leaves which droop or curl when touched.
- Mimicry to trick animals.

4.5.2.2 The brain (biology only)

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

4.5.2.3 The eye (biology only)

Content	Key opportunities for skills development
<p>Students should be able to relate the structures of the eye to their functions. This includes:</p> <ul style="list-style-type: none"> • accommodation to focus on near or distant objects • adaptation to dim light. <p>The eye is a sense organ containing receptors sensitive to light intensity and colour.</p>	
<p>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:</p> <ul style="list-style-type: none"> • retina • optic nerve • sclera • cornea • iris • ciliary muscles • suspensory ligaments. 	<p>WS 1.2</p>

<p>Accommodation is the process of changing the shape of the lens to focus on near or distant objects.</p> <p>To focus on a near object:</p> <ul style="list-style-type: none"> • the ciliary muscles contract • the suspensory ligaments loosen • the lens is then thicker and refracts light rays strongly. <p>To focus on a distant object:</p> <ul style="list-style-type: none"> • the ciliary muscles relax • the suspensory ligaments are pulled tight • the lens is then pulled thin and only slightly refracts light rays. <p>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.</p> <ul style="list-style-type: none"> • 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. 	
<p>Students should be able to interpret ray diagrams, showing these two common defects of the eye and demonstrate how spectacle lenses correct them.</p>	<p>WS 1.2, 1.4</p>

4.5.2.4 Control of body temperature (biology only)

Content	Key opportunities for skills development
<p>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.</p> <p>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.</p> <p>If the body temperature is too low, blood vessels constrict (vasoconstriction), sweating stops and skeletal muscles contract (shiver).</p>	
<p>(HT only) Students should be able to explain how these mechanisms lower or raise body temperature in a given context.</p>	

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

Content	Key opportunities for skills development
<p>Students should be able to explain the effect on cells of osmotic changes in body fluids.</p> <p>Water leaves the body via the lungs during exhalation.</p> <p>Water, ions and urea are lost from the skin in sweat.</p> <p>There is no control over water, ion or urea loss by the lungs or skin.</p> <p>Excess water, ions and urea are removed via the kidneys in the urine.</p> <p>If body cells lose or gain too much water by osmosis they do not function efficiently.</p>	
<p>(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.</p>	
<p>Students should be able to describe the function of kidneys in maintaining the water balance of the body.</p> <p>The kidneys produce urine by filtration of the blood and selective reabsorption of useful substances such as glucose, some ions and water.</p> <p>Knowledge of other parts of the urinary system, the structure of the kidney and the structure of a nephron is not required.</p>	
<p>Students should be able to translate tables and bar charts of glucose, ions and urea before and after filtration.</p>	MS 4a
<p>(HT only) Students should be able to describe the effect of ADH on the permeability of the kidney tubules.</p> <p>(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.</p>	
<p>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.</p>	<p>WS 1.4 Students should be able to describe how kidney dialysis works.</p>

	<p>WS 1.5 Evaluate the advantages and disadvantages of treating organ failure by mechanical device or transplant.</p>
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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](#) (page 99).

4.5.4.2 Use of plant hormones (HT only)

Content	Key opportunities for skills development
<p>Students should be able to describe the effects of some plant hormones and the different ways people use them to control plant growth.</p> <p>Plant growth hormones are used in agriculture and horticulture.</p> <p>Auxins are used:</p> <ul style="list-style-type: none"> • as weed killers • as rooting powders • for promoting growth in tissue culture. 	<p>WS 1.3, 1.4 Understand how the everyday use of hormones as weedkillers has an effect on biodiversity.</p>

<p>Ethene is used in the food industry to control ripening of fruit during storage and transport.</p> <p>Gibberellins can be used to:</p> <ul style="list-style-type: none"> • end seed dormancy • promote flowering • increase fruit size. 	
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4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction (biology only)

Content	Key opportunities for skills development
<p>Advantages of sexual reproduction:</p> <ul style="list-style-type: none"> • 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. <p>Advantages of asexual reproduction:</p> <ul style="list-style-type: none"> • 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. 	<p>There are links with this content to Animal and plant cells (page 19) and Cloning (biology only) (page 65).</p>
<p>Some organisms reproduce by both methods depending on the circumstances.</p> <ul style="list-style-type: none"> • 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. <p>Knowledge of reproduction in organisms is restricted to those mentioned.</p> <p>Students are expected to be able to explain the advantages and disadvantages of asexual and sexual reproduction for any organism if given appropriate information.</p>	<p>WS 1.1</p> <p>Historical developments of our understanding of the causes and prevention of malaria.</p>

4.6.1.5 DNA structure (biology only)

Content	Key opportunities for skills development
<p>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.</p> <p>DNA contains four bases, A, C, G and T.</p> <p>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.</p>	
<p>The long strands of DNA consist of alternating sugar and phosphate sections. Attached to each sugar is one of the four bases.</p> <p>The DNA polymer is made up of repeating nucleotide units.</p>	<p>WS 1.2 Interpret a diagram of DNA structure but will not be required to reproduce it.</p>
<p>(HT only) Students should be able to:</p> <ul style="list-style-type: none"> • 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 noncoding DNA by altering how genes are expressed. <p>(HT only) In the complementary strands a C is always linked to a G on the opposite strand and a T to an A.</p> <p>(HT only) Students are not expected to know or understand the structure of mRNA, tRNA, or the detailed structure of amino acids or proteins.</p> <p>(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.</p> <p>(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.</p> <p>(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.</p>	
<p>(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.</p> <p>(HT only) A few mutations code for an altered protein with a different</p>	<p>WS 1.2 Modelling insertions and deletions in chromosomes to illustrate mutations.</p>

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.

4.6.2.5 Cloning (biology only)

Content	Key opportunities for skills development
<p>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.</p> <p>Cuttings: an older, but simple, method used by gardeners to produce many identical new plants from a parent plant.</p> <p>Embryo transplants: splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers.</p> <p>Adult cell cloning:</p> <ul style="list-style-type: none"> • 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. 	<p>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.</p> <p>There are links with this content to Advantages and disadvantages of sexual and asexual reproduction (biology only) (page 57) and Selective breeding (page 63).</p>

4.6.3.1 Theory of evolution (biology only)

Content	Key opportunities for skills development
<p>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.</p> <ul style="list-style-type: none"> • 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. 	<p>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.</p>

<p>Darwin published his ideas in <i>On the Origin of Species</i> (1859). There was much controversy surrounding these revolutionary new ideas.</p> <p>The theory of evolution by natural selection was only gradually accepted because:</p> <ul style="list-style-type: none"> • 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. <p>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.</p> <p>A study of creationism is not required.</p>	
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4.6.3.2 Speciation (biology only)

Content	Key opportunities for skills development
<p>Students should be able to:</p> <ul style="list-style-type: none"> • 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. <p>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 <i>On the Origin of Species</i> (1859) the following year.</p> <p>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.</p> <p>Alfred Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of speciation.</p> <p>Students should be able to describe the steps which give rise to new species.</p>	<p>There are links with this content to Evolution (page 62).</p> <p>WS 1.1 The theory of speciation has developed over time.</p>

4.6.3.3 The understanding of genetics (biology only)

Content	Key opportunities for skills development
<p>Students should be able to:</p> <ul style="list-style-type: none"> 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. <p>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.</p> <p>In the late 19th Century behaviour of chromosomes during cell division was observed.</p>	<p>WS 1.1 Our current understanding of genetics has developed over time.</p>
<p>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.</p> <p>In the mid-20th Century the structure of DNA was determined and the mechanism of gene function worked out.</p> <p>This scientific work by many scientists led to the gene theory being developed.</p>	<p>There are links with this content to Genetic inheritance (page 60).</p> <p>WS 1.1</p>

4.7.2.3 Decomposition (biology only)

Content	Key opportunities for skills development
<p>Students should be able to explain how temperature, water and availability of oxygen affect the rate of decay of biological material.</p>	
<p>Students should be able to:</p> <ul style="list-style-type: none"> 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. 	<p>MS 1c, 4a, 4c</p>
<p>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.</p> <p>Anaerobic decay produces methane gas. Biogas generators can be used to produce methane gas as a fuel.</p>	

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](#) (page 100).

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

Content	Key opportunities for skills development
<p>Students should be able to evaluate the impact of environmental changes on the distribution of species in an ecosystem given appropriate information.</p> <p>Environmental changes affect the distribution of species in an ecosystem. These changes include:</p> <ul style="list-style-type: none"> • temperature • availability of water • composition of atmospheric gases. <p>The changes may be seasonal, geographic or caused by human interaction.</p>	<p>WS 1.4</p> <p>There are links with this content to Biodiversity and the effect of human interaction on ecosystems (page 75).</p>

4.7.4 Trophic levels in an ecosystem (biology only)

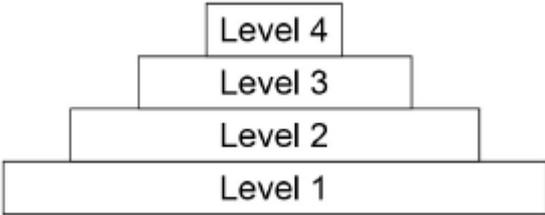
4.7.4.1 Trophic levels

Content	Key opportunities for skills development
<p>Students should be able to describe the differences between the trophic levels of organisms within an ecosystem.</p> <p>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.</p> <p>Level 1: Plants and algae make their own food and are called producers.</p> <p>Level 2: Herbivores eat plants/algae and are called primary consumers.</p> <p>Level 3: Carnivores that eat herbivores are called secondary consumers.</p> <p>Level 4: Carnivores that eat other carnivores are called tertiary</p>	

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
<p>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.</p> 	WS 1.2
<p>Students should be able to construct accurate pyramids of biomass from appropriate data.</p>	MS 2c

4.7.4.3 Transfer of biomass

Content	Key opportunities for skills development
<p>Students should be able to:</p> <ul style="list-style-type: none"> • describe pyramids of biomass • explain how biomass is lost between the different trophic levels. <p>Producers are mostly plants and algae which transfer about 1% of the incident energy from light for photosynthesis.</p>	
<p>Only approximately 10% of the biomass from each trophic level is transferred to the level above it.</p> <p>Losses of biomass are due to:</p> <ul style="list-style-type: none"> • 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. <p>Large amounts of glucose are used in respiration.</p>	<p>MS 1c</p> <p>Calculate the efficiency of biomass transfer between trophic levels.</p>

<p>Students should be able to calculate the efficiency of biomass transfers between trophic levels by percentages or fractions of mass.</p> <p>Students should be able to explain how this affects the number of organisms at each trophic level.</p>	<p>MS 1c</p>
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4.7.5 Food production (biology only)

4.7.5.1 Factors affecting food security

Content	Key opportunities for skills development
<p>Students should be able to describe some of the biological factors affecting levels of food security.</p> <p>Food security is having enough food to feed a population.</p> <p>Biological factors which are threatening food security include:</p> <ul style="list-style-type: none"> • 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. <p>Sustainable methods must be found to feed all people on Earth.</p>	<p>WS 1.4 Interpret population and food production statistics to evaluate food security.</p>

4.7.5.2 Farming techniques

Content	Key opportunities for skills development
<p>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.</p> <p>Some animals are fed high protein foods to increase growth.</p>	<p>WS 1.3 Understand that some people have ethical objections to some modern intensive farming methods.</p> <p>WS 1.4 Evaluate the advantages and disadvantages of modern farming techniques.</p>

4.7.5.3 Sustainable fisheries

Content	Key opportunities for skills development
<p>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.</p> <p>Control of net size and the introduction of fishing quotas play important roles in conservation of fish stocks at a sustainable level.</p>	<p>WS 1.4 Understand how application of different fishing techniques promotes recovery of fish stocks.</p>

4.7.5.4 Role of biotechnology

Content	Key opportunities for skills development
<p>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.</p> <p>Modern biotechnology techniques enable large quantities of microorganisms to be cultured for food.</p> <p>The fungus <i>Fusarium</i> 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.</p> <p>A genetically modified bacterium produces human insulin. When harvested and purified this is used to treat people with diabetes.</p> <p>GM crops could provide more food or food with an improved nutritional value such as golden rice.</p>	<p>There are links with this content to Genetic engineering (page 63).</p>