## 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.

### Homeostasis

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| **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. |  |

### Hormonal coordination in humans

* + - 1. Human endocrine system

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| **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. |  |

* + - 1. Control of blood glucose concentration

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| **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 |

## 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.

### Reproduction

* + - 1. DNA and the genome

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| **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 |

* + - 1. Genetic inheritance

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| **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 |

* + - 1. Inherited disorders

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| **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. | WS 1.3  Appreciate that embryo screening and gene therapy may alleviate suffering but consider the ethical issues which arise. |
| Students should make informed judgements about the economic, social and ethical issues concerning embryo screening, given appropriate information. |  |

* + - 1. Genetic engineering

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| **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. |  |

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| **Content** | **Key opportunities for skills development** |
| 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 |

### The development of understanding of genetics and evolution

* + - 1. Evidence for evolution

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| **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. |

* + - 1. Fossils

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| **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 |

* + 1. Classification of living organisms

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| **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. |  |

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| **Content** | **Key opportunities for skills development** |
| 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. | WS 1.1  Understand how scientific methods and theories develop over time. |
| 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). |  |
| 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. |

## 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.

### Adaptations, interdependence and competition

* + - 1. Communities

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| **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. |

* + - 1. Abiotic factors

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| **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. |

* + - 1. Biotic factors

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| **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. |

### Organisation of an ecosystem

* + - 1. Levels of organisation

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| **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 7:** 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: biology AT 1, 3, 4 and 6.

This practical activity also provides opportunities to develop WS and MS. Details of all skills are given in [Key opportunities for skills development](#_bookmark80) (page 179).

* + - 1. How materials are cycled

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| **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 The Earth's early atmosphere.  WS 1.2 |

* + - 1. Waste management

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| **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. | There are links with this content to GCSE Chemistry  5.9.3.1 Atmospheric pollutants from fuels. |
| 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. |  |