## 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 |
| (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. |  |

* + - 1. Hormones in human reproduction

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| **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 |

* + - 1. The use of hormones to treat infertility (HT only)

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| **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. |

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

* + - 1. Feedback systems (HT only)

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| **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. |

## 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.

* + - 1. Meiosis

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| **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. |

* + 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 |

### Biodiversity and the effect of human interaction on ecosystems

* + - 1. Biodiversity

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| **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. | WS 1.4  Explain how waste, deforestation and global warming have an impact on biodiversity. |
| 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. |  |

* + - 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. |  |

* + - 1. Global warming

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| **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. |

* + - 1. Maintaining biodiversity

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| **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. |