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.

4.5.2 The human nervous system

4.5.2.1 Structure and function



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| --- | --- | --- |
| **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, | MS 2c |
| charts and tables, about the functioning of the nervous system. |  |
|  |  |
| Students should be able to translate information about reaction | MS 4a |
| times between numerical and graphical forms. |  |  |



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

4.5.2.4 Control of body temperature (biology only)

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| --- | --- |
| **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). |  |
|  |  |
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4.5.3 Hormonal coordination in humans

4.5.3.1 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. |  |
|  |  |  |

4.5.3.2 Control of blood glucose concentration

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| **Content** | **Key opportunities for skills** |  |
|  | **development** |  |
|  |  |  |
| Blood glucose concentration is monitored and controlled by the | WS 1.3 |  |
| pancreas. | Evaluate information around |  |
|  |  |
| If the blood glucose concentration is too high, the pancreas | the relationship between |  |
| produces the hormone insulin that causes glucose to move from the | obesity and diabetes, and |  |
| blood into the cells. In liver and muscle cells excess glucose is | make recommendations |  |
| converted to glycogen for storage. | taking into account social |  |
| Students should be able to explain how insulin controls blood | and ethical issues. |  |
|  |  |
| 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. |  |  |
|  |  |  |
| Students should be able to extract information and interpret data | MS 2c |  |
| from graphs that show the effect of insulin in blood glucose levels in |  |  |
| both people with diabetes and people without diabetes. |  |  |
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4.5.3.4 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.



4.5.3.5 Contraception

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

4.5.4 Plant hormones (biology only)

4.5.4.1 Control and coordination

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| --- | --- |
| **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 newlygerminated seedlings.

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

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

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| **Content** |  | **Key opportunities for skills** |  |
|  |  | **development** |  |
|  |  |  |  |  |  |  |
| Students should understand that meiosis leads to non-identical cells |  | There are links with this |  |
| being formed while mitosis leads to identical cells being formed. |  | content to [Mitosis and the](#page22) |  |
|  |  |  |  |  |  |  |
| Sexual reproduction involves the joining (fusion) of male and female |  | [cell cycle](#page22) | (page 22). |  |
|  |  |  |
| 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. |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

4.6.1.2 Meiosis

|  |  |  |
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| **Content** | **Key opportunities for skills** |  |
|  | **development** |  |
|  |  |  |
| Students should be able to explain how meiosis halves the number | WS 1.2 |  |
| of chromosomes in gametes and fertilisation restores the full | Modelling behaviour of |  |
| number of chromosomes. |  |
| chromosomes during |  |
|  |  |
| Cells in reproductive organs divide by meiosis to form gametes. | meiosis. |  |
| 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. |  |  |
|  |  |  |

4.6.1.4 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 | WS 1.1, 1.4 |
| 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. |  |
|  |  |

4.6.1.6 Genetic inheritance



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| **Content** |  | **Key opportunities for skills** |
|  |  | **development** |
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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 | MS 2e |
| 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. |  |
|  |  |
| Students should be able to use direct proportion and simple ratios | MS 1c, 3a |
| to express the outcome of a genetic cross. |  |
|  |  |
| Students should be able to complete a Punnett square diagram and | MS 2c, 4a |
| extract and interpret information from genetic crosses and family |  |
| trees. |  |
|  |  |
|  |
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4.6.1.7 Inherited disorders

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

4.6.3 The development of understanding of genetics and evolution

4.6.3.4 Evidence for evolution

|  |  |  |
| --- | --- | --- |
| **Content** | **Key opportunities for skills** |  |
|  | **development** |  |
|  |  |  |
| Students should be able to describe the evidence for evolution | WS 1.3 |  |
| including fossils and antibiotic resistance in bacteria. | Data is now available to |  |
|  |  |
| The theory of evolution by natural selection is now widely accepted. | support the theory of |  |
| Evidence for Darwin’s theory is now available as it has been shown | evolution. |  |
|  |  |
| 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. |  |  |
|  |  |  |

4.6.3.5 Fossils

|  |  |  |
| --- | --- | --- |
| **Content** | **Key opportunities for skills** |  |
|  | **development** |  |
|  |  |  |
| Fossils are the ‘remains’ of organisms from millions of years ago, | MS 2c, 4a |  |
| which are found in rocks. | Extract and interpret |  |
|  |  |
| Fossils may be formed: | information from charts, |  |
| • from parts of organisms that have not decayed because one or | graphs and tables. |  |
|  |  |
| 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. |  |  |
|  |  |  |
| Many early forms of life were soft-bodied, which means that they | WS 1.3 |  |
| have left few traces behind. What traces there were have been | Appreciate why the fossil |  |
| mainly destroyed by geological activity. This is why scientists |  |
| record is incomplete. |  |
| cannot be certain about how life began on Earth. |  |
|  |  |
|  |  |  |
| We can learn from fossils how much or how little different | WS 1.1 |  |
| organisms have changed as life developed on Earth. | Understand how scientific |  |
|  |  |
|  | methods and theories |  |
|  | develop over time. |  |
|  |  |  |
| Students should be able to extract and interpret information from | MS 2c, 4a |  |
| charts, graphs and tables such as evolutionary trees. |  |  |
|  |  |  |

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. |  |
|  |  |

4.7.1 Adaptations, interdependence and competition

4.7.1.1 Communities

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| --- | --- | --- |
| **Content** | **Key opportunities for skills** |  |
|  | **development** |  |
|  |  |  |
| Students should be able to describe: | WS 2.6 |  |
| • different levels of organisation in an ecosystem from individual | Recording first-hand |  |
| organisms to the whole ecosystem | observations of organisms. |  |
| • 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. |  |  |
|  |  |  |
| Students should be able to extract and interpret information from | MS 2c, 4a |  |
| charts, graphs and tables relating to the interaction of organisms | Extract and interpret |  |
| within a community. |  |
|  | information from charts, |  |
|  | graphs and tables. |  |
|  |  |  |

4.7.1.2 Abiotic factors

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| --- | --- | --- |
| **Content** | **Key opportunities for skills** |  |
|  |  | **development** |  |
|  |  |  |
| Students should be able to explain how a change in an abiotic | WS 1.2 |  |
| 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. |  |  |
|  |  |  |
| Students should be able to extract and interpret information from | MS 2c, 4a |  |
| charts, graphs and tables relating to the effect of abiotic factors on | Extract and interpret |  |
| organisms within a community. |  |
|  |  | 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 | WS 1.2 |  |
| 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. |  |  |
|  |  |  |
| Students should be able to extract and interpret information from | MS 2c, 4a |  |
| charts, graphs and tables relating to the effect of biotic factors on | Extract and interpret |  |
| organisms within a community. |  |
|  |  | information from charts, |  |

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: | MS 2b, 2f, 4a, 4c |  |
| • understand the terms mean, mode and median |  |  |
| • calculate arithmetic means |  |  |
| • plot and draw appropriate graphs selecting appropriate scales |  |  |
| for the axes. |  |  |
|  |  |  |
| 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 | WS 1.2 |  |
| eaten are prey. In a stable community the numbers of predators and | Interpret graphs used to |  |
| prey rise and fall in cycles. | model predator-prey cycles. |  |
|  |  |
|  |  |  |
| Students should be able to interpret graphs used to model these | MS 4a |  |
| cycles. |  |  |
|  |  |  |

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

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 |  | WS 1.4 |  |
| changes on the distribution of species in an ecosystem given |  | There are links with this |  |
| appropriate information. |  |  |
|  | content to [Biodiversity and](#page75) |  |
| Environmental changes affect the distribution of species in an |  |  |
|  |  |  |  |  |  |
|  | [the effect of human](#page75) |  |
| ecosystem. These changes include: |  |  |  |  |  |
|  | [interaction on ecosystems](#page75) |  |  |
| • | temperature |  | (page 75). |  |
|  |  |  |  |  |  |
| • | availability of water |  |  |  |  |  |  |
| • composition of atmospheric gases. |  |  |  |  |  |  |
| The changes may be seasonal, geographic or caused by human |  |  |  |  |  |  |
| interaction. |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

4.7.3.2 Waste management

|  |  |
| --- | --- |
| **Content** | **Key opportunities for skills** |
|  | **development** |
|  |  |
| Rapid growth in the human population and an increase in the | There are links with this |
| standard of living mean that increasingly more resources are used | content to GCSE Chemistry |
| and more waste is produced. Unless waste and chemical materials | 4.9.3.1 Atmospheric |
| are properly handled, more pollution will be caused. | 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. |  |