3.3 Unit 1: Biology 1

B1.1 Keeping healthy

A combination of a balanced diet and regular exercise is needed to help keep the body healthy. Our bodies provide an excellent environment for many microbes which can make us ill once they are inside us. Our bodies need to stop most microbes getting in and deal with any microbes which do get in. Vaccination can be used to prevent infection.

Candidates should use their skills, knowledge and understanding to:

- evaluate information about the effect of food on health

Additional guidance:

Candidates will be given data to work from.

- evaluate information about the effect of lifestyle on development of disease
- analyse and evaluate claims made by slimming programmes, and slimming products.

B1.1.1 Diet and exercise

Additional guidance:

Knowledge and understanding of the specific functions of nutrients and the effects of any deficiency in the diet is **not** required.

a) A healthy diet contains the right balance of the different foods you need and the right amount of energy. Carbohydrates, fats and proteins are used by the body to release energy and to build cells. Mineral ions and vitamins are needed in small amounts for healthy functioning of the body. A person is malnourished if their diet is not balanced. This may lead to a person being overweight or underweight. An unbalanced diet may also lead to deficiency diseases or conditions such as Type 2 diabetes.

b) A person loses mass when the energy content of the food taken in is less than the amount of energy expended by the body. Exercise increases the amount of energy expended by the body.

c) The rate at which all the chemical reactions in the cells of the body are carried out (the metabolic rate) varies with the amount of activity you do and the proportion of muscle to fat in your body. Metabolic rate may be affected by inherited factors.

d) Inherited factors also affect our health; for example cholesterol level.

Additional guidance:

The effect of exercise on breathing and heart rate is **not** required.

e) People who exercise regularly are usually healthier than people who take little exercise.

B1.1.2 How our bodies defend themselves against infectious diseases

Candidates should use their skills, knowledge and understanding to:

- relate the contribution of Semmelweis in controlling infection to solving modern problems with the spread of infection in hospitals

Additional guidance:

Candidates will be given data to work from.

- explain how the treatment of disease has changed as a result of increased understanding of the action of antibiotics and immunity
- evaluate the consequences of mutations of bacteria and viruses in relation to epidemics and pandemics
- evaluate the advantages and disadvantages of being vaccinated against a particular disease.

a) Microorganisms that cause infectious disease are called pathogens.

Additional guidance:

Knowledge of the structure of bacteria and viruses is **not** required.

b) Bacteria and viruses may reproduce rapidly inside the body and may produce poisons (toxins) that make us feel ill. Viruses damage the cells in which they reproduce.

c) The body has different ways of protecting itself against pathogens.

d) White blood cells help to defend against pathogens by:

- ingesting pathogens
- producing antibodies, which destroy particular bacteria or viruses
- producing antitoxins, which counteract the toxins released by the pathogens.

e) The immune system of the body produces specific antibodies to kill a particular pathogen. This leads to immunity from that pathogen. In some cases, dead or inactivated pathogens stimulate antibody production. If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced.

f) Semmelweis recognised the importance of hand-washing in the prevention of spreading some infectious diseases. By insisting that doctors washed their hands before examining patients, he greatly reduced the number of deaths from infectious diseases in his hospital.

g) Some medicines, including painkillers, help to relieve the symptoms of infectious disease, but do not kill the pathogens.

h) Antibiotics, including penicillin, are medicines that help to cure bacterial disease by killing infectious bacteria inside the body. Antibiotics cannot be used to kill viral pathogens, which live and reproduce inside cells. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases. Overuse and inappropriate use of antibiotics has increased the rate of development of antibiotic resistant strains of bacteria.

Additional guidance:

Candidates should be aware that it is difficult to develop drugs that kill viruses without also damaging the body's tissues.

i) Many strains of bacteria, including MRSA, have developed resistance to antibiotics as a result of natural selection. To prevent further resistance arising it is important to avoid over-use of antibiotics.

Knowledge of the development of resistance in bacteria is limited to the fact that pathogens mutate, producing resistant strains.

j) Mutations of pathogens produce new strains. Antibiotics and vaccinations may no longer be effective against a new resistant strain of the pathogen. The new strain will then spread rapidly because people are not immune to it and there is no effective treatment.

Higher Tier candidates should understand that:

- **antibiotics kill individual pathogens of the non-resistant strain**
- **individual resistant pathogens survive and reproduce, so the population of the resistant strain increases**
- **now, antibiotics are not used to treat non-serious infections, such as mild throat infections, so that the rate of development of resistant strains is slowed down.**

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k) The development of antibiotic-resistant strains of bacteria necessitates the development of new antibiotics.

l) People can be immunised against a disease by introducing small quantities of dead or inactive forms of the pathogen into the body (vaccination). Vaccines stimulate the white blood cells to produce antibodies that destroy the pathogens. This makes the person immune to future infections by the microorganism. The body can respond by rapidly making the correct antibody, in the same way as if the person had previously had the disease.

MMR vaccine is used to protect children against measles, mumps and rubella.

Additional guidance:

Details of vaccination schedules and side effects associated with specific vaccines are **not** required.

m) Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.

For this:

- Petri dishes and culture media must be sterilised before use to kill unwanted microorganisms
- 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 to prevent microorganisms from the air contaminating the culture.

n) In school and college laboratories, cultures should be incubated at a maximum temperature of 25 °C, which greatly reduces the likelihood of growth of pathogens that might be harmful to humans.

o) In industrial conditions higher temperatures can produce more rapid growth.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigate the effectiveness of various antibiotic discs in killing bacteria
- growing microorganisms in Petri dishes to demonstrate sterile technique and growing pure cultures
- the use of pre-inoculated agar in Petri dishes to evaluate the effect of disinfectants and antibiotics
- computer simulations to model the effect of: balanced and unbalanced diets and exercise; the growth of bacterial colonies in varying conditions; action of the immune system and the effect of antibiotics and vaccines.

B1.2 Nerves and hormones

The nervous system and hormones enable us to respond to external changes. They also help us to control conditions inside our bodies. Hormones are used in some forms of contraception and in fertility treatments. Plants also produce hormones and respond to external stimuli.

Candidates should use their skills, knowledge and understanding to:

- evaluate the benefits of, and the problems that may arise from, the use of hormones to control fertility, including In Vitro Fertilisation (IVF)
- evaluate the use of plant hormones in horticulture as weedkillers and to encourage the rooting of plant cuttings.

Additional guidance:

Candidates will be given data to work from.

B1.2.1 The nervous system

a) The nervous system enables humans to react to their surroundings and coordinate their behaviour.

Additional guidance:

Knowledge and understanding of the structure and functions of sense organs such as the eye and the ear are **not** required.

b) Cells called receptors detect stimuli (changes in the environment).

Receptors and the stimuli they detect include:

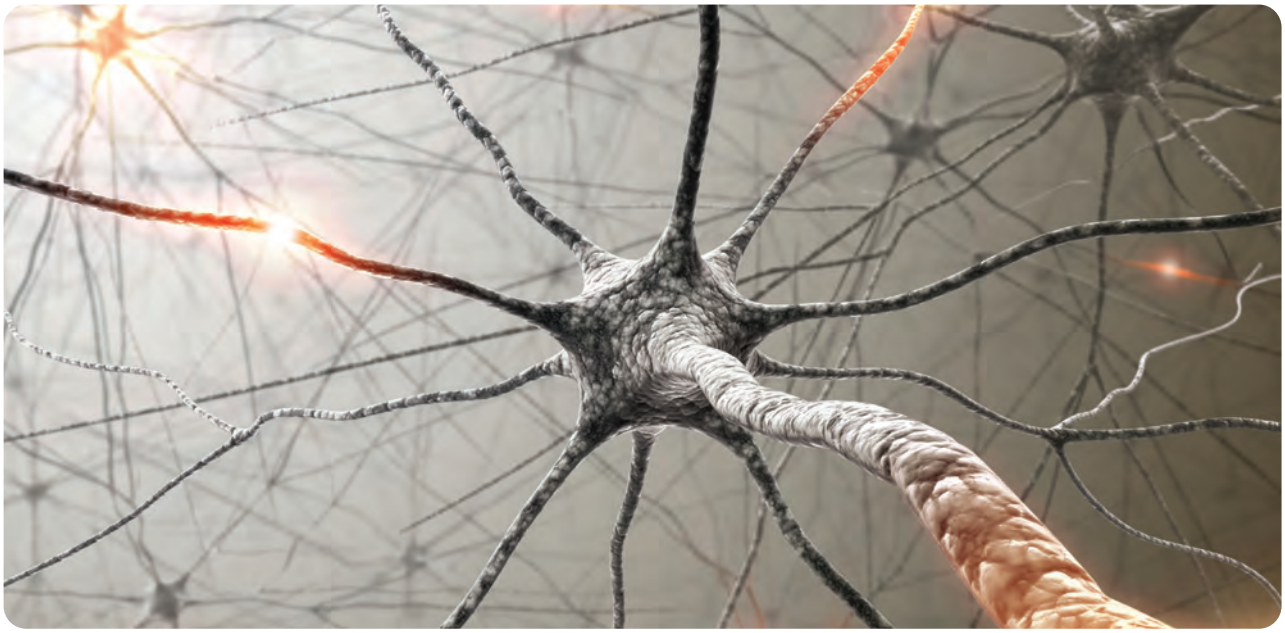
- receptors in the eyes that are sensitive to light
- receptors in the ears that are sensitive to sound
- receptors in the ears that are sensitive to changes in position and enable us to keep our balance
- receptors on the tongue and in the nose that are sensitive to chemicals and enable us to taste and to smell
- receptors in the skin that are sensitive to touch, pressure, pain and to temperature changes.

Additional guidance:

A knowledge of the functions of the cell components is **not** required.

c) Light receptor cells, like most animal cells, have a nucleus, cytoplasm and cell membrane.

d) Information from receptors passes along cells (neurones) in nerves to the brain. The brain coordinates the response. Reflex actions are automatic and rapid. They often involve sensory, relay and motor neurones.



e) Candidates should understand the role of receptors, sensory neurones, motor neurones, relay neurones, synapses and effectors in simple reflex actions.

In a simple reflex action:

- impulses from a receptor pass along a sensory neurone to the central nervous system
- at a junction (synapse) between a sensory neurone and a relay neurone in the central nervous system, a chemical is released that causes an impulse to be sent along a relay neurone
- a chemical is then released at the synapse between a relay neurone and motor neurone in the central nervous system, causing impulses to be sent along a motor neurone to the organ (the effector) that brings about the response
- the effector is either a muscle or a gland, a muscle responds by contracting and a gland responds by releasing (secreting) chemical substances.

B1.2.2 Control in the human body

Additional guidance:

Details of the action of the skin and kidneys and the control of blood sugar are **not** required.

a) Internal conditions that are controlled include:

- the water content of the body – water leaves the body via the lungs when we breathe out and via the skin when we sweat to cool us down, and excess water is lost via the kidneys in the urine
- the ion content of the body – ions are lost via the skin when we sweat and excess ions are lost via the kidneys in the urine
- temperature – to maintain the temperature at which enzymes work best
- blood sugar levels – to provide the cells with a constant supply of energy.

b) Many processes within the body are coordinated by chemical substances called hormones. Hormones are secreted by glands and are usually transported to their target organs by the bloodstream.

c) Hormones regulate the functions of many organs and cells. For example, the monthly release of an egg from a woman's ovaries and the changes in the thickness of the lining of her womb are controlled by hormones secreted by the pituitary gland and by the ovaries.

d) Several hormones are involved in the menstrual cycle of a woman. Hormones are involved in promoting the release of an egg:

- follicle stimulating hormone (FSH) is secreted by the pituitary gland and causes eggs to mature in the ovaries. It also stimulates the ovaries to produce hormones including oestrogen
- luteinising hormone (LH) stimulates the release of eggs from the ovary
- oestrogen is secreted by the ovaries and inhibits the further production of FSH.

e) The uses of hormones in controlling fertility include:

- giving oral contraceptives that contain hormones to inhibit FSH production so that no eggs mature
  - oral contraceptives may contain oestrogen and progesterone to inhibit egg maturation
  - the first birth-control pills contained large amounts of oestrogen. These resulted in women suffering significant side effects
  - birth-control pills now contain a much lower dose of oestrogen, or are progesterone only
  - progesterone-only pills lead to fewer side effects
- giving FSH and LH in a 'fertility drug' to a woman whose own level of FSH is too low to stimulate eggs to mature, for example in 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. 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).

Additional guidance:

Knowledge of the role of progesterone in the natural menstrual cycle, including details of negative feedback, is **not** required

B1.2.3 Control in plants

a) Plants are sensitive to light, moisture and gravity:

- their shoots grow towards light and against the force of gravity
- their roots grow towards moisture and in the direction of the force of gravity.

b) Plants produce hormones to coordinate and control growth. Auxin controls phototropism and gravitropism (geotropism).

Additional guidance:

Candidates should understand the role of auxin in phototropism and gravitropism.

c) The responses of plant roots and shoots to light, gravity and moisture are the result of unequal distribution of hormones, causing unequal growth rates.

d) Plant growth hormones are used in agriculture and horticulture as weed killers and as rooting hormones.

Additional guidance:

Names of specific weed killers and rooting hormones are **not** required.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigation into candidates' reaction times – measuring reaction times using metre rules, stop clocks or ICT
- using forehead thermometers before and after exercise
- demonstrating the speed of transmission along nerves by candidates standing in a semi-circle and holding hands and squeezing with eyes closed
- design an investigation to measure the sensitivity of the skin
- demonstrating the knee jerk reaction
- investigation to measure the amount of sweat produced during exercise
- investigate:
  - the effect of light on the growth of seedlings
  - the effect of gravity on growth in germinating seedlings
  - the effect of water on the growth of seedlings
  - using a motion sensor to measure the growth of plants and seedlings
  - the effect of rooting compounds and weed killers on the growth of plants.

B1.3 The use and abuse of drugs

Drugs affect our body chemistry. Medical drugs are developed and tested before being used to relieve illness or disease. Drugs may also be used recreationally as people like the effect on the body. Some drugs are addictive. Some athletes take drugs to improve performance. People cannot make sensible decisions about drugs unless they know their full effects.

Candidates should use their skills, knowledge and understanding to:

- evaluate the effect of statins in cardiovascular disease
- evaluate different types of drugs and why some people use illegal drugs for recreation
- evaluate claims made about the effect of prescribed and non-prescribed drugs on health
- consider the possible progression from recreational drugs to hard drugs
- evaluate the use of drugs to enhance performance in sport and to consider the ethical implications of their use.

Additional guidance:

Candidates will be given data to work from.

Classification of drug types is **not** required.

B1.3.1 Drugs

a) Scientists are continually developing new drugs.

b) When new medical drugs are devised, they have to be extensively tested and trialled before being used. Drugs are tested in a series of stages to find out if they are safe and effective.

New drugs are extensively tested for toxicity, efficacy and dose:

- in the laboratory, using cells, tissues and live animals
- in clinical trials involving healthy volunteers and patients. Very low doses of the drug are given at the start of the clinical trial. If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug. In some double blind trials, some patients are given a placebo, which does not contain the drug. Neither the doctors nor the patients know who has received a placebo and who has received the drug until the trial is complete.

Additional guidance:

Candidates should understand that tissues and animals are used as models to predict how the drugs may behave in humans.

c) Candidates should be aware of the use of statins in lowering the risk of heart and circulatory diseases.

d) Thalidomide is a drug that was developed as a sleeping pill. It was also found to be effective in relieving morning sickness in pregnant women.

Thalidomide had not been tested for use in pregnant women. Unfortunately, many babies born to mothers who took the drug were born with severe limb abnormalities. The drug was then banned. As a result, drug testing has become much more rigorous. More recently, thalidomide has been used successfully in the treatment of leprosy and other diseases.

e) Candidates should be aware of the effects of misuse of the legal recreational drugs, alcohol and nicotine. Candidates should understand that the misuse of the illegal recreational drugs ecstasy, cannabis and heroin may have adverse effects on the heart and circulatory system.

Additional guidance:

Knowledge and understanding of the specific effects of recreational drugs on the body, except for cannabis are **not** required. The legal classification of specific drugs is **not** required.

f) Cannabis is an illegal drug. Cannabis smoke contains chemicals which may cause mental illness in some people.

g) The overall impact of legal drugs (prescribed and non-prescribed) on health is much greater than the impact of illegal drugs because far more people use them.

Additional guidance:

Awareness of the benefits of medical drugs, the impact of non-medical drugs such as alcohol and the possible misuse of legal drugs should be considered.

h) Drugs change the chemical processes in peoples' bodies so that they may become dependent or addicted to the drug and suffer withdrawal symptoms without them. Heroin and cocaine are very addictive.

i) There are several types of drug that an athlete can use to enhance performance. Some of these drugs are banned by law and some are legally available on prescription, but all are prohibited by sporting regulations. Examples include stimulants that boost bodily functions such as heart rate; and anabolic steroids which stimulate muscle growth.

Additional guidance:

Knowledge of the mode of action of steroids and other performance-enhancing drugs is **not** required.

B1.4 Interdependence and adaptation

Organisms are well adapted to survive in their normal environment. Population size depends on a variety of factors including competition, predation, disease and human influences. Changes in the environment may affect the distribution and behaviour of organisms.

Candidates should use their skills, knowledge and understanding to:

- suggest how organisms are adapted to the conditions in which they live

Additional guidance:

Examination questions will use examples that are unfamiliar to candidates.

- observe the adaptations, eg body shape, of a range of organisms from different habitats
- develop an understanding of the ways in which adaptations enable organisms to survive
- suggest the factors for which organisms are competing in a given habitat

Additional guidance:

Factors are limited to light, water, space and nutrients in plants; food, mates and territory in animals.

- evaluate data concerned with the effect of environmental changes on the distribution and behaviour of living organisms.

B1.4.1 Adaptations

a) To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there.

b) Plants often compete with each other for light and space, and for water and nutrients from the soil.

c) Animals often compete with each other for food, mates and territory.

d) Organisms, including microorganisms have features (adaptations) that enable them to survive in the conditions in which they normally live.

e) Some organisms live in environments that are very extreme. Extremophiles may be tolerant to high levels of salt, high temperatures or high pressures.

f) Animals and plants may be adapted for survival in the conditions where they normally live, eg deserts, the Arctic.

Animals may be adapted for survival in dry and arctic environments by means of:

- changes to surface area
- thickness of insulating coat
- amount of body fat
- camouflage.

Plants may be adapted to survive in dry environments by means of:

- changes to surface area, particularly of the leaves
- water-storage tissues
- extensive root systems.

g) Animals and plants may be adapted to cope with specific features of their environment, eg thorns, poisons and warning colours to deter predators.

B1.4.2 Environmental change

a) Changes in the environment affect the distribution of living organisms.

Additional guidance:

Examples might include, but not limited to, the changing distribution of some bird species and the disappearance of pollinating insects, including bees.

b) Animals and plants are subjected to environmental changes. Such changes may be caused by living or non-living factors such as a change in a competitor, or in the average temperature or rainfall.

c) Living organisms can be used as indicators of pollution:

- lichens can be used as air pollution indicators, particularly of the concentration of sulfur dioxide in the atmosphere
- invertebrate animals can be used as water pollution indicators and are used as indicators of the concentration of dissolved oxygen in water.

Additional guidance:

Knowledge and understanding of the process of eutrophication is **not** required.

d) Environmental changes can be measured using non-living indicators such as oxygen levels, temperature and rainfall.

Candidates should understand the use of equipment to measure oxygen levels, temperature and rainfall.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigations of environmental conditions and organisms in a habitat such as a pond
- 'hunt the cocktail stick' using red and green cocktail sticks on a green background
- investigate the distribution of European banded snails
- investigate the behaviour of woodlice using choice chambers
- investigate the effect on plant growth of varying their environmental conditions, eg degrees of shade, density of sowing, supply of nutrients
- investigating particulate levels, eg with the use of sensors to measure environmental conditions
- the use of maximum–minimum thermometers, rainfall gauges and oxygen meters
- investigating the effect of phosphate on oxygen levels in water using jars with algae, water and varying numbers of drops of phosphate, then monitor oxygen using a meter
- computer simulations to model the effect on organisms of changes to the environment.

B1.5 Energy and biomass in food chains

By observing the numbers and sizes of the organisms in food chains we can find out what happens to energy and biomass as it passes along the food chain.

Candidates should use their skills, knowledge and understanding to:

- interpret pyramids of biomass and construct them from appropriate information.

Additional guidance:

An understanding of pyramids of number is **not** required.

B1.5.1 Energy in biomass

a) Radiation from the Sun is the source of energy for most communities of living organisms. Green plants and algae absorb a small amount of the light that reaches them. The transfer from light energy to chemical energy occurs during photosynthesis. This energy is stored in the substances that make up the cells of the plants.

b) The mass of living material (biomass) at each stage in a food chain is less than it was at the previous stage. The biomass at each stage can be drawn to scale and shown as a pyramid of biomass.

Additional guidance:

Construction of food webs and chains, and of pyramids of numbers, is **not** required.

c) The amounts of material and energy contained in the biomass of organisms is reduced at each successive stage in a food chain because:

- some materials and energy are always lost in the organisms' waste materials
- respiration supplies all the energy needs for living processes, including movement. Much of this energy is eventually transferred to the surroundings.

B1.6 Waste materials from plants and animals

Many trees shed their leaves each year and most animals produce droppings at least once a day. All plants and animals eventually die. Microorganisms play an important part in decomposing this material so that it can be used again by plants. The same material is recycled over and over again and can lead to stable communities.

Candidates should use their skills, knowledge and understanding to:

- evaluate the necessity and effectiveness of schemes for recycling organic kitchen or garden waste.

B1.6.1 Decay processes

a) Living things remove materials from the environment for growth and other processes. These materials are returned to the environment either in waste materials or when living things die and decay.

b) Materials decay because they are broken down (digested) by microorganisms. Microorganisms are more active and digest materials faster in warm, moist, aerobic conditions.

c) The decay process releases substances that plants need to grow.

d) In a stable community, the processes that remove materials are balanced by processes that return materials. The materials are constantly cycled.

B1.6.2 The carbon cycle

a) The constant cycling of carbon is called the carbon cycle.

In the carbon cycle:

- carbon dioxide is removed from the environment by green plants and algae for photosynthesis
- the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the body of plants and algae
- when green plants and algae respire, some of this carbon becomes carbon dioxide and is released into the atmosphere
- when green plants and algae are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins that make up their bodies
- when animals respire some of this carbon becomes carbon dioxide and is released into the atmosphere
- when plants, algae and animals die, some animals and microorganisms feed on their bodies
- carbon is released into the atmosphere as carbon dioxide when these organisms respire
- by the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally absorbed by green plants and algae has been transferred
- combustion of wood and fossil fuels releases carbon dioxide into the atmosphere.

Suggested ideas for practical work to develop skills and understanding include the following:

- design and carry out an investigation to measure the rate of decay of bread by, for example, exposing cubes of bread to air before placing them in sealed Petri dishes at different temperatures and/or different moisture levels
- investigate the rates of decay using containers (eg thermos flasks) full of grass clippings, one with disinfectant, one with dry grass, one with wet grass and one with a composting agent. If the container is sealed, a thermometer or temperature probe can be placed through a cotton wool plug to monitor the temperature
- potato decay competition, using fresh potatoes. Candidates decide on the environmental conditions and the rate of decay is measured over a 2 week period
- role play exercise – A4 sheets labelled with different stages of the carbon cycle. Candidates arrange themselves in the correct order to pass a ball along labelled as carbon
- using a sensor and data logger to investigate carbon dioxide levels during the decay process.

B1.7 Genetic variation and its control

There are not only differences between different species of plants and animals but also between individuals of the same species. These differences are due partly to the information in the cells they have inherited from their parents and partly to the different environments in which the individuals live and grow. Asexual reproduction can be used to produce individuals that are genetically identical to their parent. Scientists can now add, remove or change genes to produce the plants and animals they want.

Candidates should use their skills, knowledge and understanding to:

- interpret information about cloning techniques and genetic engineering techniques

Additional guidance:

Candidates will be given data to work from.

- make informed judgements about the economic, social and ethical issues concerning cloning and genetic engineering, including genetically modified (GM) crops.

B1.7.1 Why organisms are different

Additional guidance:

Candidates should understand that genes operate at a molecular level to develop characteristics that can be seen.

a) The information that results in plants and animals having similar characteristics to their parents is carried by genes, which are passed on in the sex cells (gametes) from which the offspring develop.

b) The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body.

c) Different genes control the development of different characteristics of an organism.

d) Differences in the characteristics of different individuals of the same kind may be due to differences in:

- the genes they have inherited (genetic causes)
- the conditions in which they have developed (environmental causes)
- or a combination of both.

Suggested ideas for practical work to develop skills and understanding include the following:

- look at variation in leaf length or width, pod length, height. Compare plants growing in different conditions – sun/shade.

B1.7.2 Reproduction

a) There are two forms of reproduction:

- sexual reproduction – the joining (fusion) of male and female gametes. The mixture of the genetic information from two parents leads to variety in the offspring
- asexual reproduction – no fusion of gametes and only one individual is needed as the parent. There is no mixing of genetic information and so no genetic variation in the offspring. These genetically identical individuals are known as clones.

b) New plants can be produced quickly and cheaply by taking cuttings from older plants. These new plants are genetically identical to the parent plant.

c) Modern cloning techniques include:

- tissue culture – using small groups of cells from part of a plant
- embryo transplants – splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers
- adult cell cloning – the nucleus is removed from an unfertilised egg cell. The nucleus from an adult body cell, eg a skin cell, is then inserted into the egg cell. An electric shock then causes the egg cell to begin to divide to form embryo cells. 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.

d) In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' using enzymes and transferred to cells of other organisms.

e) Genes can also be transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.

- new genes can be transferred to crop plants
- crops that have had their genes modified in this way are called genetically modified crops (GM crops)
- examples of genetically modified crops include ones that are resistant to insect attack or to herbicides
- genetically modified crops generally show increased yields.

f) Concerns about GM crops include the effect on populations of wild flowers and insects, and uncertainty about the effects of eating GM crops on human health.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigate the optimum conditions for the growth of cuttings, of, eg Mexican hat plants, spider plants, African violets
- investigate the best technique for growing new plants from tissue cultures (eg cauliflower).

B1.8 Evolution

Particular genes or accidental changes in the genes of plants or animals may give them characteristics which enable them to survive better. Over time this may result in entirely new species. There are different theories of evolution. Darwin's theory is the most widely accepted.

Candidates should use their skills, knowledge and understanding to:

- interpret evidence relating to evolutionary theory

Additional guidance:

Candidates will be given data to work from.

- suggest reasons why Darwin's theory of natural selection was only gradually accepted
- identify the differences between Darwin's theory of evolution and conflicting theories, such as that of Lamarck
- suggest reasons for the different theories.

Additional guidance:

Scientists may produce different hypotheses to explain similar observations. It is only when these hypotheses are investigated that data will support or refute hypotheses.

B1.8.1 Evolution

a) Darwin's theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago.

Additional guidance:

A study of creationism is **not** required.

b) The theory of evolution by natural selection was only gradually accepted because:

- the theory challenged the idea that God made all the animals and plants that live on Earth
- there was insufficient evidence at the time the theory was published to convince many scientists
- the mechanism of inheritance and variation was not known until 50 years after the theory was published.

c) Other theories, including that of 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.

Additional guidance:

Candidates should understand how evolutionary trees (models) are used to represent the relationships between organisms.

d) Studying the similarities and differences between organisms allows us to classify living organisms into animals, plants and microorganisms, and helps us to understand evolutionary and ecological relationships. Models allow us to suggest relationships between organisms.

e) Evolution occurs via natural selection:

- individual organisms within a particular species may show a wide range of variation because of differences in their genes
- individuals with characteristics most suited to the environment are more likely to survive to breed successfully
- the genes that have enabled these individuals to survive are then passed on to the next generation.

Candidates should develop an understanding of the timescales involved in evolution.

f) Where new forms of a gene result from mutation there may be relatively rapid change in a species if the environment changes.