B10 Part 1 – Human Nervous System

Homeostasis

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.

The Nervous System

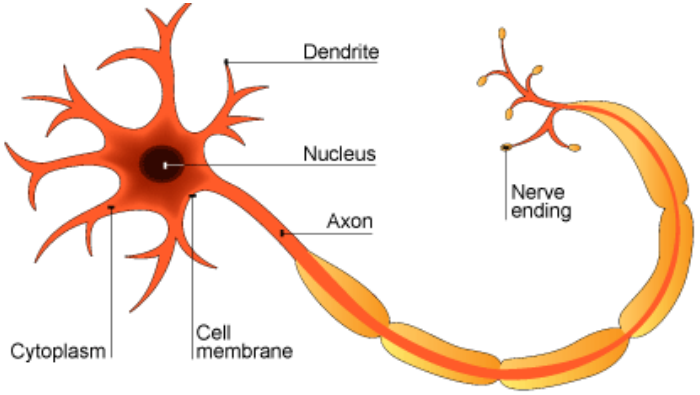
The nervous system enables humans to react to their surroundings and to coordinate their behaviour. Cells called receptors detect stimuli (changes in the environment). Information from receptors passes along cells (neurones) as electrical impulses to the central nervous system (CNS). The CNS is the brain and spinal cord. The CNS coordinates the response of effectors which may be muscles contracting or glands secreting hormones.

stimulus → receptor → coordinator → effector → response

Neurones

Neurones are nerve cells. They carry information as tiny electrical signals. There are three different types of neurones, each with a slightly different function:

1. sensory neurones carry signals from receptors to the spinal cord and brain.
2. relay neurones carry messages from one part of the CNS to another.
3. motor neurones carry signals from the CNS to effectors.



The axon is surrounded by a fatty layer known as the myelin sheath. This helps to protect the neurone and allow impulses to travel faster.

Synapses

Where two neurones meet, there is a tiny gap called a synapse. Signals cross this gap using chemicals released by a neurone. The chemical diffuses across the gap makes the next neurone transmit an electrical signal.

1. An electrical impulse travels along an axon.
2. This triggers the nerve-ending of a neuron to release chemical messengers called neurotransmitters.
3. These chemicals diffuse across the synapse (the gap) and bind with receptor molecules on the membrane of the next neuron.
4. The receptor molecules on the second neuron bind only to the specific chemicals released from the first neuron. This stimulates the second neuron to transmit the electrical impulse

Reflex actions

When a receptor is stimulated, it **sends a signal to the central nervous system**, where the brain co-ordinates the response. But sometimes **a very quick response is needed**, one that does not need the involvement of the brain. This is a reflex action.

Reflex actions are rapid and happen without us thinking. For example, you would pull your hand away from a hot flame without thinking about it.

This is what happens:

1.receptor detects a stimulus - change in the environment

2.sensory neurone sends signal to relay neurone

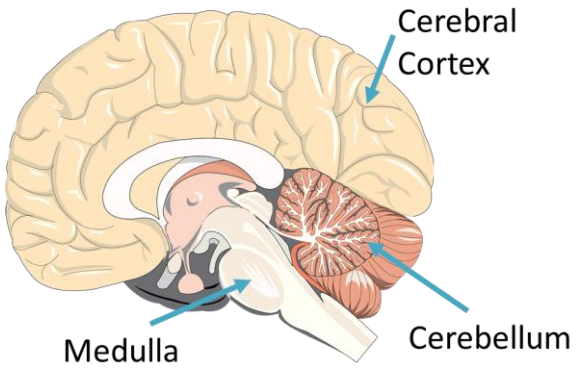
3.motor neurone sends signal to effector

4.effector produces a response

B10 Part 2 – Human Nervous System

The Brain

The brain controls complex behaviour. It is made of billions of interconnected neurones and has different regions that carry out different functions.



- The cerebral cortex which controls memory, personality, intelligence and conscious thought
- The cerebellum which controls balance and co-ordination of movement
- The medulla which controls heart rate and breathing rate

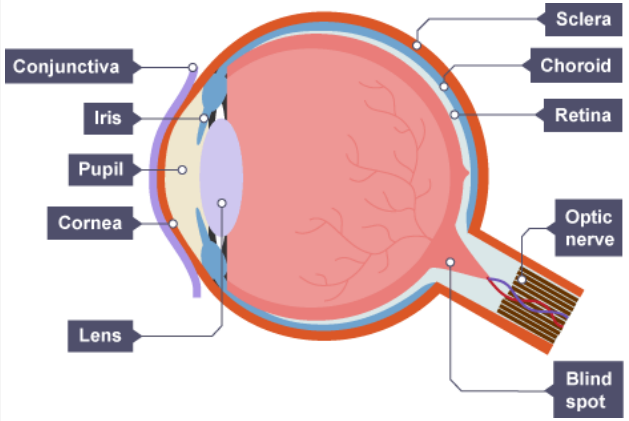
Studying the Brain

Neuroscientists have been able to map the regions of the brain to particular functions by studying patients with brain damage, electrically stimulating different parts of the brain and using MRI scanning techniques. The complexity and delicacy of the brain makes investigating and treating brain disorders very difficult. The brain is very complex and even simple processes such as eating involve neurones in lots of different areas of the brain. The brain can be very difficult to treat because surgery is very difficult and it is not fully understood what each area of the brain does, so it is easy to cause unintended damage. Drugs do not always reach the brain through the membranes that are around it.

The Eye

The eye is a sense organ containing receptors sensitive to light intensity and colour.

Part	Description	Function
Cornea	Front part of the tough outer coat, the sclera. It is convex and transparent.	refracts light into the eye.
Iris	Pigmented - decides the colour of your eyes - Its muscles contract and relax to alter the size of its central hole or pupil.	controls how much light enters the pupil
Lens	Transparent, bi-convex, flexible disc attached by the suspensory ligaments to the ciliary muscles.	focuses light onto the retina
Retina	The lining of the back of eye containing two types of photoreceptor cells - rods - sensitive to dim light and black and white - and cones - sensitive to colour.	contains the light receptors
Optic nerve	Bundle of sensory neurones at back of eye.	carries impulses from the eye to the brain



Accommodation

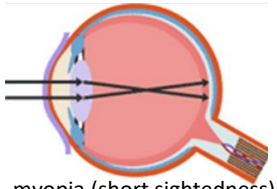
Accommodation is the process of changing the shape of the lens to focus on near or distant objects.

To focus on a near object:
- the ciliary muscles contract
- the suspensory ligaments loosen
- the lens is then thicker and refracts light rays strongly.

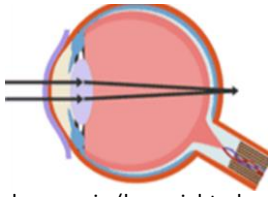
To focus on a distant object:
- the ciliary muscles relax
- the suspensory ligaments are pulled tight
- the lens is then pulled thin and slightly refracts light rays.

Problems with the eye

Two common defects of the eyes are myopia (short sightedness) and hyperopia (long sightedness) in which rays of light do not focus on the retina.

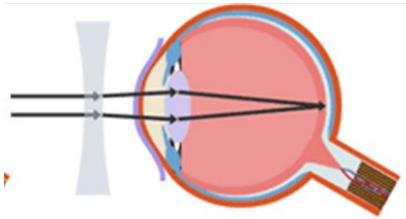


myopia (short sightedness)

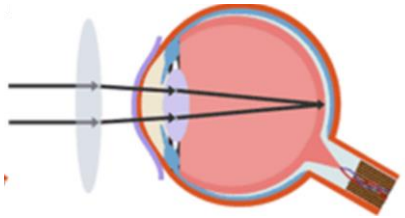


hyperopia (long sightedness)

Generally these defects are treated with spectacle lenses which refract the light rays so that they do focus on the retina.



Concave lens corrects myopia.



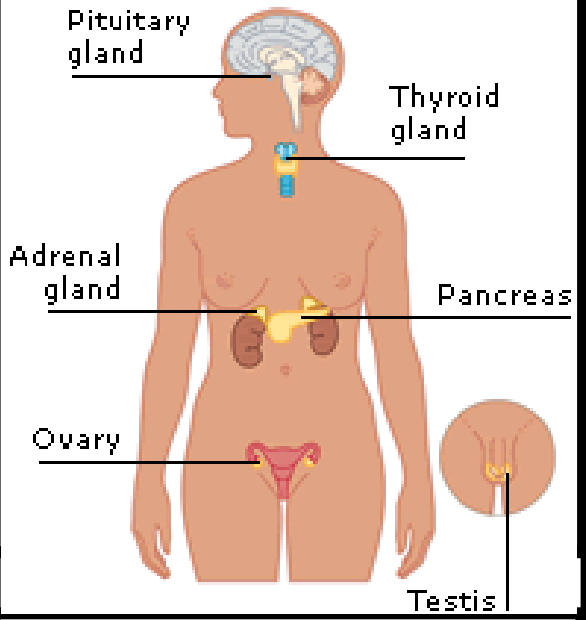
Convex lens corrects hyperopia.

- New technologies now include hard and soft contact lenses, laser surgery to change the shape of the cornea and a replacement lens in the eye.

B11 Hormonal Coordination

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.



Blood Glucose Levels

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. 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.

The Pituitary gland

The pituitary gland in the brain is a 'master gland' which secretes several hormones into the blood in response to body conditions.

Gland - Hormone	Effect
Adrenal gland - adrenalin	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'.
Thyroid gland – thyroxine	Stimulates the basal metabolic rate. It plays an important role in growth and development.
Ovary - oestrogen	Controls puberty and the menstrual cycle in females; stimulates production of LH and suppresses the production of FSH in the pituitary gland.
Ovary - progesterone	Maintains the lining of the womb - suppresses FSH production in the pituitary gland.
Pancreas - insulin	Controls blood sugar levels.
Pituitary gland - anti-diuretic hormone	(ADH) Controls blood water level by triggering uptake of water in kidneys.
Pituitary gland - follicle stimulating hormone	(FSH) Triggers egg ripening and oestrogen production in ovaries.
pituitary gland - luteinising hormone	(LH) Triggers egg release and progesterone production in ovaries.
Testes - testosterone	Controls puberty in males.

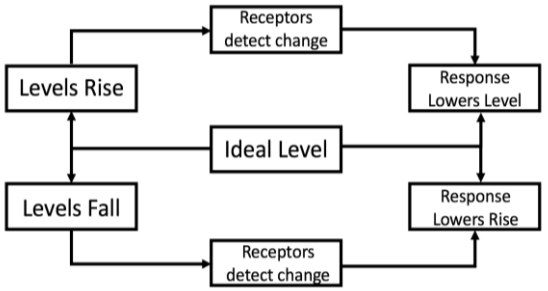
Diabetes

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. Type 1 diabetes can be treated by Injecting insulin into the blood before meals. The extra insulin causes glucose to be taken up by the liver and other tissues. Cells get the glucose they need for respiration, and the blood glucose concentration stays normal.

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. A treatment for type 2 diabetes is a carbohydrate controlled diet, regular exercise and insulin infections if this fails to work.

Negative Feedback

Negative feedback systems work to maintain a steady state. An important example of a **negative feedback loop** is seen in control of thyroid hormone secretion. Adrenaline however, is not controlled by negative feedback.



B11 Hormonal Coordination

Puberty

During puberty reproductive hormones cause secondary sex characteristics to develop. Testosterone is the main male reproductive hormone produced by the testes and it stimulates sperm production. The time when the physical changes and emotional changes happen is called **adolescence**.

Boys

Here are some changes that happen only to boys:
voice breaks (gets deeper)
testes and penis get bigger
testes start to produce sperm cells
shoulders get wider
hair grows on face and chest.

Girls

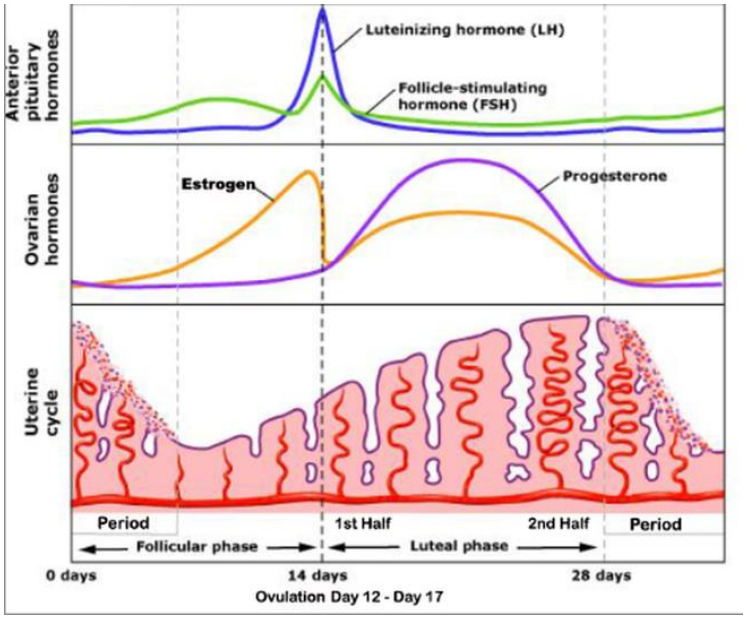
Here are some changes that happen only to girls:
breasts develop
ovaries start to release egg cells (periods start)
hips get wider.

Menstrual Cycle

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**. During days 1-7 of the menstrual cycle the uterus lining is shed and the woman has her period.

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.



Control of Fertility

Fertility can be controlled by a variety of hormonal and non-hormonal methods of contraception. These include:

- oral contraceptives that contain hormones to inhibit FSH production so that no eggs mature
- injection, implant or skin patch of slow release progesterone to inhibit the maturation and release of eggs for a number of months or years
- barrier methods such as condoms and diaphragms which prevent the sperm reaching an egg
- intrauterine devices which prevent the implantation of an embryo or release a hormone
- 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.

Fertility Treatment

FSH and LH can be used as a fertility drug to stimulate ovulation in women with low levels of FSH.

In vitro Fertilisation

- 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).

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, IVF is expensive, not always free on the NHS and it can lead to multiple births which are a risk to both the babies and the mother.

Some religious groups disagree with IVF as embryos are destroyed during the process and they believe that life begins at conception.

B12 – Homeostasis in Action

Control of Body Temperature

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).

Maintaining water balance

Water leaves the body via the lungs during exhalation. Water, ions and urea are lost from the skin in sweat. There is no control over water, ion or urea loss by the lungs or skin. Excess water, ions and urea are removed via the kidneys in the urine. If body cells lose or gain too much water by osmosis they do not function efficiently.

Anti-Diuretic Hormone

The water level in the body is controlled by the hormone ADH which acts on the kidney tubules. ADH is released by the pituitary gland when the blood is too concentrated and it causes more water to be reabsorbed back into the blood from the kidney tubules. This is controlled by negative feedback.

Ammonia

The digestion of proteins from the diet results in excess amino acids which need to be excreted safely. In the liver these amino acids are deaminated to form ammonia. Ammonia is toxic and so it is immediately converted to urea for safe excretion.

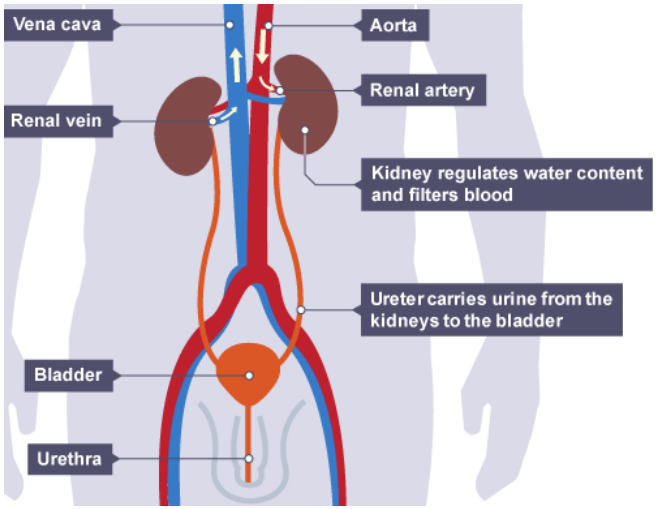
The Kidneys

The kidneys produce urine by filtration of the blood and selective reabsorption of useful substances such as glucose, some ions and water.

The inner part of the kidney is called the medulla and the outer part is the cortex. The renal arteries take blood with waste products to the kidneys to be filtered. Renal veins then return the filtered blood to be circulated around the body. Blood vessels take the blood though the kidneys where the waste products are removed into tubules. The ureter carries urine from the kidney to the bladder. Blood is filtered at high pressure to remove glucose, water, salts and urea. All the glucose, and some water and salts, are reabsorbed back into the blood. Note that urea is not reabsorbed. Urine is then passed from the bladder to the urethra to be released.

Kidney Dialysis

Kidney failure has serious consequences as it means that the water and ion balance cannot be regulated, and the levels of toxic urea build up in the body. This would ultimately be fatal if not treated. One method of treatment is kidney dialysis. In this procedure, patients are connected to a dialysis machine which acts as an artificial kidney to remove most of the urea and restore/maintain the water and ion balance of the blood. 'Dirty' blood (high in urea) is taken from a blood vessel in the arm, mixed with blood thinners to prevent clotting, and pumped into the machine. Inside the machine - separated by a partially permeable membrane the blood flows in the opposite direction to dialysis fluid, allowing exchange to occur between the two where a concentration gradient exists.



Kidney Transplants

Kidney transplantation is an alternative method for treating kidney failure. This procedure involves implanting a kidney from an organ *donor* into the patient's body to replace the damaged kidney. Two precautions can be taken to reduce organ rejection; Tissue typing and patients taking Immuno-suppressant drugs

Plant Hormones

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.

Uses of Plant Hormones

Plant growth hormones are used in agriculture and horticulture. Auxins are used as weed killers, as rooting powders and for promoting growth in tissue culture. Ethene is used in the food industry to control ripening of fruit during storage and transport. Gibberellins can be used to; end seed dormancy, promote flowering and increase fruit size.

B13 Part 1 - Reproduction

Sexual and Asexual Reproduction

Sexual reproduction involves the joining (fusion) of male and female 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.

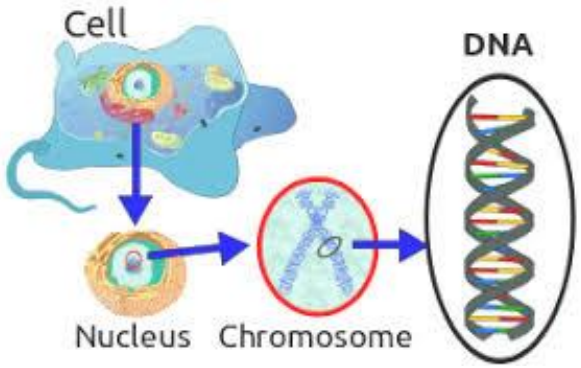
Meiosis

Meiosis leads to non-identical cells being formed while mitosis leads to identical cells being formed. In meiosis the number of chromosomes in gametes halves 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.

DNA

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

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.

By studying the human genome we can:

- search for genes linked to different types of disease
- understand and treat inherited disorders
- trace human migration patterns from the past.

Inherited Disorders

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.

Inheritance

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.

Sex Determination

Ordinary human body cells contain 23 pairs of chromosomes. 22 pairs control characteristics only, but one of the pairs carries the genes that determine sex.

- In females the sex chromosomes are XX.
- In males the chromosomes are different (XY).

For your exam you need to be able to construct a Punnett square diagram and use it to calculate the probability of a child inheriting a disorder or being male or female.

Embryo Screening

Embryos can be screened for the alleles that cause polydactyly, cystic fibrosis and other genetic disorders. Note that you do not need to know or understand how embryo screening works for the examination. But you do need to know the risks associated with embryo screening.

B13 Part 2 - Reproduction

Advantages of sexual reproduction:
- produces variation in the offspring
- if the environment changes variation gives a survival advantage by natural selection
- natural selection can be speeded up by humans in selective breeding to increase food production.

Advantages of asexual reproduction:
- only one parent needed
- more time and energy efficient as do not need to find a mate
- faster than sexual reproduction
- many identical offspring can be produced when conditions are favourable.

Reproduction in Plants, fungi and parasites

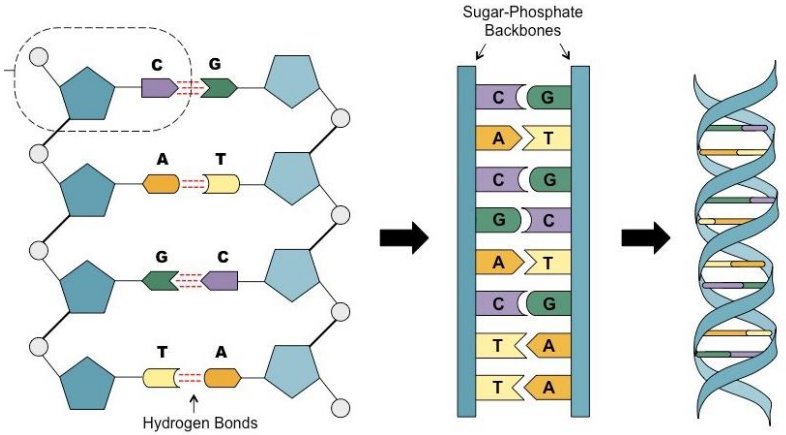
Some organisms reproduce by both methods depending on the circumstances.
- Malarial parasites reproduce asexually in the human host, but sexually in the mosquito.
- Many fungi reproduce asexually by spores but also reproduce sexually to give variation.
- Many plants produce seeds sexually, but also reproduce asexually by runners such as strawberry plants, or bulb division such as daffodils.

Mutation

A change in DNA structure may result in a change in the protein synthesised by a gene. Mutations occur continuously. Most do not alter the protein, or only alter it slightly so that its appearance or function is not changed. A few mutations code for an altered protein with a different shape. An enzyme may no longer fit the substrate binding site or a structural protein may lose its strength. Not all parts of DNA code for proteins. Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.

DNA Structure

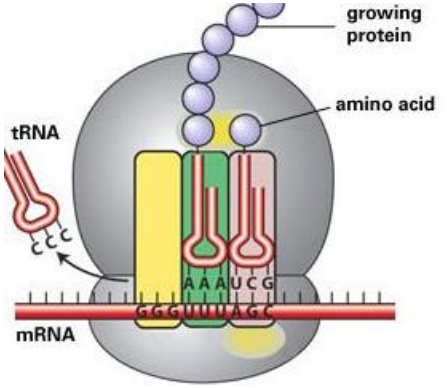
DNA as a polymer made from four different nucleotides. Each nucleotide consists of a common sugar and phosphate group with one of four different bases attached to the sugar. DNA contains four bases, A, C, G and T. A sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein. The long strands of DNA consist of alternating sugar and phosphate sections. Attached to each sugar is one of the four bases. The DNA polymer is made up of repeating nucleotide units. In the complementary strands a C is always linked to a G on the opposite strand and a T to an A. You do not need to know the names of A, T, G and C.



The repeating units are wound into a double helix shape.

Protein Synthesis

Proteins are synthesised on ribosomes, according to a template. Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order. When the protein chain is complete it folds up to form a unique shape. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen. You are not expected to know or understand the structure of mRNA, tRNA, or the detailed structure of amino acids or proteins.



B14: Variation and Evolution

Variation

Differences in the characteristics of individuals in a population is called variation and may be due to differences in:

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

There is usually extensive genetic variation within a population of a species. All variants arise from mutations and most have no effect on the phenotype. Some influence phenotype and very few determine phenotype. Mutations occur continuously. Very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Evolution

Evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species. The theory of evolution by natural selection states that all species of living things have evolved from simple life forms (single cell organisms) that first developed more than three billion years ago.

Natural selection

The theory of evolution states that evolution happens by natural selection. Here are the key points:

- Individuals in a species show a wide range of variation.
- This variation is because of differences in genes.
- Individuals with characteristics most suited to the environment are more likely to survive and reproduce.
- The genes that allowed the individuals to be successful are passed to the offspring in the next generation.

Selective Breeding

Selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics. Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals. Selective breeding involves choosing parents with the desired characteristic from a mixed population. They are bred together. From the offspring those with the desired characteristic are bred together. This continues over many generations until all the offspring show the desired characteristic.

The characteristic can be chosen for usefulness or appearance:

- Disease resistance in food crops.
- Animals which produce more meat or milk.
- Domestic dogs with a gentle nature.
- Large or unusual flowers.

Selective breeding can lead to 'inbreeding' where some breeds are particularly prone to disease or inherited defects.

Speciation

A species is a group of organisms that reproduce to produce fertile offspring. If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species. For example, a horse and a donkey both evolved from a common ancestor to become two separate species.

Genetic Engineering

Genetic engineering is a process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic. In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms.

Plant crops have been genetically engineered to be resistant to diseases or to produce bigger better fruits. 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. Bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.

In genetic engineering:

- enzymes are used to isolate the required gene; this gene is inserted into a vector, usually a bacterial plasmid or a virus
- the vector is used to insert the gene into the required cells
- genes are transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.

Cloning

There are 4 methods of cloning.

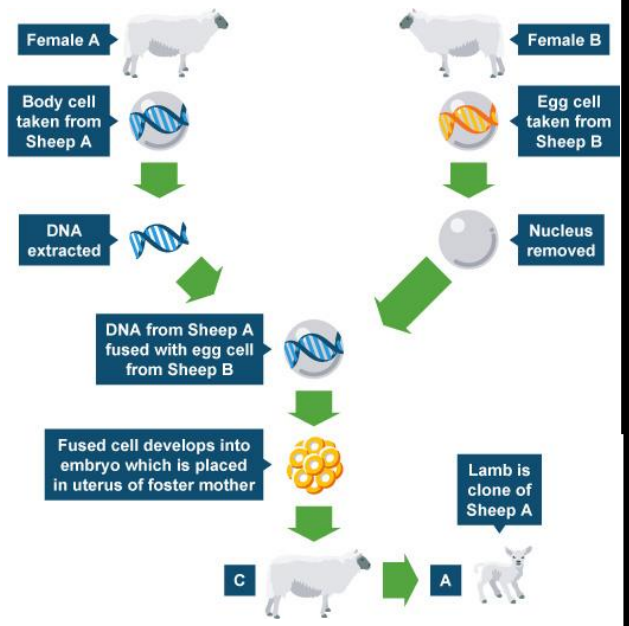
Tissue culture: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.

Cuttings: an older, but simple, method used by gardeners to produce many identical new plants from a parent 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, such as a skin cell, is inserted into the egg cell.
- An electric shock stimulates the egg cell to divide to form an embryo.
- These embryo cells contain the same genetic information as the adult skin cell.
- When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.



Theory of Evolution - Darwin

Charles Darwin, as a result of observations on a round the world expedition, backed by years of experimentation and discussion and linked to developing knowledge of geology and fossils, proposed the theory of evolution by natural selection.

- Individual organisms within a particular species show a wide range of variation for a characteristic.
- Individuals with characteristics most suited to the environment are more likely to survive to breed successfully.
- The characteristics that have enabled these individuals to survive are then passed on to the next generation.

Darwin published his ideas in On the Origin of Species (1859). There was much controversy surrounding these revolutionary new ideas. 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 (DNA) and variation was not known until 50 years after the theory was published.

Jean-Baptiste Lamarck, theorised 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.

Wallace

Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published joint writings with Darwin in 1858 which prompted Darwin to publish On the Origin of Species (1859) the following year. Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on warning colouration in animals and his theory of speciation. Alfred Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of speciation.

Mendel

In the mid-19th century Gregor Mendel carried out breeding experiments on plants. One of his observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged.

In the late 19th century behaviour of chromosomes during cell division was observed.

In the early 20th century it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units', now called genes, were located on chromosomes.

In the mid-20th century the structure of DNA was determined and the mechanism of gene function worked out. This scientific work by many scientists led to the gene theory being developed.

The importance of Mendel's discovery was not recognised until after his death.

B15: Genetics and Evolution

The theory of evolution

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.

Extinction

Extinctions occur when there are no remaining individuals of a species still alive. This is caused by new diseases, climate change, urbanisation, deforestation, predators, hunting, poaching and natural disasters.

Mass extinction is when there is a permanent loss of several species in a similar time frame. For example when the dinosaurs became extinct. Extinction on a large scale is caused by changes to the environment and catastrophic events such as massive volcanic eruptions or collisions with asteroids.

Fossils

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.

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.

We can learn from fossils how much or how little different organisms have changed as life developed on Earth.

Resistant Bacteria

Bacteria can evolve rapidly because they reproduce at a fast rate. Mutations of bacterial pathogens produce new strains. Some strains might be resistant to antibiotics, and so are not killed. They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment.

MRSA (recent superbug out break) is resistant to antibiotics.

To reduce the rate of development of antibiotic resistant strains:

- doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections
- patients should complete their course of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted. The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.

Classification

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.

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).

The Importance of Communities

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.

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.

Adaptations

Organisms have features (adaptations) that enable them to survive in the conditions in which they normally live. These adaptations may be structural, behavioural or functional.

Structural: Shape or colour of organism. For example camouflage.

Behavioural: Migration to move to an area of better climate.

Functional: Related to processes such as reproduction and metabolism. For example camels produce urine with a small percentage of water.

Abiotic (non-living) factors

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.

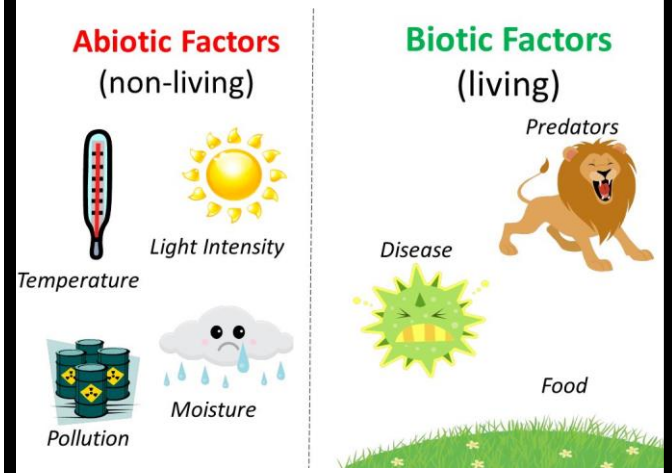
Biotic (living) factors

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.

Extremophiles

Some organisms live in environments that are very extreme, such as at high temperature, pressure, or salt concentration. These organisms are called extremophiles. Bacteria living in deep sea vents are extremophiles.



B17: Organising an Ecosystem

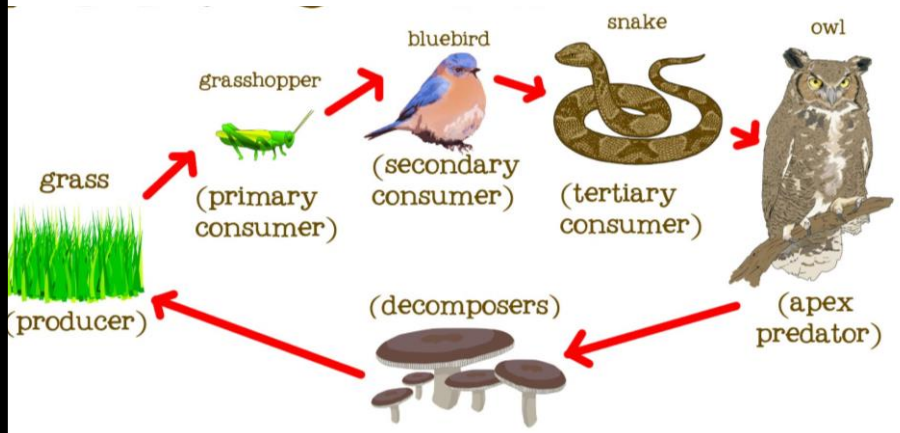
Ecosystems

An ecosystem is a community of animals, plants and micro-organisms, together with the habitat where they live. A habitat a place where plants and animals live. A population is all the members of a single species that live in a habitat. An environment is all the conditions that surround any living organism - both the other living things and the non-living things or physical surroundings. Photosynthetic organisms are the producers of biomass for life on Earth. A range of experimental methods using transects and quadrats are used by ecologists to determine the distribution and abundance of species in an ecosystem. Environment - all the conditions that surround any living organism - both the other living things and the non-living things or physical surroundings.

Feeding Relationships

Feeding relationships within a community can be represented by food chains. All food chains begin with a producer which synthesises new molecules. On land this is usually a green plant that makes glucose by photosynthesis.

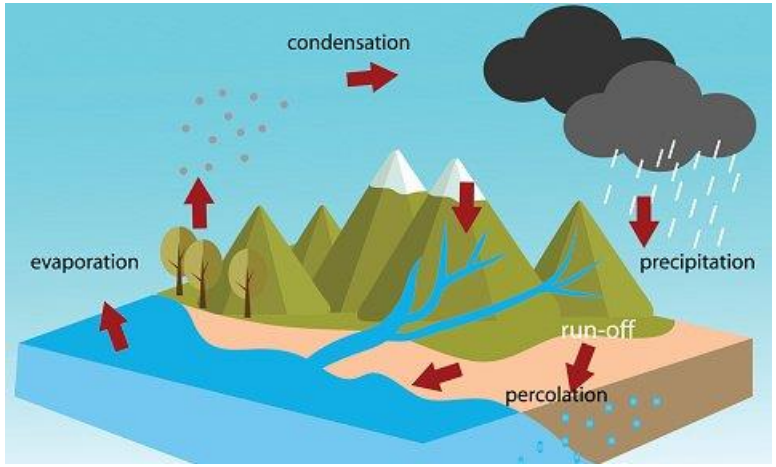
Producers are eaten by primary consumers, which in turn may be eaten by secondary consumers and then tertiary consumers. Consumers that kill and eat other animals are predators, and those eaten are prey. In a stable community the numbers of predators and prey rise and fall in cycles.



Recycling Materials

Recall that many different materials cycle through the abiotic and biotic components of an ecosystem. All materials in the living world are recycled to provide the building blocks for future organisms.

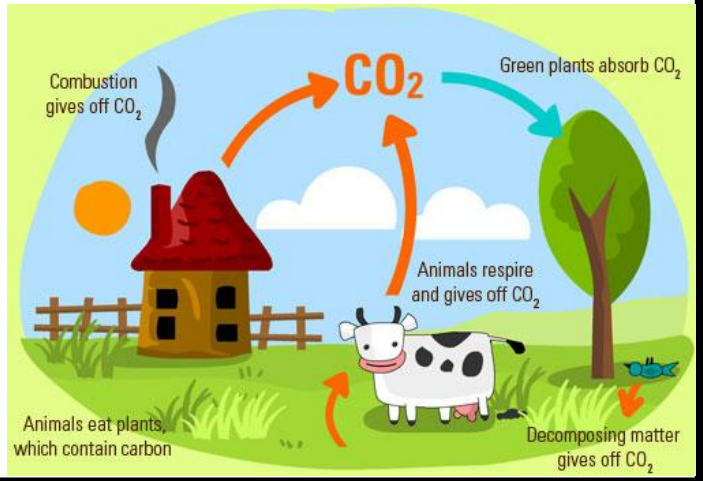
The **water cycle** provides fresh water for plants and animals on land before draining into the seas. Water is continuously evaporated and precipitated.



The main stages of the water cycle are: condensation, precipitation, evaporation, transpiration and respiration.

The **carbon cycle** returns carbon from organisms to the atmosphere as carbon dioxide to be used by plants in photosynthesis. The decay of dead plants and animals by microorganisms returns carbon to the atmosphere as carbon dioxide.

The main stages of the carbon cycle are: burning of fossil fuels, feeding on plant life, death of plants and animals, respiration, photosynthesis.



B18: Biodiversity and Ecosystems

Biodiversity

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. 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.

Waste Management

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. 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.

Land Use

Humans reduce the amount of land available for other animals and plants by building, quarrying, farming and dumping waste. The destruction of peat bogs, and other areas of peat to produce garden compost, reduces the area of this habitat and thus the variety of different plant, animal and microorganism species that live there (biodiversity). The decay or burning of the peat releases carbon dioxide into the atmosphere.

Maintaining 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.

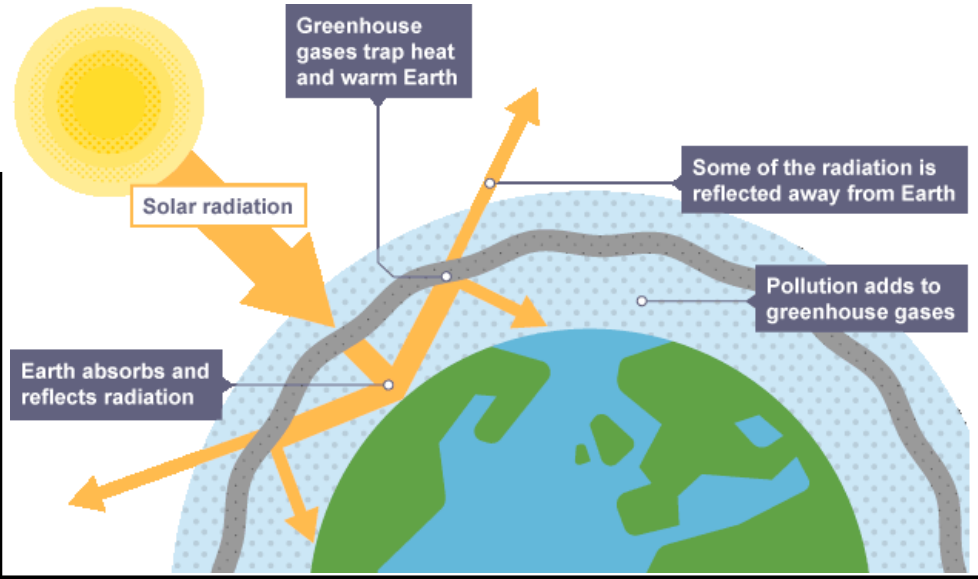
Deforestation

Large-scale deforestation in tropical areas has occurred to:

- provide land for cattle and rice fields
- grow crops for biofuels.

Global Warming

Levels of carbon dioxide and methane in the atmosphere are increasing, and contribute to 'global warming'.



B18: Biodiversity and Ecosystems

Trophic levels

Trophic levels can be represented by numbers, starting at level 1 with plants and algae. Further trophic levels are numbered subsequently according to how far the organism is along the food chain.

Level 1: Plants and algae make their own food and are called producers.

Level 2: Herbivores eat plants/algae and are called primary consumers.

Level 3: Carnivores that eat herbivores are called secondary consumers.

Level 4: Carnivores that eat other carnivores are called tertiary consumers. Apex predators are carnivores with no predators. Decomposers break down dead plant and animal matter by secreting enzymes into the environment. Small soluble food molecules then diffuse into the microorganism.

Food Security

Food security is having enough food to feed a population. Biological factors which are threatening food security include:

- the increasing birth rate has threatened food security in some countries
- changing diets in developed countries means scarce food resources are transported around the world
- new pests and pathogens that affect farming
- environmental changes that affect food production, such as widespread famine occurring in some countries if rains fail
- the cost of agricultural inputs
- conflicts that have arisen in some parts of the world which affect the availability of water or food. Sustainable methods must be found to feed all people on Earth.

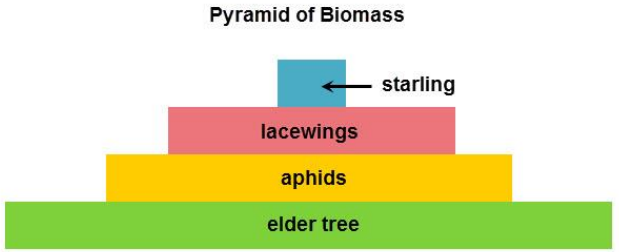
Farming Techniques

The efficiency of food production can be improved by restricting energy transfer from food animals to the environment. This can be done by limiting their movement and by controlling the temperature of their surroundings. Some animals are fed high protein foods to increase growth.

Pyramids of Biomass

Pyramids of biomass can be constructed to represent the relative amount of biomass in each level of a food chain. Trophic level 1 is at the bottom of the pyramid. Producers are mostly plants and algae which transfer about 1% of the incident energy from light for photosynthesis. Only approximately 10% of the biomass from each trophic level is transferred to the level above it. Losses of biomass are due to:

- not all the ingested material is absorbed, some is egested as faeces
- some absorbed material is lost as waste, such as carbon dioxide and water in respiration and water and urea in urine. Large amounts of glucose are used in respiration.



Sustainable Fisheries

Fish stocks in the oceans are declining. It is important to maintain fish stocks at a level where breeding continues or certain species may disappear altogether in some areas. Control of net size and the introduction of fishing quotas play important roles in conservation of fish stocks at a sustainable level.

Role of Biotechnology

Modern biotechnology techniques enable large quantities of microorganisms to be cultured for food. The fungus Fusarium is useful for producing mycoprotein, a protein-rich food suitable for vegetarians. The fungus is grown on glucose syrup, in aerobic conditions, and the biomass is harvested and purified. A genetically modified bacterium produces human insulin. When harvested and purified this is used to treat people with diabetes. GM crops could provide more food or food with an improved nutritional value such as golden rice.

Decomposition

Gardeners and farmers try to provide optimum conditions for rapid decay of waste biological material. The compost produced is used as a natural fertiliser for growing garden plants or crops. Anaerobic decay produces methane gas. Biogas generators can be used to produce methane gas as a fuel.