Cell Structure and Transport: Biology Specification

Cell Structures

Plant and animal cells (eukaryotic cells) have a cell membrane, cytoplasm and genetic material enclosed in a nucleus. Bacterial cells (prokaryotic cells) are much smaller in comparison. They have cytoplasm and a cell membrane surrounded by a cell wall. The genetic material is not enclosed in a nucleus. It is a single DNA loop and there may be one or more small rings of DNA called plasmids. Most animal cells have the following parts: nucleus, cytoplasm, a cell membrane, mitochondria, ribosomes. In addition to the parts found in animal cells, plant cells often have: chloroplasts, a permanent vacuole filled with cell sap. Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell.

Part	Function
Nucleus	Contains genetic material, which controls the activities of the cell
Cytoplasm	Most chemical processes take place here, controlled by enzymes
Cell membrane	Controls the movement of substances into and out of the cell
Mitochondria	Most energy is released by respiration here
Ribosomes	Protein synthesis happens here
Cell wall	Strengthens the cell
Chloroplasts	Contain chlorophyll, which absorbs light energy for photosynthesis
Permanent vacuole	Filled with cell sap to help keep the cell *turgid*

As an organism develops, cells differentiate to form different types of cells. Most types of animal cell differentiate at an early stage. Many types of plant cells retain the ability to differentiate throughout life. In mature animals, cell division is mainly restricted to repair and replacement. As a cell differentiates it acquires different sub-cellular structures to enable it to carry out a certain function. It has become a specialised cell.

Specialised Cells

Cells may be specialised to carry out a particular function:

Nerve Cell- Carry electrical impulses around the body of an animal for rapid communication. Have long axons to carry information. Synapses are adapted to pass impulse to another cell. Lots of dendrites to make connections with other cells. Contain lots of mitochondria to provide energy that is needed to make neurotransmitters.

Sperm Cell

Contain the genetic information of the male parent and move to reach an egg. Has an acrosome that contains enzymes for breaking through the egg. Middle section has lots of mitochondria to transfer energy needed for the tail to work. A long tail that moves from side to side to help the cell move. A large nucleus that contains genetic information. Streamlined shape.

Muscle Cell

Cells that contract and relax to bring about movement. Store glycogen that can be used in respiration. Contain lots of mitochondria to transfer energy needed for cells to contract and relax. Contain proteins that slide over each other.

Palisade Cell

A photosynthetic cell that carries out photosynthesis. Have a permanent vacuole to keep the cells rigid to keep the leaf spread out and the stem supported. Contain chloroplasts containing chlorophyll that absorb light for Found in layers in the leaf and outer layers of the stem to absorb as much light as possible. Regular shape so that cells can be closely packed together.

Root Hair Cell

Take up water and mineral ions from the soil. Have lots of mitochondria to transfer energy for active transport of mineral ions. Have a large permanent vacuole to speed up the movement of water by osmosis. Have a large surface area for water to enter the cell.

Phloem Cell

Cells that make up a tissue to transport food around the plant. The cell walls between the cells break down to form sieve plates. Have very few supporting structures. Supported by companion cells. The mitochondria of these cells provide energy to the other cell.

Xylem Cell

Cells that make up a tissue to transport water around the plant. Have spirals and rings of lignin to make them very strong. The cells die and form long hollow tubes.

Binary Fission

Bacteria multiply by simple cell division every 20 mins if they have enough nutrients and a suitable temperature. They can be grown in a nutrient broth solution or as colonies on an agar gel plate. Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.

An **electron microscope** has much higher magnification and resolving power than a **light microscope**. This means that it can be used to study cells in much finer detail. This has enabled biologists to see and understand many more sub-cellular structures. Electron microscopes are more expensive and take up more space. Light microscopes are easy to use and cheap.

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

Diffusion

Diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration. Some of the substances transported in and out of cells by diffusion are oxygen and carbon dioxide in gas exchange, and of the waste product urea from cells into the blood plasma for excretion in the kidney.

Factors which affect the rate of diffusion are:

- the difference in concentrations (concentration gradient),
- the temperature
- the surface area of the membrane.

Stem Cells: Biology Specification

Osmosis
Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.

Active transport
Active transport moves substances from a more dilute solution to a more concentrated solution (against a concentration gradient). This requires
energy from respiration. Active transport allows mineral ions to be absorbed into plant root hairs from very dilute solutions in the soil. Plants require ions for healthy growth. It also allows sugar molecules to be absorbed from lower concentrations in the gut into the blood which has a higher sugar concentration. Sugar molecules are used for cell respiration.

Surface Area to volume ratio
A single-celled organism has a relatively large surface area to volume ratio. This allows sufficient transport of molecules into and out of the cell to meet the needs of the organism.
In multicellular organisms, surfaces and organ systems are specialised
for exchanging materials. This is to allow sufficient molecules to be transported into and out of cells for the organism's needs. The effectiveness of an exchange surface is increased by:
• having a large surface area
• a membrane that is thin, to provide a short diffusion path
• having an efficient blood supply
• (in animals, for gaseous exchange) being ventilated

Stem Cells
A stem cell is an undifferentiated cell of an organism which is capable of giving rise to many more cells of the same type, and from which certain other cells can arise from differentiation. Stem cells can be found in human embryos and adult bone marrow. Stem cells from human embryos can be cloned and made to differentiate into most different types of human cells. Stem cells from adult bone marrow can form many types of cells including blood cells.

Uses of Stem Cells
Stem cells, directed to differentiate into specific cell types, offer the possibility of a renewable source of replacement cells and tissues to treat diseases including macular degeneration, paralysis, spinal cord injury, stroke, burns, heart disease, diabetes, osteoarthritis, and rheumatoid arthritis.

Therapeutic Cloning
In therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient's body so they may be used for medical treatment.

Problems with using embryonic stem cells
The use of stem cells has potential risks such as transfer of viral infection, and some people have ethical or religious objections.
Human embryonic stem cell research is ethically and politically controversial because it involves the destruction of human embryos. Many religions believe that life begins at conception and therefore disagree with the destruction of embryos.

Stem cells in plants
Meristem tissue in plants can differentiate into any type of plant cell, throughout the life of the plant. Stem cells from meristems in plants can be used to produce clones of plants quickly and economically.
- Rare species can be cloned to protect from extinction.
- Crop plants with special features such as disease resistance can be cloned to produce large numbers of identical plants for farmers.
- **Cloning** allows growers to mass produce **plants** that may be difficult to grow from seed.
- Cloning allows growers to mass produce plants that may be difficult to grow from seed.
- All the plants are genetically identical, which is useful because you can be sure of their characteristics

Information in the cells
The nucleus of a cell contains chromosomes made of DNA molecules. Each chromosome carries a large number of genes. In body cells the chromosomes are normally found in pairs.

The Cell Cycle
Cells divide in a series of stages called the cell cycle. During the cell cycle the genetic material is doubled and then divided into two identical cells. The three stages of the cell cycle are:
Stage 1:
Before a cell can divide it needs to grow and increase the number of sub-cellular structures such as ribosomes and mitochondria. The DNA replicates to form two copies of each chromosome.
Stage 2:
In mitosis one set of chromosomes is pulled to each end of the cell and the nucleus divides.
Stage 3:
Finally the cytoplasm and cell membranes divide to form two identical cells.

Organisation and the Digestive System: Biology Specification

Organisation

Cells are the basic building blocks of all living organisms. A tissue is a group of cells with a similar structure and function. Organs are aggregations of tissues performing specific functions. Organs are organised into organ systems, which work together to form organisms.

The Digestive System

The digestive system is an example of an organ system in which several organs work together to digest and absorb food. The food you take in and eat is made up of large molecules that need to be digested to form smaller, soluble molecules that can be absorbed and used by your cells. The digestive system contains many different organs.

The stomach is an organ made of muscular tissue, glandular tissue and epithelial tissue. Muscular tissue churns food and digestive juice together. Glandular tissue produces digestive juices to break down food. Epithelial tissue covers the inside and the outside of the organ. There are also glands such as the pancreas and salivary glands. The pancreas produces hormones to control blood sugar and enzymes that break down food. Saliva contains enzymes that break down food.

The small intestine is where the soluble food molecules are absorbed into the blood stream, so they can be transported round your body. The small intestine is adapted to have a very large surface area as it is covered in villi. It has a good blood supply and short diffusion distances to blood vessels.

Chemistry of Food

Carbohydrates provide us with fuel and are made up of units of sugar. Simple sugars are carbohydrates that contain only one or two sugar units. Complex carbohydrates (starch) contain long chains of simple sugar units bonded together. Lipids are an efficient energy store and consist of three molecules of fatty acids bonded to a molecule of glycerol. Proteins are required for growth and repair. Protein molecules are made up of long chains of amino acids.

Food Tests

Food	Test	Result
Carbohydrates	Iodine solution (yellow-red)	Iodine turns blue-black if starch is present.
	Benedict's solution (blue)	Benedict's solution turns red on heating if glucose is present.
Protein	Biuret Reagent (blue)	Turns purple if protein is present.
Lipids	Ethanol test	Cloudy white layer if lipid is present.

Lock and Key Model

Catalysts increase the rate of chemical reactions without changing chemically themselves. Enzymes are biological catalysts which are specific, they will only speed up one type of reaction. Enzymes are proteins. The amino acid chains are folded to form the active site, which matches the shape of a specific substrate molecule. The substrate binds to the active site and the reaction is catalysed by the enzyme. The **lock** is the enzyme and the **key** is the substrate. Only the correctly sized **key** (substrate) fits into the **key** hole (active site) of the **lock** (enzyme). **Metabolism** is the sum of all the reactions in a cell or the body.

Bile

Bile is made in the liver and stored in the gall bladder. It is alkaline to neutralise hydrochloric acid from the stomach. It also emulsifies fat to form small droplets which increases the surface area. The alkaline conditions and large surface area increase the rate of fat breakdown by lipase.

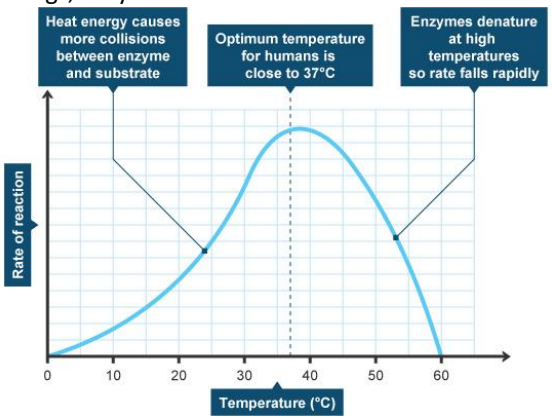
Digestive Enzymes

Digestive enzymes convert food into small soluble molecules that can be absorbed into the bloodstream. Carbohydrase break down carbohydrates to simple sugars. Amylase is a carbohydrase which breaks down starch. Proteases break down proteins to amino acids. Lipases break down lipids (fats) to glycerol and fatty acids. The products of digestion are used to build new carbohydrates, lipids and proteins. Some glucose is used in respiration.

Factors Affecting Enzyme Action

Enzymes work best at their optimum temperature. This is why homeostasis is important - to keep our body temperature at a constant 37°C. As the temperature increases, so does the rate of chemical reaction. This is because heat energy causes more collisions, with more energy, between the enzyme molecules and other molecules.

However, if the temperature gets too high, high temperatures denature the enzyme, changing the shape of the active site. So the enzyme will stop working. A common error in exams is to write that enzymes are killed at high temperatures. Since enzymes are not living things, they cannot be killed.



Organising Animals: Biology Specification

The Blood

Blood is a tissue consisting of plasma, in which the red blood cells, white blood cells and platelets are suspended. Re blood cells carry oxygen around the body. They are biconcave discs, so have an increase surface area to volume ratio for diffusion. They have no nucleus to fit more haemoglobin in, haemoglobin binds to oxygen to transport it from the lungs. White blood cells are larger and form part of the body's defence system. Platelets are tiny cell fragments without a nucleus whose function is to stop bleeding by clumping and clotting blood vessel injuries.

Blood Vessels

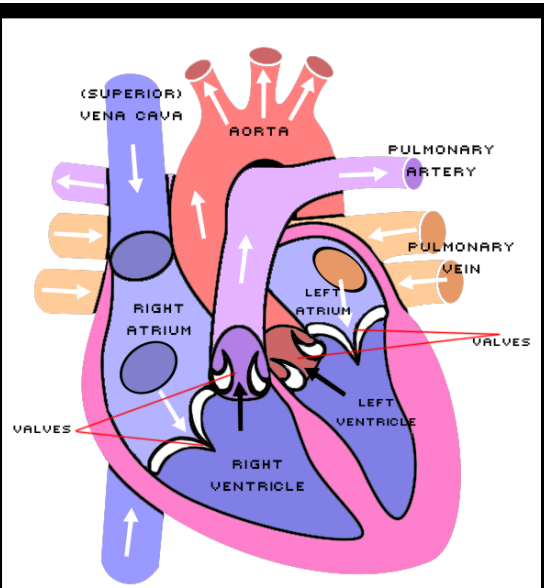
The body contains three different types of blood vessel: arteries, veins and capillaries. Arteries carry oxygenated blood away from your heart. Arteries have thick walls and elastic fibres. The veins carry deoxygenated heart away from your organs. They have thinner walls than arteries and valves that prevent the backflow of blood. Capillaries allow substances in and out of the blood. Capillaries are narrow and have thin walls to allow substances to diffuse quickly.

The Heart

The heart is an organ that pumps blood around the body in a double circulatory system. Blood enters the top chambers of your heart, which are called the **atria**. The blood coming into the right atrium from the **vena cava** is deoxygenated blood from your body. The blood coming into the left atrium in the **pulmonary vein** is oxygenated blood from your lungs. The right ventricle pumps blood to the lungs through the **pulmonary artery**, where gas exchange takes place. The left ventricle pumps blood around the rest of the body in the **aorta**.

Statins and Stents

A stent is a metal mesh inserted into the clogged artery with a balloon. The balloon is inflated and the **stent** expands and locks in place. This holds the artery open and allows blood to flow more freely. This surgery is potentially dangerous. **Statins** are drugs which reduce the cholesterol levels in the blood, reducing the risk of coronary heart disease. They have to be taken everyday and may have side effects.



Coronary heart Disease

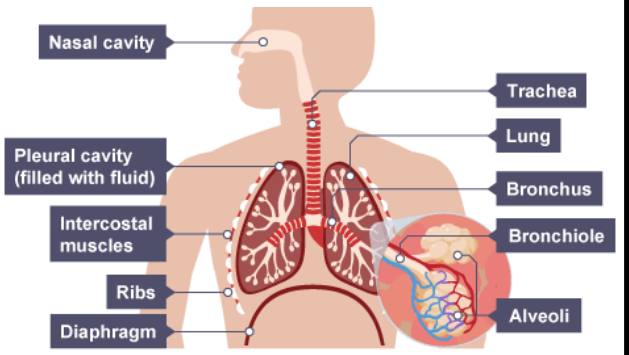
In coronary heart disease layers of fatty material build up inside the coronary arteries, narrowing them. This reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle. In some people heart valves may become faulty, preventing the valve from opening fully, or the heart valve might develop a leak. Faulty heart valves can be replaced using biological or mechanical valves. In the case of heart failure a donor heart, or heart and lungs can be transplanted. Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest as an aid to recovery.

Gas exchange

Gas exchange is the delivery of oxygen from the lungs to the bloodstream, and the elimination of carbon dioxide from the bloodstream to the lungs and out of the body.

The Gas Exchange System

Air enters the body through the mouth or nose, from here it moves to the pharynx (throat), passes through the larynx (voice box) and enters the **trachea**. The trachea splits into two branches, the left and right **bronchus**, each bronchus divides many times into smaller branches called **bronchioles**. Each bronchiole finally leads to a bunch of tiny air sacs, called **alveoli**, which inflate during inhalation, and deflate during exhalation.



Adaptations of the alveoli

To maximise the efficiency of gas exchange, the alveoli have several adaptations:

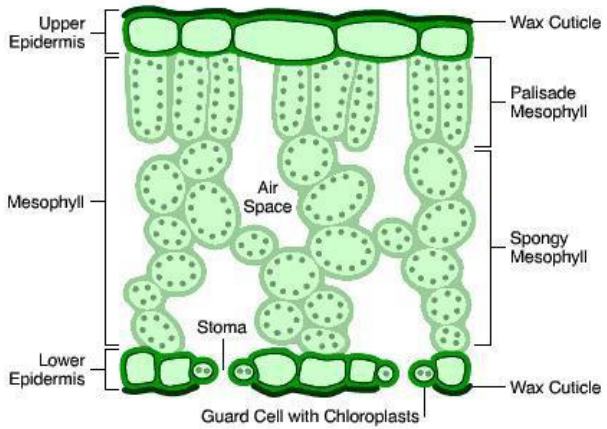
- They are folded, providing a much greater surface area for gas exchange to occur.
- The walls of the alveoli are only one cell thick. This makes the exchange surface very thin - shortening the diffusion distance across which gases have to move.
- Each alveolus is surrounded by blood capillaries which ensure a good blood supply. This is important as the blood is constantly taking oxygen away and bringing in more carbon dioxide - which helps to maintain the maximum concentration gradient between the blood and the air in the alveoli.
- Each alveolus is ventilated, removing waste carbon dioxide and replenishing oxygen levels in the alveolar air. This also helps to maintain the maximum concentration gradient between the blood and the air in the alveoli.

Organising Plants: Biology Specification

Plant Tissues

Plants are multicellular organisms, just like animals. They also usually contain differentiated cells, tissues and organs. The leaves, stems and roots are all plant organs. They form a plant organ system for the transport of substances around the plant. **Epidermal tissues** cover the surface and protect them. These cells often secrete a waxy substance that waterproofs the surface of the leaf. **Palisade mesophyll** tissue contains lots of chloroplasts, which carry out photosynthesis. **Spongy mesophyll** tissue contains some chloroplasts for photosynthesis but also has big air spaces and a large surface area to make diffusion of gases earlier.

Structure of the leaf



Adaption	Purpose
Thin, waxy cuticle	To protect the leaf without blocking out light
Thin epidermis	To allow more light to reach the palisade cells
Palisade cells on the top surface	To absorb light
Many chloroplasts in the palisade cells	To increase absorption of light
Spongy mesophyllinside the leaf	Air spaces allow carbon dioxide to diffuse through the leaf, and increase the surface area

Phloem and Xylem

Plants have two different types of transport tissue. Xylem tissue transports water and mineral ions from the roots to the stems and leaves. It is composed of hollow tubes strengthened by lignin adapted for the transport of water in the transpiration stream.

Phloem tissue transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage. The movement of food molecules through phloem tissue is called **translocation.** Phloem is composed of tubes of elongated cells. Cell sap can move from one phloem cell to the next through pores in the end walls.

Root hair cells

Root hair cells are adapted for the efficient uptake of water by osmosis, and mineral ions by active transport. Root hair cell contains lots of mitochondria, which release energy from glucose during respiration to provide the energy needed for active transport

Transpiration

Transpiration explains how water moves up the plant against gravity in tubes made of dead xylem cells without the use of a pump.

Water on the surface of spongy and palisade cells (inside the leaf) evaporates and then diffuses out of the leaf. This is called transpiration. More water is drawn out of the xylem cells inside the leaf to replace what's lost. As the xylem cells make a continuous tube from the leaf, down the stem to the roots, this acts like a drinking straw, producing a flow of water and dissolved minerals from roots to leaves.

Guard Cells

The role of stomata and guard cells are to control gas exchange and water loss. The opening and closing of the **stomata** is controlled by the guard cells. In light, guard cells take up water by osmosis and become turgid. Because their inner walls are rigid they are pulled apart, opening the pore. In darkness water is lost and the inner walls move together closing the pore.

Factors that affect transpiration rate

Factor	Description	Explanation
Light	In bright light transpiration increases	The stomata (openings in the leaf) open wider to allow more carbon dioxide into the leaf for photosynthesis
Temperature	Transpiration is faster in higher temperatures	Evaporation and diffusion are faster at higher temperatures
Wind	Transpiration is faster in windy conditions	Water vapour is removed quickly by air movement, speeding up diffusion of more water vapour out of the leaf
Humidity	Transpiration is slower in humid conditions	Diffusion of water vapour out of the leaf slows down if the leaf is already surrounded by moist air

Communicable Disease: Biology Specification

Health and Disease

Health is the state of physical and mental well-being. Diseases, both communicable and non-communicable, are major causes of ill health. Other factors including diet, stress and life situations may have a profound effect on both physical and mental health. Different types of disease may interact. Defects in the immune system mean that an individual is more likely to suffer from infectious diseases. Viruses living in cells can be the trigger for cancers. Immune reactions initially caused by a pathogen can trigger allergies such as skin rashes and asthma. Severe physical ill health can lead to depression and other mental illness.

Communicable Disease

Pathogens are microorganisms that cause infectious disease, in animals and plants. Pathogens may be viruses, bacteria, protists or fungi. They depend on their host to provide the conditions and nutrients that they need to grow and reproduce. They frequently produce toxins that damage tissues and make us feel ill. They can be spread by direct contact, by water or by air. Bacteria and viruses may reproduce rapidly inside the body. Bacteria may produce poisons (toxins) that damage tissues and make us feel ill. Viruses live and reproduce inside cells, causing cell damage.

Bacterial Diseases

Salmonella food poisoning is spread by bacteria ingested in food, or on food prepared in unhygienic conditions. In the UK, poultry are vaccinated against Salmonella to control the spread. Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.

Gonorrhoea is a sexually transmitted disease (STD) with symptoms of a thick yellow or green discharge from the vagina or penis and pain on urinating. It is caused by a bacterium and was easily treated with the antibiotic penicillin until many resistant strains appeared. Gonorrhoea is spread by sexual contact. The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom.

Viral Diseases

Measles is a viral disease showing symptoms of fever and a red skin rash. Measles is a serious illness that can be fatal if complications arise. For this reason most young children are vaccinated against measles. The measles virus is spread by inhalation of droplets from sneezes and coughs.

HIV initially causes a flu-like illness. Unless successfully controlled with antiretroviral drugs the virus attacks the body's immune cells. Late stage HIV infection, or AIDS, occurs when the body's immune system becomes so badly damaged it can no longer deal with other infections or cancers. HIV is spread by sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.

Tobacco mosaic virus (TMV) is a widespread plant pathogen affecting many species of plants including tomatoes. It gives a distinctive 'mosaic' pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.

Human Defence System

The skin covers the whole body, protecting against physical damage, microbe infection and dehydration. Its dry, dead outer cells are difficult for microbes to penetrate, and the sebaceous glands produce oils that help kill microbes. The respiratory system is protected in several ways. Nasal hairs keep out dust and larger microorganisms. Sticky mucus traps dust and microbes, which are then carried away by cilia. The stomach contains **hydrochloric acid**, which destroys microorganisms.

If a pathogen enters the body the immune system tries to destroy the pathogen. White blood cells help to defend against pathogens by; phagocytosis (ingesting pathogens), antibody production and antitoxin production.

Fungal Diseases

There are relatively few fungal diseases that affect humans. A common example is athlete's foot. Rose black spot is a fungal disease where purple or black spots develop on leaves, which often turn yellow and drop early. It affects the growth of the plant as photosynthesis is reduced. It is spread in the environment by water or wind. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

Malaria

The pathogens that cause malaria are protists. A **protist** is any eukaryotic organism that is not an animal, plant or fungus. The malarial protist has a life cycle that includes the mosquito. Malaria causes recurrent episodes of fever and can be fatal. The spread of malaria is controlled by preventing the vectors, mosquitos, from breeding and by using mosquito nets to avoid being bitten.

Preventing Infections

The spread of disease can be prevented by simple hygiene, for example handwashing. By isolating infected individuals the risk of infection being spread can be reduced. Some diseases are spread by vectors such as mosquitoes, by controlling or destroying these vectors you can prevent the spread of this disease. Vaccination will also prevent disease.

Preventing and Treating Disease: Biology Specification

Bacterial Growth

Bacteria multiply by simple cell division (binary fission) as often as once every 20 minutes if they have enough nutrients and a suitable temperature. Bacteria can be grown in a nutrient broth solution or as colonies on an agar gel plate. Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.

Growing bacteria in the lab

An uncontaminated culture of microorganisms can be grown using sterilised Petri dishes and agar. You sterilise the inoculating loop before use and fix the lid of the petri dish to prevent unwanted microorganisms getting in. Uncontaminated cultures of microorganisms are needed for investigating the action of disinfectants and antibiotics. Vultures should be incubated at a maximum temperature of 25°C in schools and colleges to reduce the likelihood of pathogens growing that might be harmful to humans.

Plant Disease Identification

Plants can be infected by a range of viral, bacterial and fungal pathogens as well as by insects. Plant diseases can be detected by: stunted growth, spots on leaves, areas of decay (rot), growths, malformed stems or leaves, discolouration and the presence of pests.

Identification can be made by: reference to a gardening manual or website, taking infected plants to a laboratory to identify the pathogen and using testing kits that contain monoclonal antibodies.

Plants can be damaged by a range of ion deficiency conditions; stunted growth caused by nitrate deficiency and chlorosis (yellow leaves) caused by magnesium deficiency. Nitrate ions needed for protein synthesis and therefore growth, and magnesium ions needed to make chlorophyll.

Plant Defence Responses

Physical defence responses to resist invasion of microorganisms.

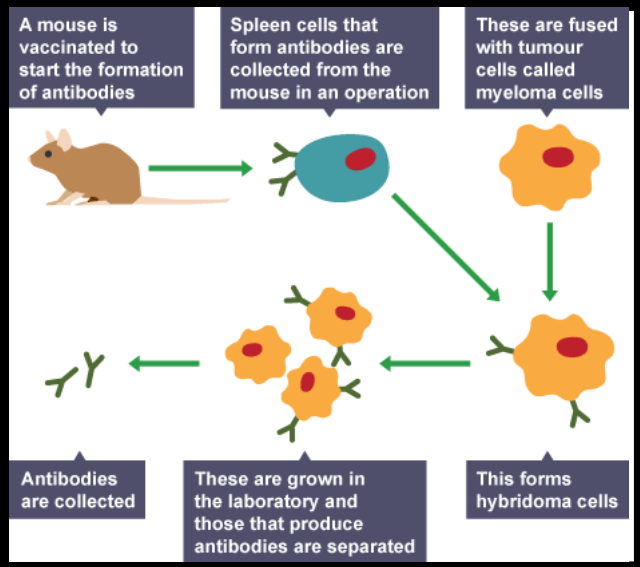
- Cellulose cell walls.
- Tough waxy cuticle on leaves.
- Layers of dead cells around stems (bark on trees) which fall off.

Chemical plant defence responses.

- Antibacterial chemicals.
- Poisons to deter herbivores.

Mechanical adaptations.

- Thorns and hairs deter animals.
- Leaves which droop or curl when touched.
- Mimicry to trick animals.



Monoclonal antibodies

Monoclonal antibodies are produced from a single clone of cells. The antibodies are specific to one binding site on one protein antigen and so are able to target a specific chemical or specific cells in the body.

They are produced by stimulating mouse lymphocytes to make a particular antibody. The lymphocytes are combined with a particular kind of tumour cell to make a cell called a hybridoma cell. The hybridoma cell can both divide and make the antibody. Single hybridoma cells are cloned to produce many identical cells that all produce the same antibody. A large amount of the antibody can be collected and purified.

Uses of Monoclonal Antibodies

Uses of Monoclonal Antibodies include in laboratories to measure the levels of hormones and other chemicals in blood, or to detect pathogens. Also they are used in research to locate or identify specific molecules in a cell or tissue by binding to them with a fluorescent dye. They can be used to treat some diseases: for cancer the monoclonal antibody can be bound to a radioactive substance, a toxic drug or a chemical which stops cells growing and dividing. It delivers the substance to the cancer cells without harming other cells in the body. They are used in pregnancy test kits to identify the small levels of a hormone called human chorionic gonadotrophin, which is present in the urine of pregnant women.

Preventing and Treating Disease and Non-Communicable Disease

Vaccination

Vaccination involves introducing small quantities of dead or inactive forms of a pathogen into the body to stimulate the white blood cells to produce antibodies. If the same pathogen re-enters the body the white blood cells respond quickly to produce the correct antibodies, preventing infection. If a large proportion of the population is immune to a pathogen the spread of the pathogen is much reduced. This is known as herd immunity.

Discovery and development of drugs

Traditionally drugs were extracted from plants and microorganisms.

- The heart drug digitalis originates from foxgloves.
- The painkiller aspirin originates from willow.
- Penicillin was discovered by Alexander Fleming from the Penicillium mould.

Most new drugs are synthesised by chemists in the pharmaceutical industry. However, the starting point may still be a chemical extracted from a plant. New medical drugs have to be tested and trialled before being used to check that they are safe and effective. New drugs are extensively tested for toxicity, efficacy and dose. Toxicity is the degree to which a chemical substance or a particular mixture of substances can damage an organism. Efficacy is a measure of how effectively they work. Dose is the quantity of medicine that should be prescribed to be taken at one time.

Preclinical testing is done in a laboratory using cells, tissues and live animals.

Clinical trials involve the large scale testing of drugs on healthy volunteers and provide essential information about their safety and efficacy (how effectively they work). During clinical trials, the volunteers are monitored closely and any side effects can be discovered too. 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 double blind trials, some patients are given a placebo. Neither the doctor or the patient will know who has been given the placebo.

Antibiotics and Painkillers

Antibiotics, such as penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases. However, the emergence of strains resistant to antibiotics is of great concern. Antibiotics cannot kill viral pathogens. Painkillers and other medicines are used to treat the symptoms of disease but do not kill pathogens. It is difficult to develop drugs that kill viruses without also damaging the body's tissues.

Non-communicable Diseases

A non-communicable disease cannot be passed from on individual to another. Risk factors are aspects of a person's lifestyle, or substances present in a person's body or environment, that have been shown to be linked to an increased rate of a disease. For some non-communicable diseases, a casual mechanism for some risk factors has been proven, but not in others. A casual mechanism explains how one factor influences another through a biological process. Correlation does not prove causation and doctors have to do lots of research to prove a casual mechanism.

Diet, exercise and disease

Regular exercise and a balanced diet are needed to keep the body healthy. Too little food leads to a person being underweight and prone to illness, while too much food and not enough exercise leads to a person being overweight and prone to other illnesses.

Excess cholesterol increases the risk of heart disease. Excess salt causes high blood pressure and increases the risk of heart disease and stroke. Obesity is a strong risk factor for type 2 diabetes.

Cancer

Cancer is the result of changes in cells that lead to uncontrolled growth and division. Benign tumours are growths of abnormal cells which are contained in one area, usually within a membrane. They do not invade other parts of the body. Malignant tumour cells are cancers. They invade neighbouring tissues and spread to different parts of the body in the blood where they form secondary tumours. Scientists have identified lifestyle risk factors for various types of cancer. There are also genetic risk factors for some cancers.

Smoking

Smoking can cause cardiovascular disease including coronary heart disease, lung cancer, and lung diseases such as bronchitis and COPD.

A fetus exposed to smoke has restricted oxygen, which can lead to premature birth, low birthweight and even stillbirth. Tobacco smoke contains many harmful substances. These include: tar, nicotine and carbon monoxide. Tar causes cancer of the lungs, mouth and throat. It coats the surface of the breathing tubes and the alveoli. Nicotine is addictive - it causes a smoker to want more cigarettes. Carbon monoxide is a gas that takes the place of oxygen in red blood cells. This reduces the amount of oxygen that the blood can carry.

Alcohol

Alcohol can damage the liver and cause cirrhosis and liver cancer. Alcohol can cause brain damage and death. Alcohol taken in by a pregnant woman can affect the development of her unborn baby.

Photosynthesis: Biology Specification

Photosynthesis

Plants harness the Sun's energy in photosynthesis in order to make food. This process liberates oxygen which has built up over millions of years in the Earth's atmosphere. Both animals and plants use this oxygen to oxidise food in a process called aerobic respiration which transfers the energy that the organism needs to perform its functions. Photosynthesis is an endothermic reaction in which energy is transferred from the environment to the chloroplasts by light.

Photosynthesis is represented by the equation:

$$\text{Carbon Dioxide + Water} \xrightarrow{\text{Light}} \text{Glucose + Oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Plants absorb water through their roots, and carbon dioxide through their leaves. Some glucose is used for respiration, while some is converted into insoluble *starch* for storage. The stored starch can later be turned back into glucose and used in respiration. Oxygen is released as a by-product of photosynthesis. Leaves are adapted to perform their function e.g. they have a large surface area to absorb sunlight and lots of chloroplasts in the palisade cells.

Uses of glucose from photosynthesis

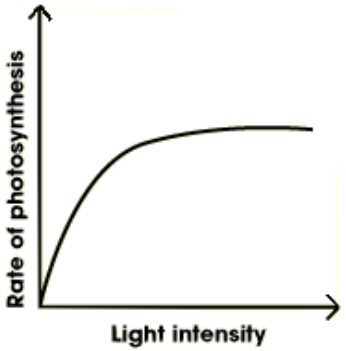
The glucose produced in photosynthesis may be:

- used for respiration
- converted into insoluble starch for storage
- used to produce fat or oil for storage
- used to produce cellulose, which strengthens the cell wall
- used to produce amino acids for protein synthesis.

To produce proteins, plants and algal cells also use nitrate ions that are absorbed from the soil or water to make the amino acids used to make proteins.

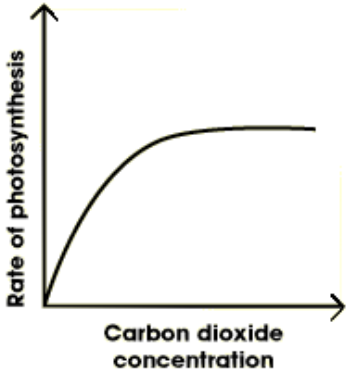
Factors limiting photosynthesis

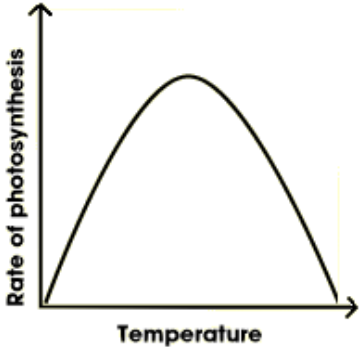
Three factors can limit the speed of photosynthesis - light intensity, carbon dioxide concentration and temperature.



Without enough light, a plant cannot photosynthesise very quickly, even if there is plenty of water and carbon dioxide. Increasing the light intensity will boost the speed of photosynthesis.

Sometimes photosynthesis is limited by the concentration of carbon dioxide in the air. Even if there is plenty of light, a plant cannot photosynthesise if there is insufficient carbon dioxide.





If it gets too cold, the rate of photosynthesis will decrease. Plants cannot photosynthesise if it gets too hot.

These factors interact and any one of them may be the factor that limits photosynthesis.

Making the most of Photosynthesis

Limiting factors are important in the economics of enhancing the conditions in greenhouses to gain the maximum rate of photosynthesis while still maintaining profit. Farmers can use their knowledge of these limiting factors to increase crop growth in greenhouses. They may use artificial light so that photosynthesis can continue beyond daylight hours. The use of paraffin lamps inside a greenhouse increases the rate of photosynthesis because the burning paraffin produces carbon dioxide, and heat too.

Respiration: Biology Specification

Respiration

Cellular respiration is an exothermic reaction which is continuously occurring in living cells. The energy transferred supplies all the energy needed for living processes. Respiration in cells can take place aerobically (using oxygen) or anaerobically (without oxygen), to transfer energy.

The equation to represent respiration is:

Glucose + Oxygen → Carbon dioxide + Water

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Organisms need energy for: chemical reactions to build larger molecules, movement and keeping warm.

Anaerobic respiration

Anaerobic respiration does not require oxygen to transfer energy. During vigorous exercise the human body is unable to supply the cells with sufficient oxygen and it switches to anaerobic respiration. This process will supply energy but also causes the build-up of lactic acid in muscles which causes fatigue.

Anaerobic respiration in muscles is represented by the equation:

glucose → lactic acid

As the oxidation of glucose is incomplete in anaerobic respiration much less energy is transferred than in aerobic respiration.

Fermentation

Anaerobic respiration in plant and yeast cells is represented by the equation:

glucose → ethanol + carbon dioxide

Anaerobic respiration in yeast cells is called fermentation and has economic importance in the manufacture of bread and alcoholic drinks.

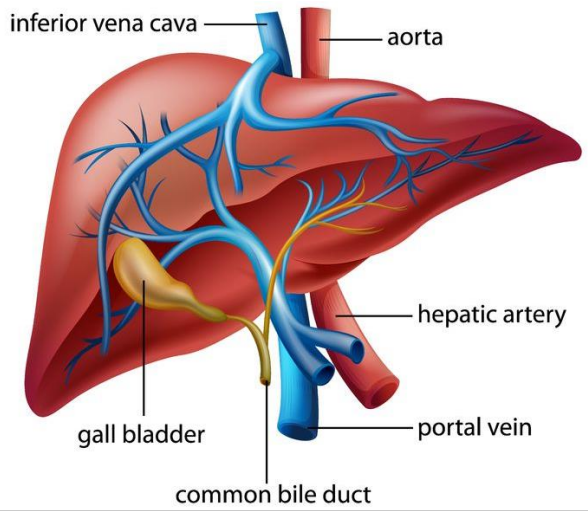
Response to Exercise

During exercise the human body reacts to the increased demand for energy. The heart rate, breathing rate and breath volume increase during exercise to supply the muscles with more oxygenated blood. If insufficient oxygen is supplied anaerobic respiration takes place in muscles. The incomplete oxidation of glucose causes a build up of lactic acid and creates an oxygen debt. During long periods of vigorous activity muscles become fatigued and stop contracting efficiently.

Metabolism

Metabolism is the sum of all the reactions in a cell or the body. The energy transferred by respiration in cells is used by the organism for the continual enzyme controlled processes of metabolism that synthesise new molecules. Metabolism includes:

- conversion of glucose to starch, glycogen and cellulose
- the formation of lipid molecules from a molecule of glycerol and three molecules of fatty acids
- the use of glucose and nitrate ions to form amino acids which in turn are used to synthesise proteins
- respiration
- breakdown of excess proteins to form urea for excretion.



The Liver

Blood flowing through the muscles transports the lactic acid to the liver where it is converted back into glucose. Oxygen debt is the amount of extra oxygen the body needs after exercise to react with the accumulated lactic acid and remove it from the cells.