BIOLOGY GCSE
SUBJECT REVIEW
2017

GCSE Biology

What is biology?

Biology is basically the study of life and living organisms.

This presentation is an introduction to Biology for GCSE, hopefully it will be interesting too! ENJOY!

CELLS – The basic units

All living things are made up of cells.
They carry out Life's important functions;

Movement
Reproduction
Sensitivity
Homeostasis
Growth
Respiration
Excretion
Nutrition

There are two types of cells: Prokaryotes and Eukaryotes

CELLS

Prokaryotes

Old Greek *Pro* (meaning before)

Eukaryotes

Eu (good/true)

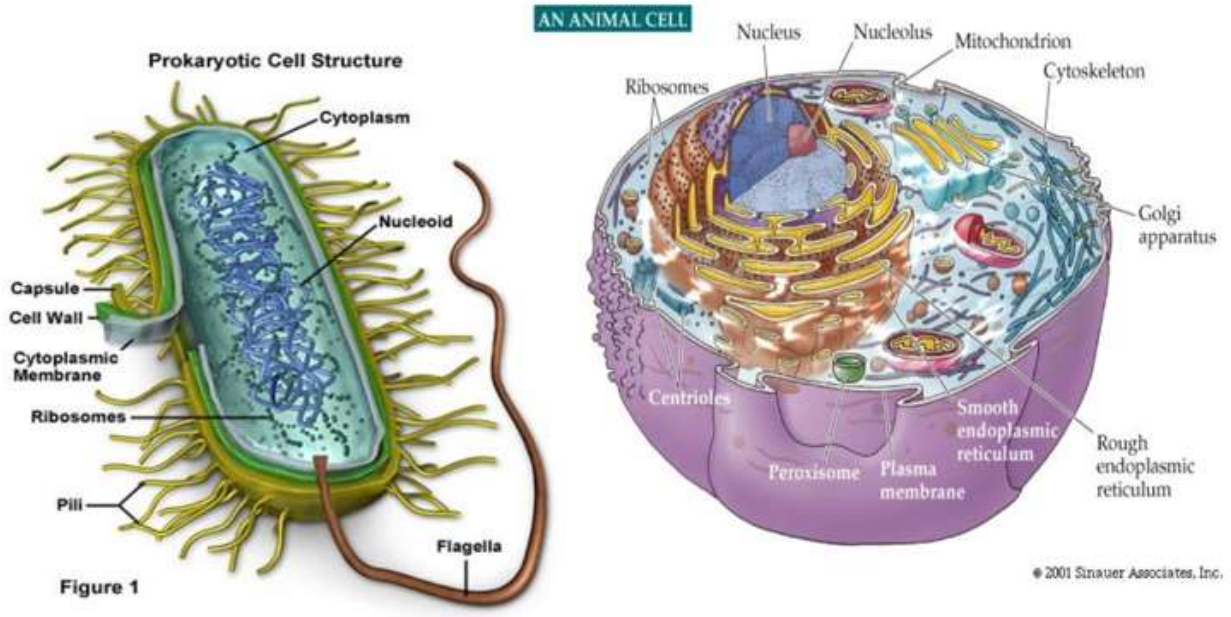
Membrane bound Nucleus

Are single organisms (often called unicellular) which includes Bacteria and Microorganisms

Include; Animal, Plant and Fungal multicellular organisms.

Differences between Two Types

Prokaryotic vs Eukaryotic Cells



https://biochemanics.files.wordpress.com/2013/03/125817436.png (accessed: 1st June 2017)

Whilst different, they do share a few common factors:

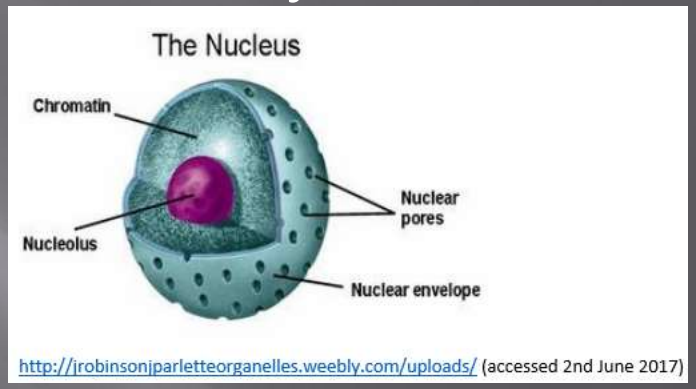
They contain DNA (The Cell blueprint), Cytoplasm and Cell membrane.

Differences between Two Types

	Eukaryotic Cell (Animals, Plants and Fungi)	Prokaryotic Cell
Nucleus	Yes	Absent
Number of chromosomes	More than one bound inside nucleus	Referred to as naked. Plasmids
Membrane bound Nucleus	Yes	Absent
Genetic Recombination	Meiosis & fusion of gametes	Simple / Asexual Fission
Lysosomes and peroxisomes	Yes	Absent
Microtubules	Yes	Absent or rare
Endoplasmic reticulum	Yes	Absent
Mitochondria	Yes	Absent
Ribosomes	larger	smaller
Vesicles	Yes	Yes
Golgi apparatus	Yes	Absent
Chloroplasts	In plant cells	Absent
Flagella	Not present	
Cell wall	Only in plant cells and fungi	Chemically complexed (slime capsule)
Vacuoles	Present	Present
Cell size	10-100um	1-10um

Fundamental Parts of Cells

Nucleus: Contains the genetic material (chromosomes and DNA) of the cell, controlling cell activity.



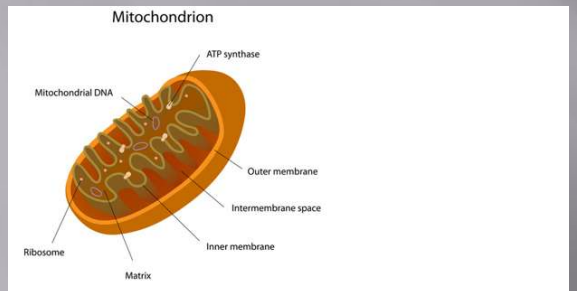
http://jrobinsonjparletteorganelles.weebly.com/uploads/ (accessed 2nd June 2017)

Cell membrane: It separates and protects the interior of all **cells** from the outside environment allowing the movement of substances in and out of cells.

Cytoplasm: Cellular fluid containing water, salts, proteins and nutrients.

Fundamental Parts of Cells

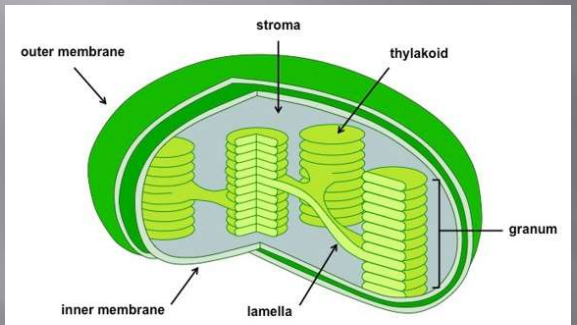
Other Organelles (mini organs):



http://science-tuition.co.uk/wp-content/uploads/2013/10/mitochondria_labeled.jpg (accessed 2nd June 2017)

Mitochondrion: Provides the Cell with energy in the form of ATP (see diagram)

Ribosomes: Sites for protein / amino acid / RNA synthesis



http://ib.bioninja.com.au/_Media/chloroplast-structure_med.jpeg (accessed 2nd June 2017)

Chloroplasts (Plant): Site of photosynthesis, they absorb light and CO_2 (see diagram)

Vacuoles (Plant): Contain sugary sap – helps maintain turgidity.

Specialised animal Cells

Nerve Cells - carry long fibres that carry electrical impulses

Muscle Cells (smooth and striated) – have fibres that shorten in length

Blood Cells (white) – help fight infection by attacking and destroying bacteria, viruses, and germs

Blood Cells (red) – contain haemoglobin that carry's Oxygenated blood around the body

Sperm Cells – propel and move to find the unfertilised egg

Epithelial Cells - provide protective layer i.e. Skin

Others include;

Bone Cells, Gland cells and unspecialised Stem cells.

Specialised plant Cells

UPPER EPIDERMIS, Palisade Cells - are responsible for photosynthesis because they contain high numbers of chloroplasts. Cell arrangement is tightly packed for maximum efficiency. (Slide 92)

LOWER EPIDERMIS, Spongy mesophyll Cells – not as closely packed with fewer chloroplasts within the cells. Intercellular air spaces allow for the interchange of gases

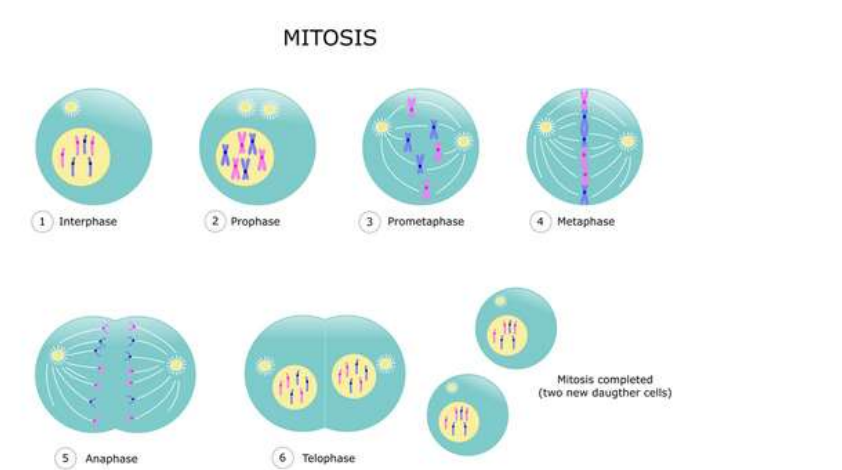
Guard cells – Regulate the rate of transpiration (through a stomatal pore) and provide air spaces for gas exchange (CO_2 and O_2) into and out of the lower leaf**.**

CELL DIVISION: Mitosis

Important for growth and development.

Occurs in cells all over our bodies and those of plants (occurs in the Meristem [roots and buds]) and Fungi.

Produced identical copies of Cell.



http://www.livescience.com/images/i/000/079/054/i02/mitosis-stages.jpg (accessed 1st June 2017)

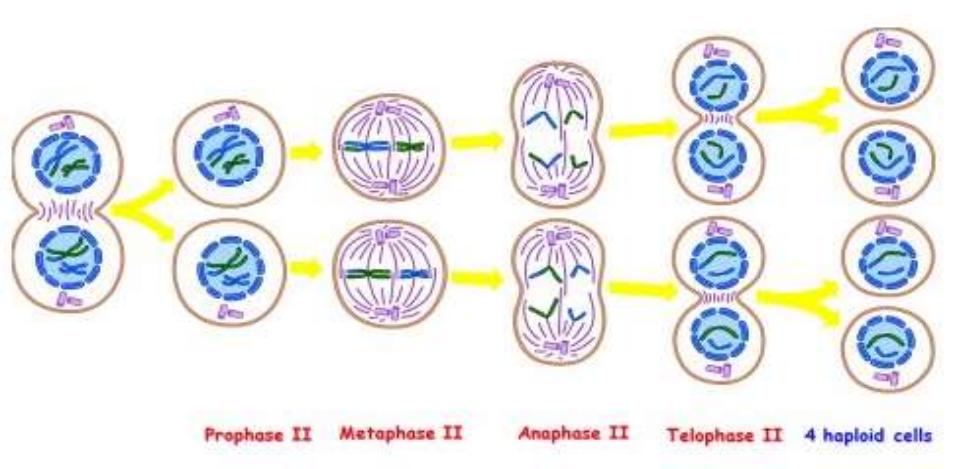
However, cell mutations in animals can cause uncontrolled divisions sometimes resulting in Cancer.

▣

CELL DIVISION: Meiosis

Unlike Mitosis, cellular Meiosis is not cyclic and involves complex stages within the reproductive tissue.

It involves creating sperm or ova with haploid cells (containing half number of chromosomes).

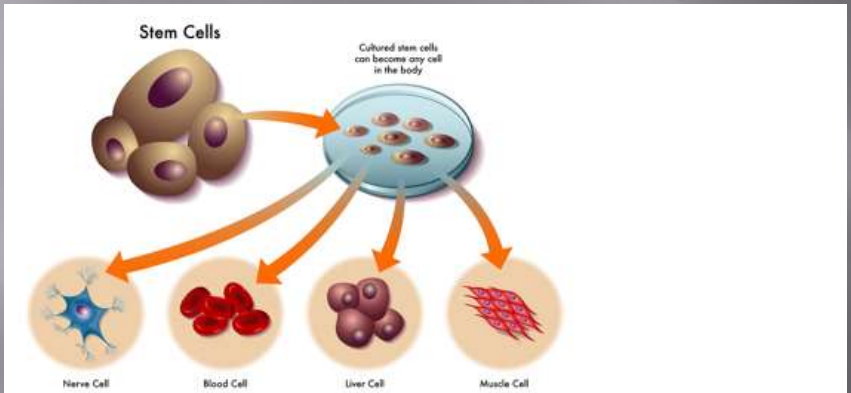


Once fused during fertilisation (Zygote), genetic information is exchanged.

It ensures production of genetically varied offspring. This is important for survival and natural selection.

Stem Cell Therapy.

Culturing involves using embryonic cells (in embryos) from the tissue layers to grow muscle cells, blood cells, bone cells, neurones and liver cells.



http://www.askdrray.com/wp-content/uploads/2015/01/bigstock-stem-cells-74626423.jpg

(accessed 1st June 2017)

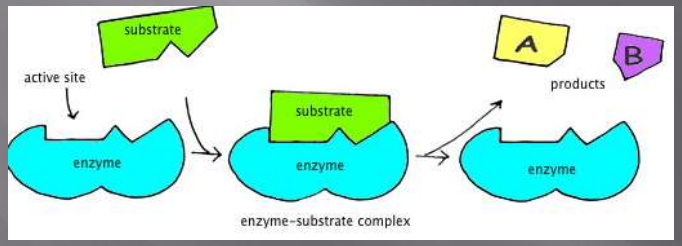
It may be used to treat a variety of diseases such as Diabetes and Alzheimer's.

However, there are ethical questions and long term effects are yet to be thoroughly determined.

Enzymes

Biological catalysts made up of amino acids / proteins designed to speed up reactions inside our bodies.

They have **Active sites** that bind to specific substrates (Lock and Key mechanism) to break them down.



They come in a variety of shapes and sizes and are used widely in food production, biotechnology and household items such as detergents and wash powders.

Enzyme reactions are dependent upon pH, temperature and substrate concentrations.

Unfavourable conditions may lead to enzyme failure or denaturing.

Respiration

Cells derive energy from food (site of respiration in cells is the Mitochondria [the molecule ATP]) – Aerobic respiration involves complete oxidation of Glucose to Carbon dioxide and Water.

Glucose + oxygen → carbon dioxide + water (+ energy)

In animals, anaerobic respiration occurs when the lungs and heart cannot work fast enough to supply the Oxygen needed. Incomplete breakdown of glucose occurs:

Glucose → lactic acid (+ energy released)

Anaerobic respiration in plant cells and yeast (fungus / microorganism) produces ethanol and carbon dioxide.

Glucose → ethanol + carbon dioxide (+ energy released)

Digestion and Synthesis

Digestion occurs by hydrolysis.

Many Enzymes are involved in this process:

- Lipase (Fat into Glycerol and Fatty acids)
- Protease (Protein into Amino Acids and Sugars)
- Amylase (Starch into Sugars)

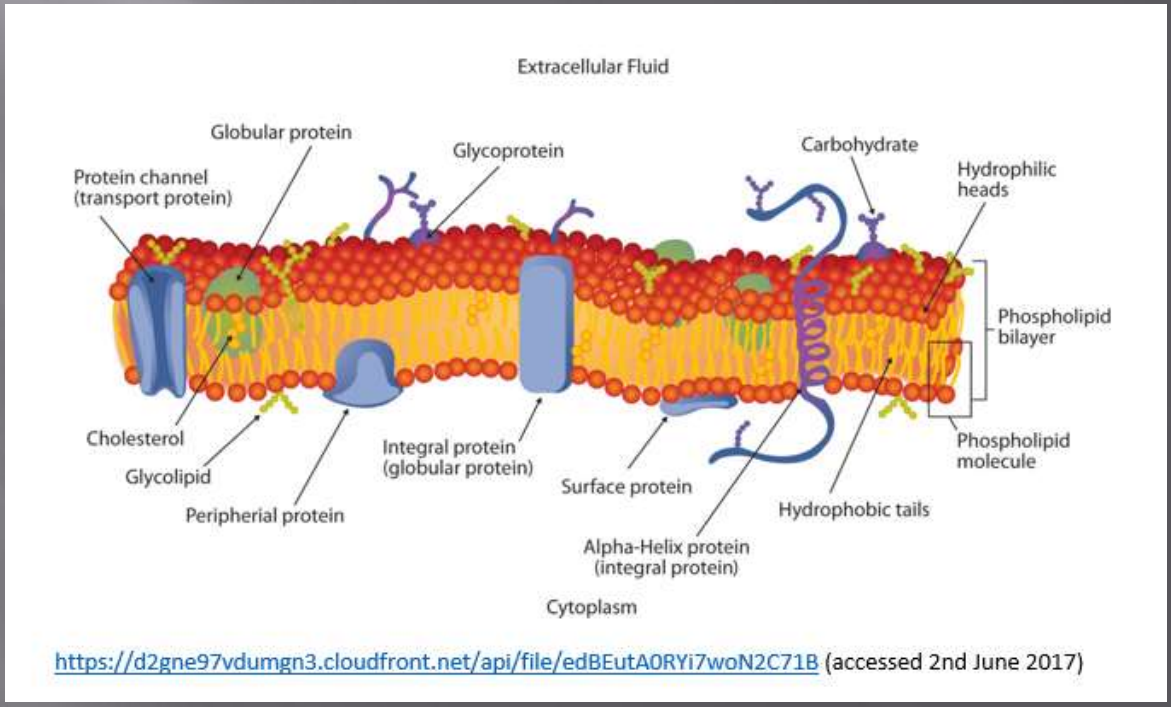
Synthesis of proteins, peptides, sugars and fats occurs by condensation reactions. These can form the complex chemicals of life including;

Carbohydrates, Polysaccharides, Amino Acids, DNA and RNA, Enzymes and Triglycerides.

Cellular Transport

The plasma membrane surrounds all living eukaryote cells, and is the cell's most important organelle. It controls how substances can move in and out of the cell. Cell organelles also have a similar membrane surrounding them. It is composed of phospholipids, proteins and carbohydrates.

The delivery and exchange of substances is important to maintain Homeostasis.



https://d2gne97vdumgn3.cloudfront.net/api/file/edBEutA0RYi7woN2C71B (accessed 2nd June 2017)

Cellular Transport

Three types of movement into / out of Cells. These are;

Diffusion – The simple movement of gases (oxygen and carbon dioxide [waste products]) down a concentration gradient through gaps in the phospholipid bilayer.

Osmosis – The constant movement of water concentration across the cell membrane (from high water potential to lower water potential / concentrated solutes) into and out of the cell reaching osmotic potential and avoiding lysis or shrinkage.

Active Transport –The transport of substances (i.e. sodium / potassium [charged ions]) via channel proteins against their concentration gradient. This requires Energy [ATP]

Exchange Surfaces

In simple unicellular organisms, where no cell membrane is present, bacteria have adopted a method of exchanging gases and useful substances via simple diffusion.

Due to the size and large surface area in comparison to their volume (ratio of Volume vs SA), oxygen is easily absorbed into the cell without any specialised exchange mechanisms.

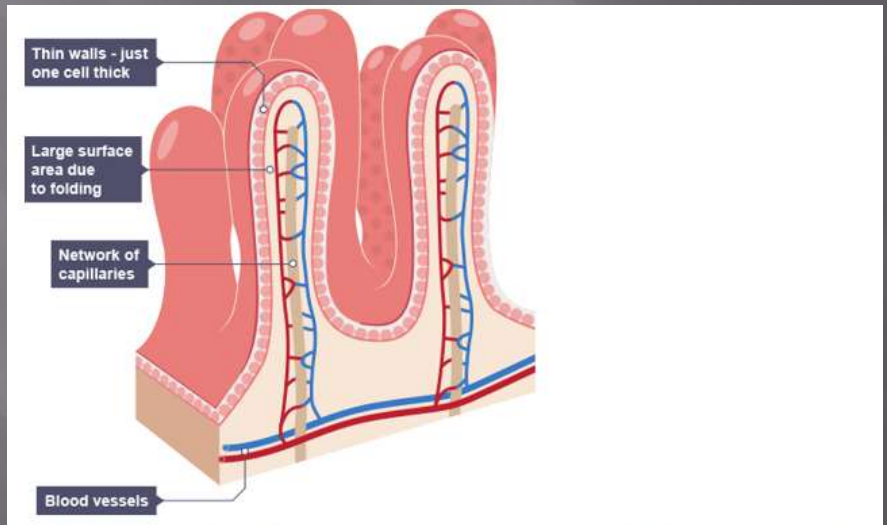
Exchange surfaces are adapted to maximising diffusion by having a large surface area, a short diffusion pathway and having mechanisms that maintain a large concentration gradient.

Different organisms have unique methods of exchanging gases. For example plants (through surface of roots & leaves) fish (gills), insects (air gaps) and animals (complex vessels).

Exchange surfaces

Rate of diffusion and absorption increases with a larger surface area.

This can be increased by having surface folds, tubules (kidney tissue), ciliated surfaces (microvilli) and sponge like tissue (alveoli in lungs) with single layer cells (for thin surface) for efficient diffusion and absorption of useful substances.

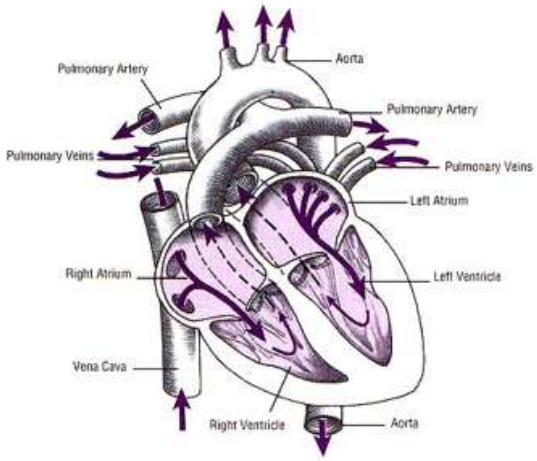


http://www.bbc.co.uk/schools/gcsebitesize/science/images/triple_science/025_bitesize_gcse_tsbiology_dissolvedsubstances_villi_464.gif (accessed 2nd June 2017)

Human circulatory system

Made up of Heart (muscle) and different types of blood vessels.

Two sides to heart (cardiac muscles), both acting as individual pumps.



http://www.human-body-facts.com/images/heart.jpg (accessed 2nd June2017)

1 Cycle = 1 heartbeat

Oxygenated blood (red) from the lungs enters the left atrium.

Deoxygenated blood (blue) from the body enters the right atrium.

Human circulatory system

There are 4 chambers of the heart; two atria (thin walled, receive blood from veins, low pressure) and two ventricles (thick wall, to pump blood into arteries at high pressure and around the body).

There are **2 main stages** - diastole (relaxation and filling of blood) systole (contraction and ejection of blood from heart).

The left ventricle and atrium pumping oxygen rich blood away from the heart via arteries (blood vessels) to the body.

Veins carry deoxygenated blood from the body back towards the heart (right ventricle) via pulmonary artery and to the lungs.

One way heart valves prevent backflow of blood and maintain pressure.

Each day, it beats about 100,000 times!

Respiratory and circulatory system

So, the cardiac cycle allows oxygenated blood to be collected from the lungs and pumped around the body.

The Lungs are two sponge-like, cone-shaped structures that fill most of the chest cavity and are protected by the flexible rib cage. Our lungs form one of the largest organs of our body. We need lungs to provide oxygen from inhaled air to the capillaries and to exhale the carbon dioxide delivered from them.

There is a clear relationship between circulation and respiratory system

Blood

Red Blood Cells are adapted to efficiently carry and hold oxygenated blood around the body from the circulatory system to tissues. They contain Haemoglobin which combines easily with oxygen. RBC shape (biconcave surface, flexible and thin) ensure maximum storage efficiency. RBCs have no nucleus.

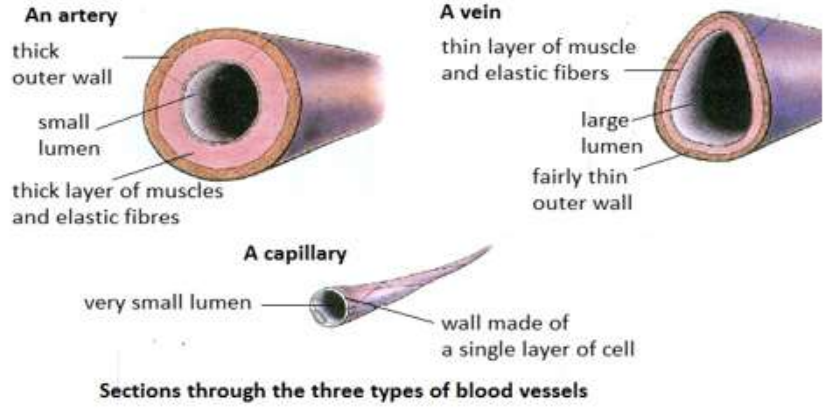
Blood also contains plasma (water, blood proteins, nutrients, salts) which transports CO_2 and soluble nutrients and waste products. Plasma proteins include fibrinogen. Platelets inside the blood contain fibrinogen, a soluble protein that can be activated to form a blood clot.

White blood cells. There are several different types all with different properties. They have nucleus and cytoplasm. They protect us from germs and destroy foreign bodies (phagocytosis).

Blood and vessels cont'd

Blood vessels: arteries (muscle and thick elastic fibres) and veins (thinner wall, one way valves) are key components in the cardiac cycle.

Capillaries (very thin, single cell thick, high surface area bed of vessels) contain tissue fluid for the exchange gas, dissolved oxygen and waste products and are key entities for homeostasis.



Sections through the three types of blood vessels

http://4.bp.blogspot.com/-TmDdlW1wdJ4/UYyTzlhhWHI/AAAAAAAACLU/UTKU-LPfT_E/s1600/vein+artery+capillary+2.jpg (accessed 2nd June 2017)

Transport in plants

Transport vessels / vascular tissues are inside the root, stem and leaf transport substances for plant growth. (Slide 92)

Xylem: made of hollow columns (dead cells) transport water and minerals from roots to stems and leaves. The strengthened cell walls made of lignin (woody substance) give the plant support and structure.

Phloem: dissolves substances around the plant and transports substances in both directions depending upon plant requirements. Several types of living cells (sieve tubes and companion cells) to transport sugars through their cytoplasm from one cell to another (sources to sinks).

Root hair: give the root large surface area for absorbing water (via osmosis) and mineral ions from soil. Root hair cells have large sap vacuole to lower the water potential and high concentration of mitochondrion for active transport.

Transpiration and Translocation

The transpiration stream is powered by the evaporation of water from the leaves. The evaporation (upward pull of the column of water) takes place via osmosis through the plant (xylem cells) to the leaf's open stomatal pore.

Translocation is the movement of organic solutes from leaves to other parts throughout the plant. Those nutrients are translocated from sources (palisade or spongy mesophyll cells in the leaf) to a sink (flower bud or fruiting body) where there is for example a lower sucrose concentration. This is done via active transport to the sieve tubes (in the phloem) then to the bud or fruiting body.

Factors effecting the rate of transpiration in plants

Light intensity increases the rate of transpiration (stomatal pores open to get more CO2) to a maximum, then reduces.

A rise in temperature increases the rate of transpiration until it reaches a plateau. Very high temperatures cause stomatal closure to prevent water loss.

Increased air humidity (water outside the leaf) reduces the rate of transpiration. However, dryer air will increase transpiration.

Effect of wind speed / air movement on the boundary layer. The greater the wind, the more water loss occurs.

Types of plant adaptation (leaf shape, leaf size, cuticle layer and number of stomata) help to reduce water loss in its environment.

HEALTH AND DISEASE

Disease is an illness or sickness caused by pathogens (bacteria, virus, fungi or protozoa), malfunctions in cells, tissues or organs with specific symptoms that affect a person, plant or animal.

They can be communicable (spread by person to person) or non-communicable (those not contagious, often spread through unhealthy lifestyles or through occupational exposure).

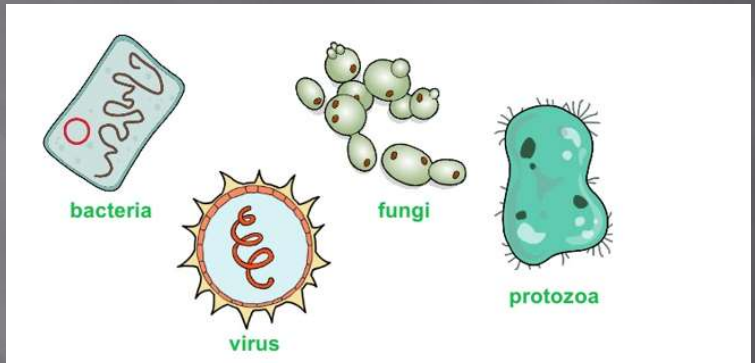
Bacteria are prokaryotes (as explained earlier) and can multiply by cell division extremely quickly under the right conditions. They can be ingested (food poisoning), inhaled (airborne bacteria) or injected (breaking the surface of the skin and into blood stream) into our bodies.

Disease (continued)

Viruses are extremely tiny and can invade our cells, causing many diseases including HIV (AIDS), measles and Influenza (flu).

Fungi can be unicellular or multicellular and can cause Athlete's foot, respiratory diseases and Candida infections.

Protozoa are parasites which invade host cells, for example, plasmodium that causes malaria.



http://image.slidesharecdn.com/lecture11-131120051336-phpapp02/95/infections-and-immunity-7-638.jpg?cb=1384924604 (accessed 3rd June 2017)

Non communicable disease (NCDs)

Cancer - Affects all ages. The most common cancers are breast, prostate, lung and colorectal.

Mesothelioma - A type of cancer of the lung caused by occupational exposure to carcinogens such as asbestos.

Diabetes affects the way the body uses blood glucose. Type 1 (the body produces little or no insulin) and Type 2 (non-insulin dependent, linked with obesity)

Heart disease affects the way the heart and circulatory system performs and includes rhythm irregularities, heart attack, heart failure and angina.

Others include Fibromyalgia, Alzheimer's and Arthritis.

Communicable disease

Bacterial infections are often ingested, for example through drinking poor water, often contaminated by sewerage (faeces) and resulting in, for example, cholera. Bacteria inside the stomach and intestines multiply and cause vomiting, diarrhoea and severe dehydration.

Other diseases spread by person to person are:

Flu, Hepatitis B, Measles, MRSA, Ebola and Sexually Transmitted Diseases.

Some human skin diseases transmitted from person to person include Athletes foot (fungal) and Scabies (skin mites)

Examples of Infections

Infections that are spread by animals (vectors) and insects;

Flies – spread Dysentery to food

Mosquitos – Malaria

Ticks – Lyme's disease (Borreliosis)

Dogs – Rabies

Rats – Weils disease (Leptospirosis)

Food poisoning such as salmonella, E.coli and staphylococcus breakouts are spread from eating undercooked meat (often poultry), fish and eggs. They are preventable by having good personal hygiene (washing hands) and food hygiene standards (protecting food from flies and insects, keeping food in a fridge.

Other good practices include safe household waste disposal and treatment of sewage or dirty water.

HIV / AIDS

Some viral infections can only be passed from one person to another (direct contact) through unprotected sex with an infected person, from mother to unborn child or by sharing needles or other devices exposed to blood.

HIV means 'human immunodeficiency virus'. This is the virus that is the cause of AIDS.

HIV cannot live on its own in the environment. So, to survive, the virus must attack other living cells and use their metabolism to make copies of itself. It destroys immune cells and the victim develops opportunistic infections such as Influenza and Pneumonia. Death may sometimes occur as a result of these illnesses.

HIV hides from immune system and can be difficult to treat.

Mechanical defences / physical and chemical barriers

Our own skin (thick protective layer of keratin) and hair.

Sticky mucus traps in lungs (internal covered tissues with cilia) and nose (nostril hair).

Sebaceous glands in skin (secrete an oily or waxy matter, called sebum).

Tears, saliva and sweat contain lysozyme (an antimicrobial enzyme).

Stomach acid (HCL breaking down harmful agents).

Phagocytosis, non specific engulfing and breaking of bacteria and foreign bodies (Lysis).

Lymphocytes secrete antibodies that bind to and kill antigens.

Specific immune response

There are two main types of lymphocytes (known as **B Cells and T Cells)** that respond to antigens on the surface of bacteria or viruses.

An antibody is Y-shaped with antigen binding regions.

B Lymphocytes

These cells secrete antibodies which bind to antigens on the surfaces of bacteria or viruses. By binding to the bacteria, they act as a label and allow phagocytes to recognise and destroy the cell.

Each B cell produces one specific antibody which will bind to only one specific antigen on the surface of a cell. The B cells divide and form memory cells and antibody-secreting plasma cells.

T Lymphocytes

These cells have one specific antigen receptor on the surface that only binds to an antigen with complementary shape.

Monoclonal Antibodies

Monoclonal antibodies are highly specific (recognising one). Antigens can be injected into an animal and the resulting lymphocytes produced in response can be cultured. Other antibodies can be cloned in this way.

Monoclonal antibodies can be used to identify substances (hCG hormone in pregnancy testing sticks).

MAB are made to target different types of cancer and can:

Trigger the immune system to attack and kill cancer cells.

Attach themselves to cancer cells, making them easier for the cells of the immune system to find them.

Block molecules that stop the immune system working

Block signals telling cancer cells to divide

Carry cancer drugs or radiation to cancer cells (drugs or radiation attached to them).

Plant Defences

Physical Defenses

The most common defense is having thick waxy cuticles, bark (lignin), needles, spines, thick hairs and thorns (blackthorn and hawthorn).

Chemical Defenses

Some plants produce bitter tasting saps and unpalatable chemicals that prevent disease or stop animals from feeding on their foliage i.e. Junipers, vernonia, rue and some other herbages.

Plants contain thousands of chemicals that are used to ward off insects and diseases. Some Plants have their own antimicrobial properties to protect against infection and disease i.e. Cloves and Cinnamon

Stinging nettles are protected from herbivores. They produce toxins and an uncomfortable sting when touched or eaten.

Infections can be avoided with cultivated plants. This relies upon the farmer considering: The soil should be free from disease or pests, fertile, free draining and free of excessive moisture to prevent rot and fungal disease (i.e. potato blight, mildew or botrytis). Monitoring for disease is key to a healthy crop.

Research and vaccination

Bacteria and fungi can be isolated and cultured on agar to identify the pathogen and potentially find a cure.

Vaccines may be a dead or weakened form of pathogen and contain antigens that alert an immune response. After the first exposure through vaccination, the person's immune system will be stimulated and will recognise the antigen (memory cells) and immediately produce the antibodies they need to fight it, ensuring a stronger and faster response.

Mass vaccinations can lead to heard immunity. As more of the population is vaccinated, the disease can sometimes disappear (smallpox, Edward Jenner).

Many communicable diseases (such as measles) can be prevented by vaccine. This has been proven historically.

Research and vaccination (Continued)

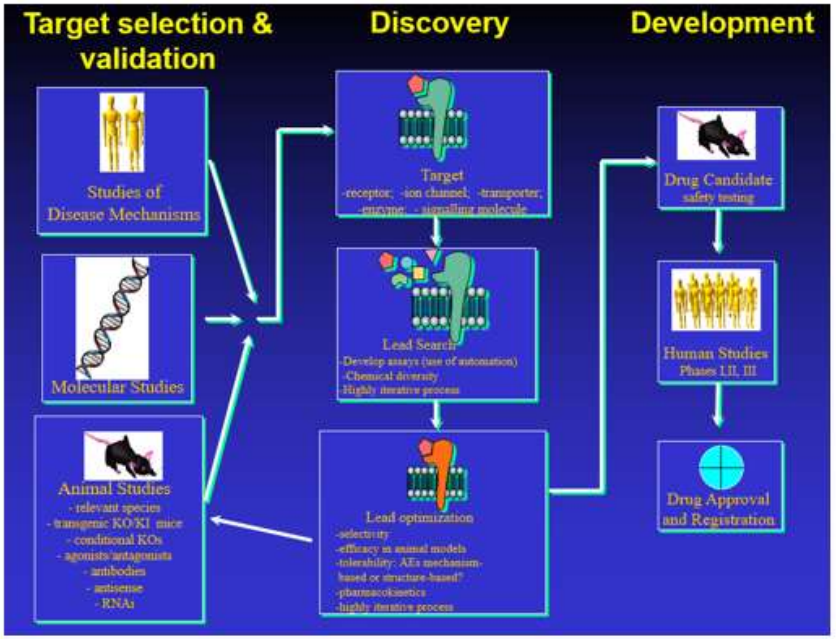
Antibiotics - substances that kill bacteria / stop their growth.

Some here:

antibiotic	how it works
penicillin	breaks down cell walls
erythromycin	stops protein synthesis
neomycin	stops protein synthesis
vancomycin	stops protein synthesis
ciprofloxacin	stops DNA replication

Most common antibiotic is penicillin (Fleming)

The process of drug development is complex and time consuming.



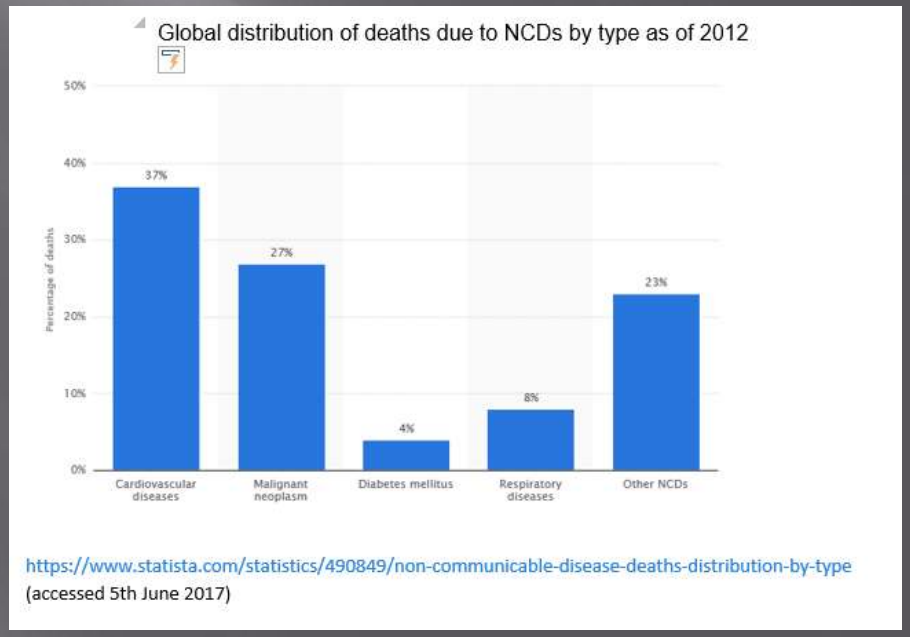
www.the-aps.org/.../APS-Committees/piic/The-Drug-Discovery-PPT **(accessed 5th June 2017)**

Causes of Non communicable disease

For many diseases in the developed world, unhealthy lifestyle is a common factor.

Lack of exercise, bad diet, obesity, excessive smoking, drinking alcohol and (raised blood pressure) stress are common causes.

Age (as people become weaker), gender, genetics or ethnicity might also be a cause.



https://www.statista.com/statistics/490849/non-communicable-disease-deaths-distribution-by-type
(accessed 5th June 2017)

Causes of NCDs (continued)

Smoking cigarettes for example increases the risk of lung diseases as it exposes the cells and lung tissue to carcinogens (tar, smoke). It is incurable.

Poor eating (foods rich in fat, sugars, salts) is a contributory factor to coronary heart disease. Surgical treatment may include widening vessels (stent) or coronary bypass surgery. Drugs may include beta blockers, statins or aspirin. Regular exercise and healthy diet reduce risk.

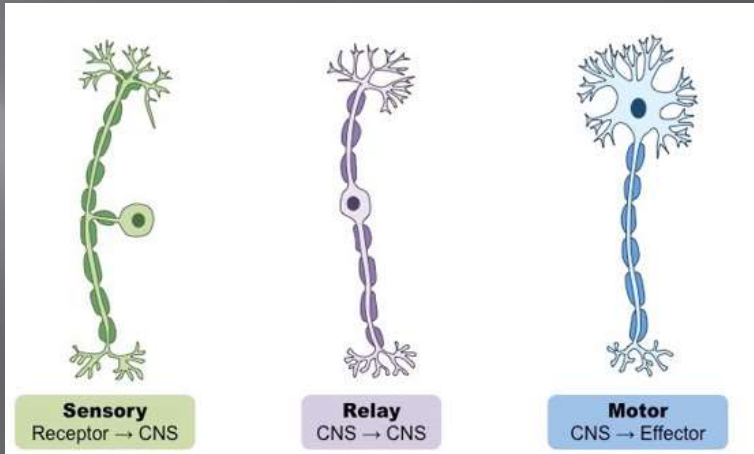
Risk of diabetes (Type 2 where people cannot control insulin release leading to high blood sugar) may increase with age but lifestyle is also a common factor. Treatment involves regular exercise and healthy diet (fewer carbohydrates) and taking drugs which target the liver (Metformin).

The Central Nervous System

An animal's response to a stimulus is coordinated by The CNS and consists of the brain and the spinal cord. It gathers information about, and responds to, changes in the environment.

Once a stimulus is triggered, it sends information and impulses along motor neurons to the effectors, which bring about a response in this sequence:

- Stimulus
- Receptor
- **Sensory neuron**
- Central nervous system
- **Motor neuron**
- Effector
- Response



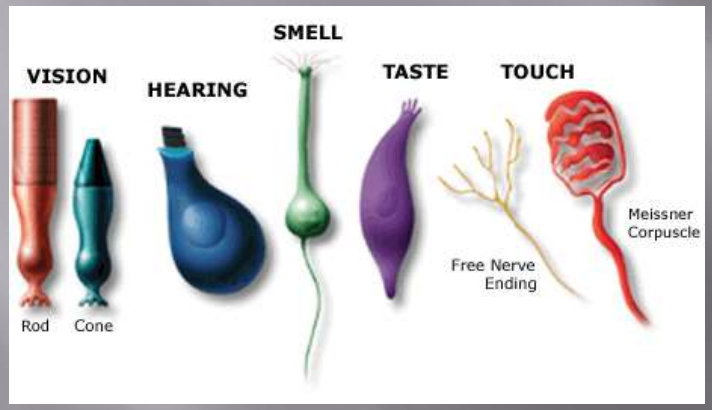
http://ib.bioninja.com.au/_Media/types-of-neurons_med.jpeg (accessed 16th June 2017)

Each neurone has a cell body and long thin fibres (axon surrounded by a myelin sheath) that carry the impulses.

Types of receptors

Receptors detect stimuli and convert them to electrical impulses and are carried to the CNS by sensory neurones.

Different types of receptors are found in different sense organs (example: eye, ear, skin, tongue and nose)



A receptor must detect a stimulus to cause an electrical impulse.

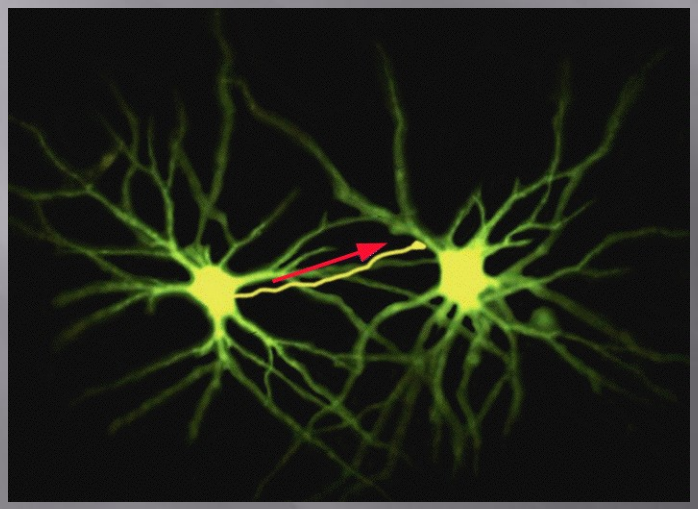
A Pacinian corpuscle is a type of touch receptor located in the skin. It is part of the group of sensory receptors that respond to touch and pressure (e.g. feeling rough surfaces and detecting vibration).

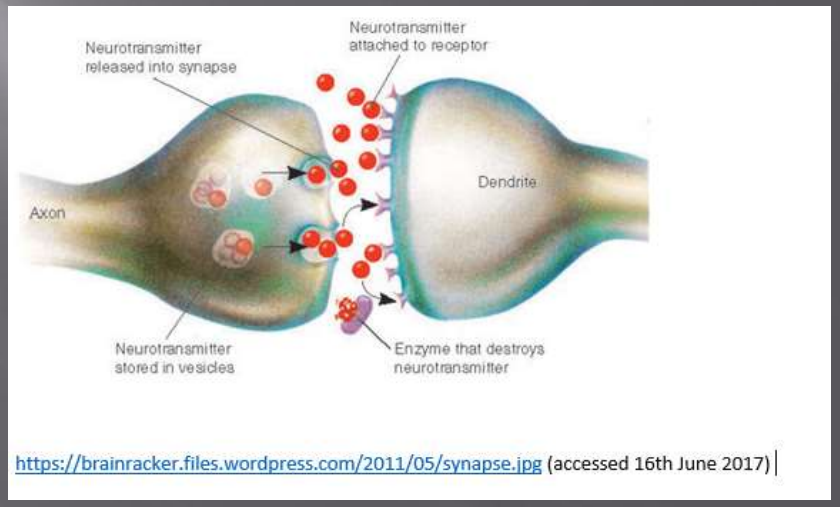
Skin receptors that detect temperature are called thermoreceptors. They respond to burns and cold, as well as overall environmental changes.

And finally, Nociceptors detect pain.

Electrical impulses and Synapses

When a nerve impulse reaches the synapse at the end of a neurone, it triggers the neurone to release a chemical neurotransmitter (chemical signal) that bridges the gap between one neurone and the next.



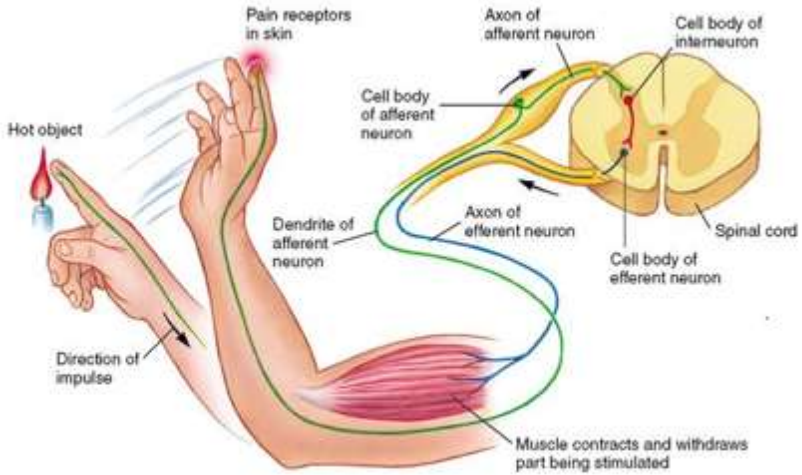


https://brainracker.files.wordpress.com/2011/05/synapse.jpg (accessed 16th June 2017)

The Reflex Arc

Reflex reactions in humans (and all animals) are controlled by the **reflex arc**.

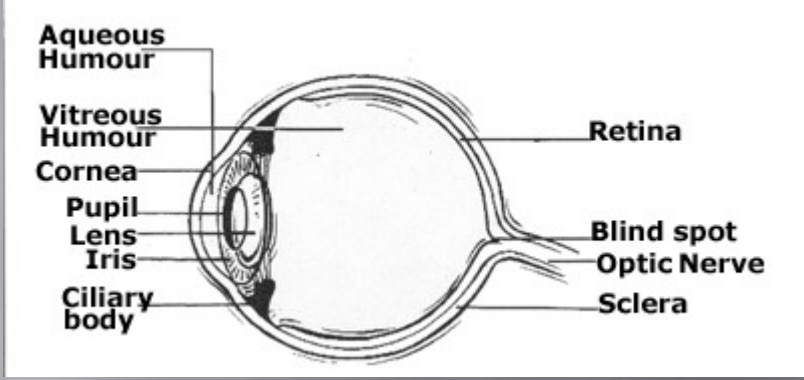
When the safety of an organism demands a very quick response, the signals may be passed directly from a sensory neurone, via a relay neurone, to a motor neurone for an instant reaction. This is a reflex action.



http://www.mhhe.com/socscience/intro/ibank/ibank/0022.jpg (access 16th June2017)

The Eye – How it works

The eye works in a similar way to a camera - light passes through the lens and is 'recorded' on the back of the eye (the retina).



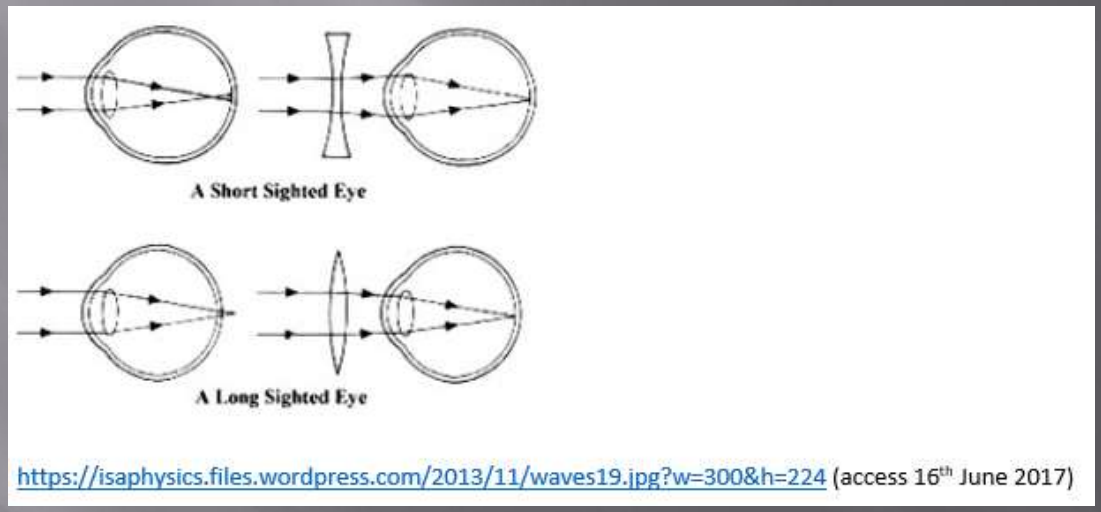
1. When light enters the eye, the ciliary muscles change the thickness of the lens
2. The light is focused by your lens onto the retina
3. The light sensitive cells in the retina send electrical impulses through the optic nerve to your brain
4. Your brain processes these impulses and shows you what the object looks like

The iris reflex. In dim conditions, more light is allowed to enter so that a clear image can be formed on the retina. In bright conditions less light is allowed to enter so that the retina is not damaged.

This adjustment is done by two sets of muscles in the iris. Its circular muscles contract to close up the iris, making the pupil smaller. Its radial muscles contract to open up the iris, making the pupil larger.

Short and Long sightedness

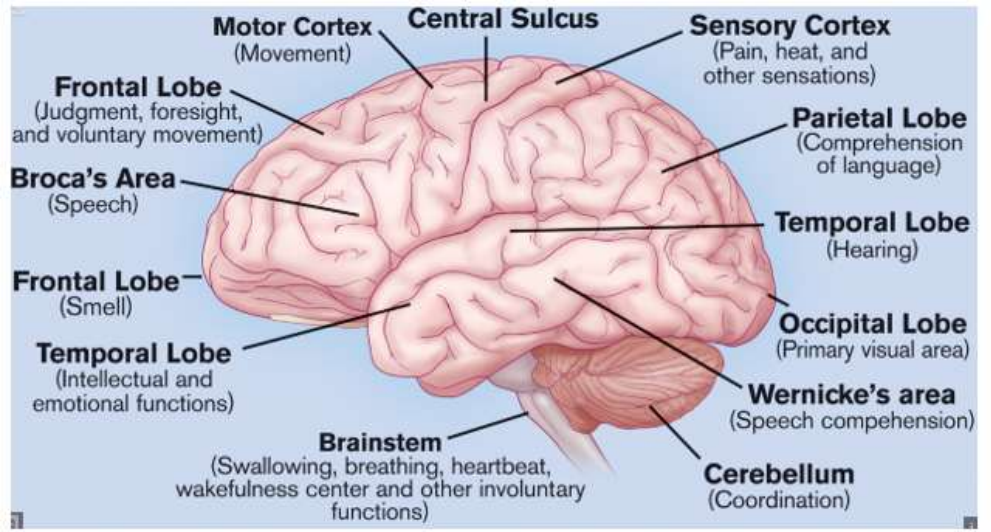
A **short-sighted** person can see things close-up, but not further away. The lens in a **myopic** eye focuses the light too much, causing the focal point to be in front of the retina. This can be corrected with a **concave** lens, which causes the light to spread, and so converge on the retina.



https://isaphysics.files.wordpress.com/2013/11/waves19.jpg?w=300&h=224 (access 16th June 2017)

A **long-sighted** person struggles to see near objects, but can see distant objects. The lens does not cause the light to bend enough, leading to the focal point being beyond the retina. To rectify this, a long-sighted person can wear glasses with a **convex** lens. This causes the light to bend more, and converge on the retina.

The Brain



http://fullfrontalanatomy.com/images/F13/NS/Labeled-Brain-Image.jpg

The **cerebral cortex** is the part of the brain responsible for **intelligence**, **language**, **memory** and **consciousness**.

Other parts of the brain include:

The **cerebellum** that coordinates posture and learned movements

The **medulla** controls breathing and heart rate

The **hypothalamus** coordinates homeostasis and controls the **Pituitary gland** which produces many hormones.

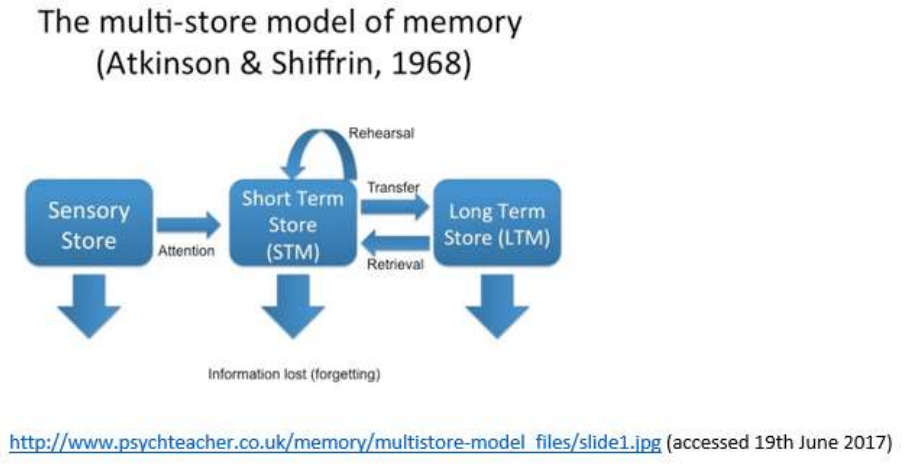
Memories

Two types of memory:

Short-term memory lasts for about 30 seconds.

Long-term memory may last for the whole of your life. There is no limit to how much information you can store and memory can be improved through repetition. Repeating things, especially over a long period of time, we are much more likely to remember them in our long-term memory.

The **Hippocampus** is responsible for creating new memories.



Brain injuries and Disease

Brain injuries are often caused by trauma and can damage brain tissue, neurones, and nerves. This damage affects your brain's ability to communicate with the rest of your body. Examples include:

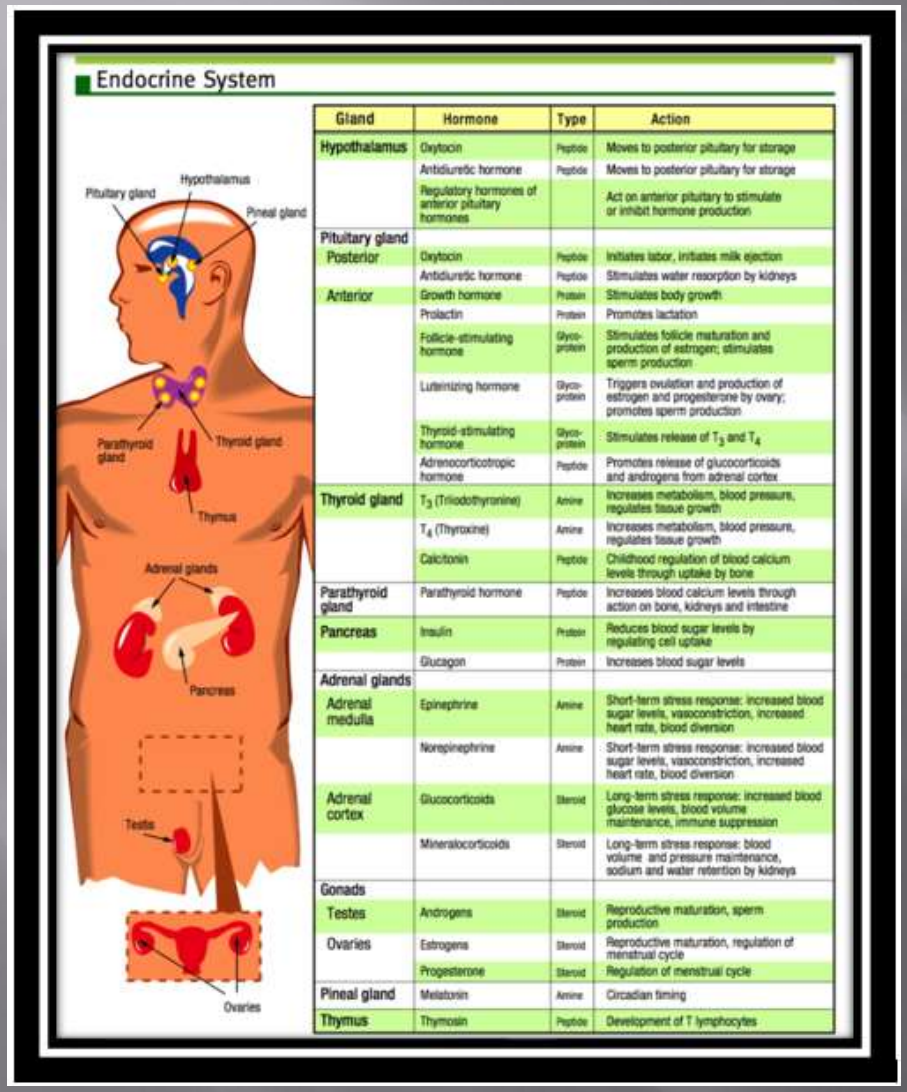
- Hematomas
- Concussions
- Blood clots
- Strokes.

Strokes occur when a blood clot blocks a blood vessel or artery, or when a blood vessel breaks and interrupts blood flow to an area of the brain. The most common cause of stroke is high blood pressure.

Neurodegenerative diseases cause your brain and nerves to deteriorate over time. For example, Alzheimer's disease, develops with age. They can slowly impair your memory and thought processes. Other diseases include:

- Huntington's disease
- Parkinson's disease
- All forms of dementia

The Endocrine system



Gland	Hormone	Type	Action
Hypothalamus	Oxytocin	Peptide	Moves to posterior pituitary for storage
	Antidiuretic hormone	Peptide	Moves to posterior pituitary for storage
	Regulatory hormones of anterior pituitary hormones		Act on anterior pituitary to stimulate or inhibit hormone production
Pituitary gland			
Posterior	Oxytocin	Peptide	Initiates labor, initiates milk ejection
	Antidiuretic hormone	Peptide	Stimulates water resorption by kidneys
Anterior	Growth hormone	Protein	Stimulates body growth
	Prolactin	Protein	Promotes lactation
	Follicle-stimulating hormone	Glyco-protein	Stimulates follicle maturation and production of estrogen; stimulates sperm production
	Luteinizing hormone	Glyco-protein	Triggers ovulation and production of estrogen and progesterone by ovary; promotes sperm production
	Thyroid-stimulating hormone	Glyco-protein	Stimulates release of T_3 and T_4
	Adrenocorticotropic hormone	Peptide	Promotes release of glucocorticoids and androgens from adrenal cortex
Thyroid gland	T_3 (Triiodothyronine)	Amine	Increases metabolism, blood pressure, regulates tissue growth
	T_4 (Thyroxine)	Amine	Increases metabolism, blood pressure, regulates tissue growth
	Calcitonin	Peptide	Childhood regulation of blood calcium levels through uptake by bone
Parathyroid gland	Parathyroid hormone	Peptide	Increases blood calcium levels through action on bone, kidneys and intestine
Pancreas	Insulin	Protein	Reduces blood sugar levels by regulating cell uptake
	Glucagon	Protein	Increases blood sugar levels
Adrenal glands			
Adrenal medulla	Epinephrine	Amine	Short-term stress response: increased blood sugar levels, vasoconstriction, increased heart rate, blood diversion
	Norepinephrine	Amine	Short-term stress response: increased blood sugar levels, vasoconstriction, increased heart rate, blood diversion
Adrenal cortex	Glucocorticoids	Steroid	Long-term stress response: increased blood glucose levels, blood volume maintenance, immune suppression
	Mineralocorticoids	Steroid	Long-term stress response: blood volume and pressure maintenance, sodium and water retention by kidneys
Gonads			
Testes	Androgens	Steroid	Reproductive maturation, sperm production
Ovaries	Estrogens	Steroid	Reproductive maturation, regulation of menstrual cycle
	Progesterone	Steroid	Regulation of menstrual cycle
Pineal gland	Melatonin	Amine	Circadian timing
Thymus	Thymosin	Peptide	Development of T lymphocytes

The collection of endocrine glands control many functions in the body, secreting hormones into the blood that affect target organs. By regulating the functions of organs in the body, these glands help to maintain the body's homeostasis.

The endocrine system works alongside the nervous system to form the control systems of the body.

Negative feedback ensures that, in any control system, **changes are reversed** and returned to the set level such as: blood oxygen, sugar and salt levels.

The Endocrine system

The **pituitary gland**, also known as the hypophysis, is a small pea-sized lump of tissue near to the Hypothalamus (part of the brain that is responsible for the direct control of the endocrine system through the pituitary gland). It secretes:

1. Oxytocin - triggers uterine contractions during childbirth and the release of milk during breastfeeding.
2. Antidiuretic hormone (ADH) - prevents water loss in the body by increasing the re-uptake of water in the kidneys and reducing blood flow to sweat glands.
3. Thyroid stimulating hormone (TSH) - responsible for the stimulation of the thyroid gland and stimulates metabolism.
4. Adrenocorticotropic hormone (ACTH) - stimulates the adrenal cortex, the outer part of the adrenal gland, to produce its hormones.
5. Follicle stimulating hormone (FSH) - stimulates an egg to mature in the ovary. Stimulates the ovary to release oestrogen.
6. Luteinizing hormone (LH) - stimulates the release of a mature egg at ovulation. Stimulates the ovary release progesterone.
7. Human growth hormone (HGH) - affects many target cells throughout the body by stimulating their growth, repair, and reproduction.
8. Prolactin (PRL) - has many effects on the body, chief of which is that it stimulates the mammary glands of the breast to produce milk.

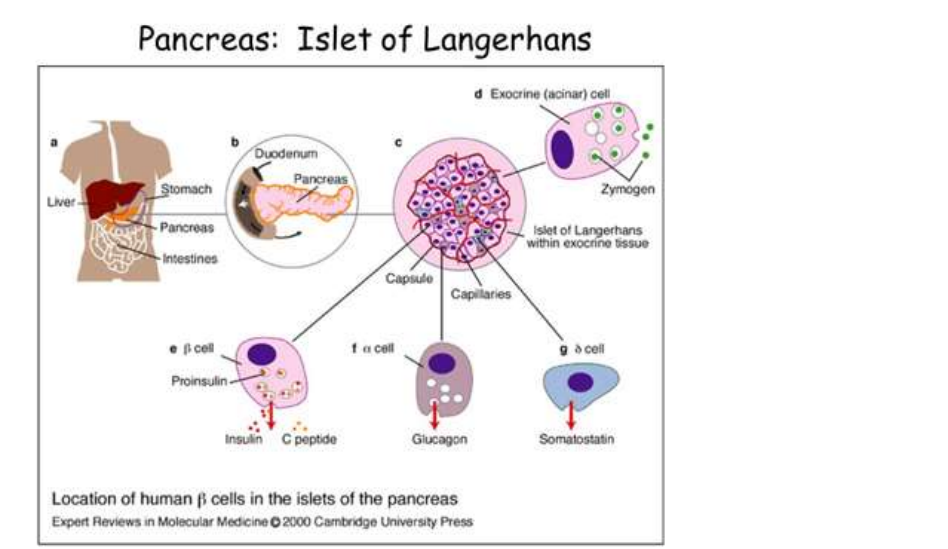
The Endocrine system

Other glands:

- The T**hyroid gland** produces three major hormones: Calcitonin (reduce calcium ions in the blood if they rise above a certain level), Triiodothyronine and Thyroxine.
- The **gonads** (ovaries in females and testes in males) are responsible for producing the sex hormones of the body. These sex hormones determine the secondary sex characteristics of adult females and adult males.
- The **pineal gland** produces the hormone melatonin that helps to regulate the human sleep-wake cycle known as the circadian rhythm.
- The **adrenal glands** regulate and maintain many of your internal processes—from metabolism to the fight-or-flight response.
- The T**hymus** produces hormones called thymosins that help to train and develop T-lymphocytes during foetal development and childhood. The T-lymphocytes produced in the thymus go on to protect the body from pathogens throughout a person's entire life. The thymus becomes inactive during puberty and is slowly replaced by adipose tissue throughout a person's life.
  The **parathyroid glands** are four small masses of glandular tissue found on the posterior side of the thyroid gland.

The Endocrine System

The **pancreas** is a large gland located in the abdominal cavity close to the **stomach**. The endocrine cells are found in small groups throughout the pancreas called **islets of Langerhans (two types – alpha and beta).**

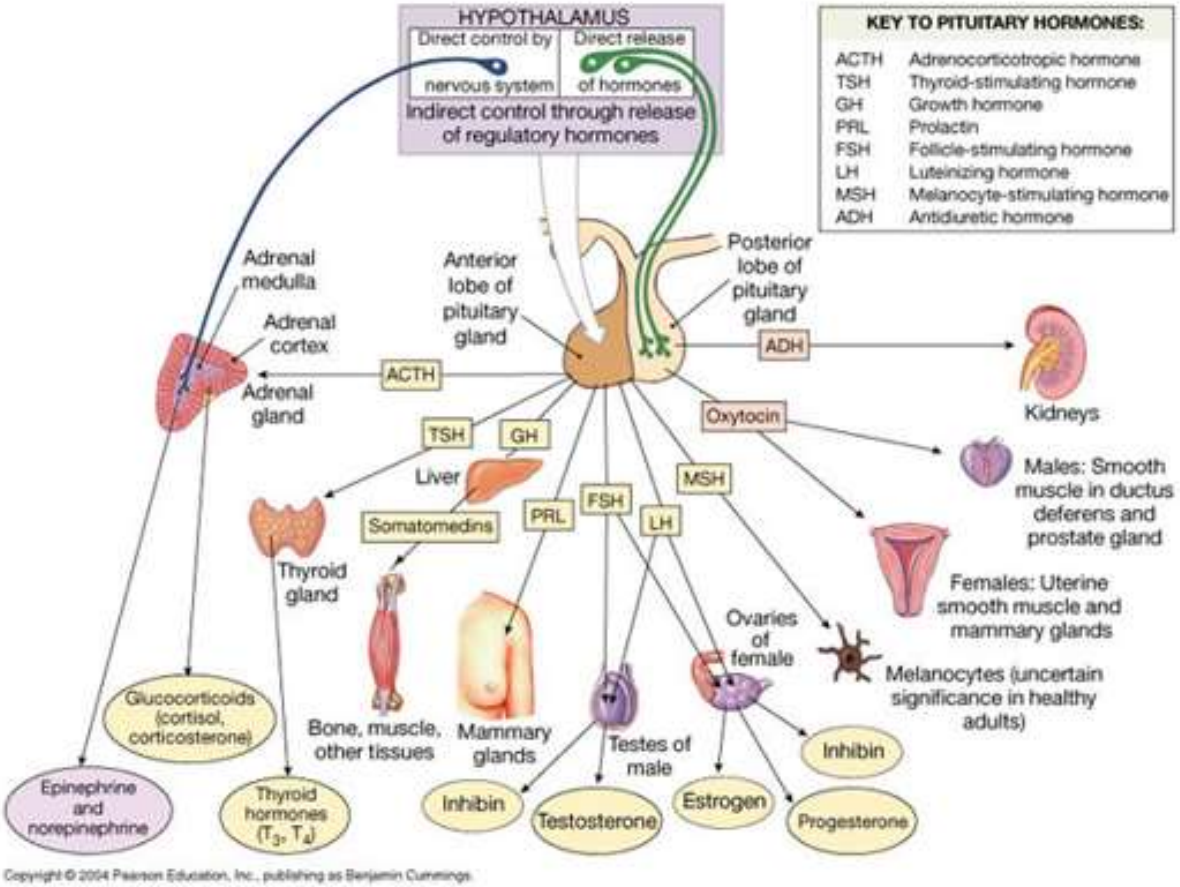


http://slideplayer.com/slide/4767187/15/images/15/Pancreas:+Islet+of+Langerhans.jpg (accessed 20th June 2017)

The alpha cells produce the hormone glucagon, which is responsible for raising blood glucose levels. Glucagon triggers muscle and liver cells to break down the polysaccharide glycogen to release glucose into the bloodstream.

The beta cells produce the hormone insulin, which is responsible for lowering blood glucose levels after a meal. Insulin triggers the absorption of glucose from the blood into cells, where it is added to glycogen molecules for storage.

Endocrine system- Summary



https://cellularphysiology.wikispaces.com/file/view/.jpg **(accessed 20th June 2017)**

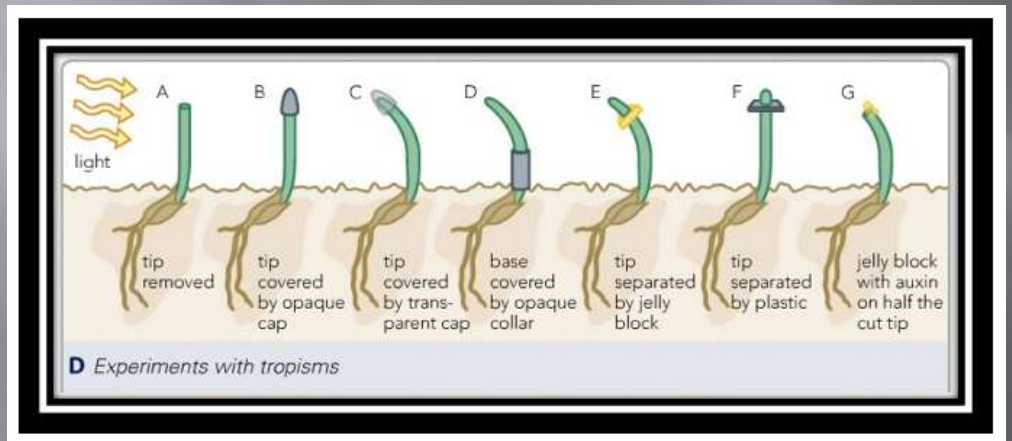
Plant Hormones

Physiological response is controlled by the plant hormone growth regulator **auxin**.

When light strikes one side of a stem, auxin accumulates in the shaded side, causing the cells there to grow at a faster rate and so the plant is forced to bend towards the light.

A **tropism** is a growth response to an external stimulus.

Phototropism is the growth response of a plant to light and is exhibited by sun-loving species. An example of phototropism is when a plant is placed indoors, near a window. Stem curvature takes place as the plant grows towards the light.



http://1.bp.blogspot.com/tropism+experiment.jpg (accessed 20th Jue2017)

Some of the earliest experiments on phototropism were carried out by Charles Darwin.

Geotropism or gravitropism are the names given to this physiological process. Most roots are positively geotropic and so they grow in the direction of gravity. Stems are typically negatively geotropic, growing in the opposite direction to the gravitational force.

Plant Hormones (and uses)

Auxins (such as IAA): growth promoters – the principal function of auxin is to stimulate increases in cell length, especially near stem and root tips (meristems).

The family of **Gibberellins** have a similar effect to that of auxins; they promote cell division and elongation. The major difference is that gibberellins do not inhibit growth. Gibberellic Acid (GA) is an example of one of the gibberellin family.

The effect of increasing gibberellin is to produce more lateral growth. Gibberellins are also responsible for promoting growth in the embryo of a seed.

(Cytokinins are growth promoters – stimulate cell division and differentiation).

Synthetic Plant Growth Regulators:

These are **inorganic substances** which are manufactured by the agrochemical industry that affect plant growth and are used for a variety of purposes:

Rooting Powder: increases the success of stem cutting by promoting extensive early rooting.

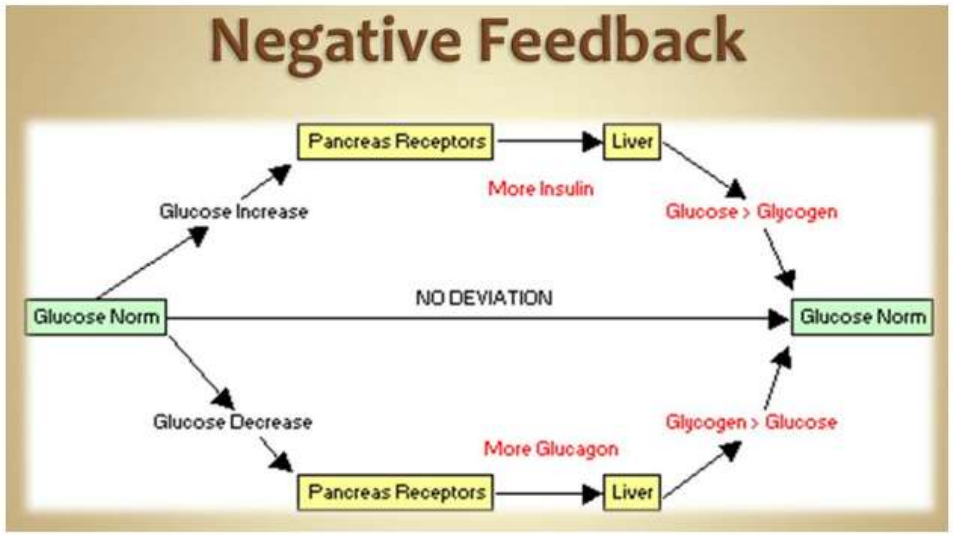
Auxin: as a selective weed killer to reduce competition and promote crop growth.

Homeostasis

Homeostasis is how the body keeps internal conditions the same using receptors (via a processing centre) and effectors (for example the endocrine system).

Scientists describe it as the maintenance of a **constant internal environment**.

Examples of things that the body keeps the same are: Body temperature at **37°C** and the **amount of water, pH and blood glucose** inside our body using Negative Feedback.



http://4.bp.blogspot.com/-IYYC7Mc97BI/FZIPO-AUy_E/s1600/Slide4.JPG (accessed 20th June)

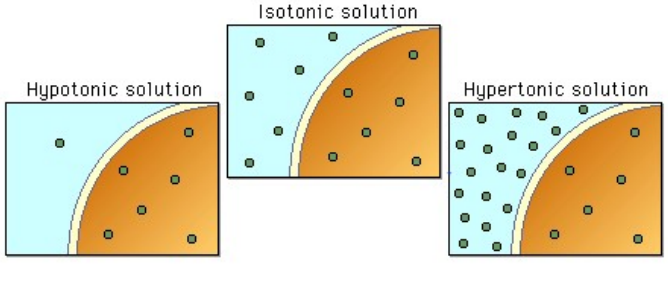
In negative feedback, any change or deviation from the normal range of function is opposed, or resisted enabling the return of normal conditions.

Homeostasis

The skin is an important organ in maintaining temperature. It has sweat glands for heat relief and small hairs to facilitate heat retention (vasodilation and vasoconstriction of arterioles). The hypothalamus and skin combined is the thermoregulatory centre.

Without this temperature constant, it is likely that dehydration (resulting in shock, fainting, confusion or stroke) and hypothermia would occur.

High or low Blood glucose levels (islets of langerhans / pancreas) can also result in feeling unwell, shock or much worse if suffering from type 1 or type 2 diabetes.



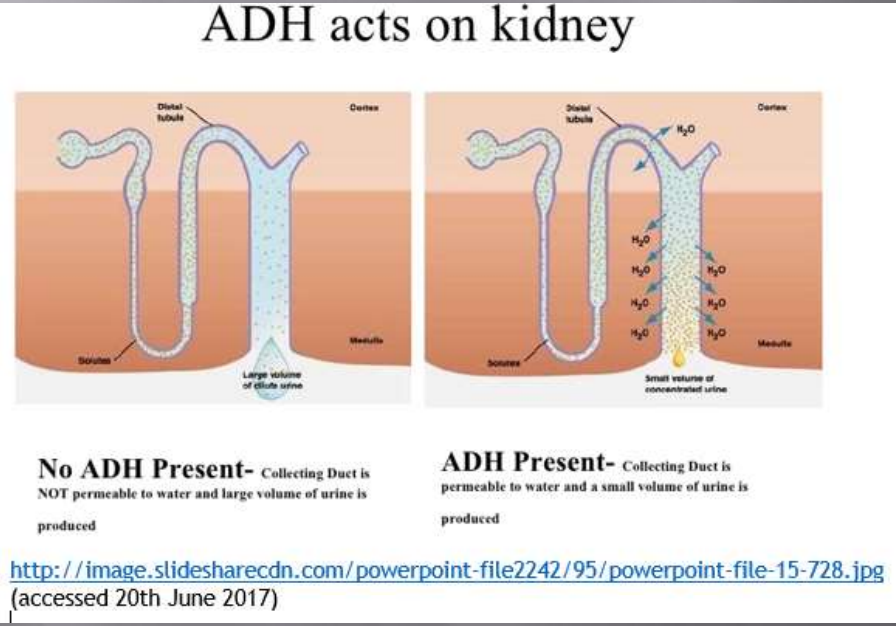
http://www.phschool.com/science/biology_place/biocoach/biomembrane1/solutions.html (accessed 20th June 2017)

Water potential in cells, red blood cells and tissue fluid must also be maintained.

Too little (can cause shrinkage) and too much water (potential outside cell) can cause lysis (cell burst).

Homeostasis

Kidneys balance bodily fluids (through **nephron filters**), process waste (urea) and retain certain useful mineral ions and proteins. The permeability of the kidney tubules can be altered by Anti-diuretic hormone secreted by the pituitary gland using neg feedback.



http://image.slidesharecdn.com/powerpoint-file2242/95/powerpoint-file-15-728.jpg (accessed 20th June 2017)

Dehydration can be caused by high temperatures, over exercise, being poorly (sickness and diarrhoea) and over consumption of alcohol and drugs.

Genome and Gene Expression

The Genome refers to the entire genetic material of an organism which is composed of DNA.

DNA is a double helix made of two polymer strands linked by hydrogen bonds between complementary base pairs.

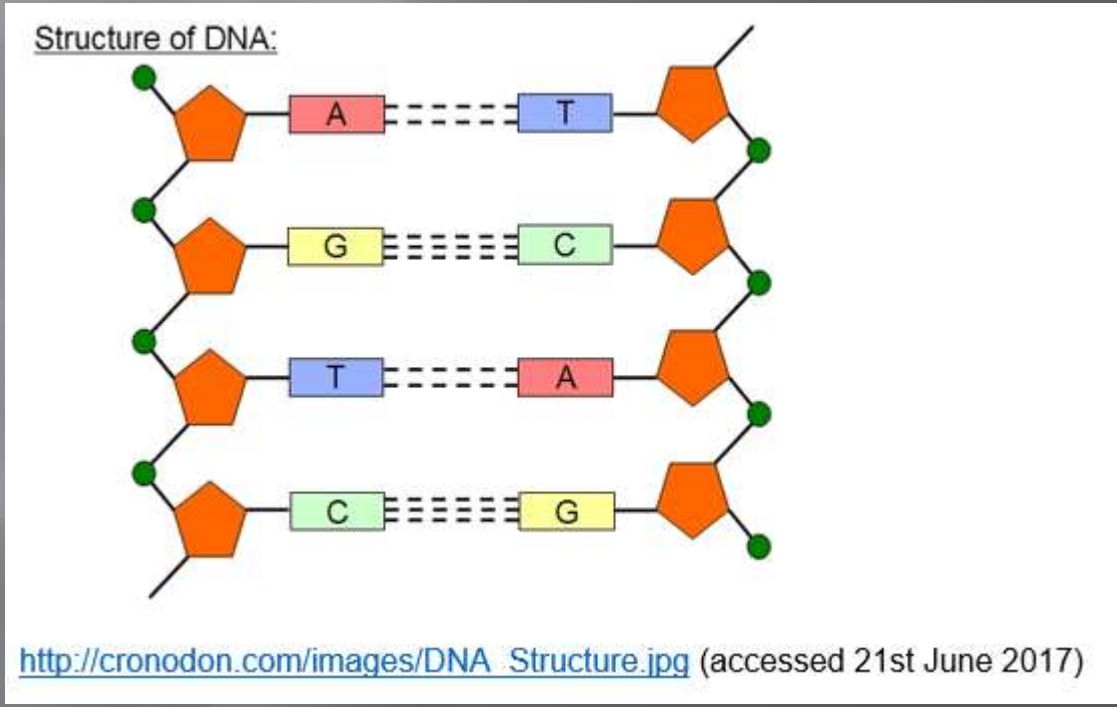
A nucleotide of DNA is composed of three components:

A sugar – deoxyribose, linked to a phosphate group via a covalent bond and a nitrogenous base (A, T, G or C). Bases A & T fit together (complementary pairing) and bases C & G are fit together.

Two nucleotide bases at opposite ends are linked via hydrogen bond. The strong ‘sugar-phosphate backbone’ creates the DNA chain double helix structure.

DNA

Inside the nucleus of a human cell‘s DNA there are 3 billion base pairs, storing its individual blueprint (info, amino acid sequence etc).



http://cronodon.com/images/DNA_Structure.jpg (accessed 21st June 2017)

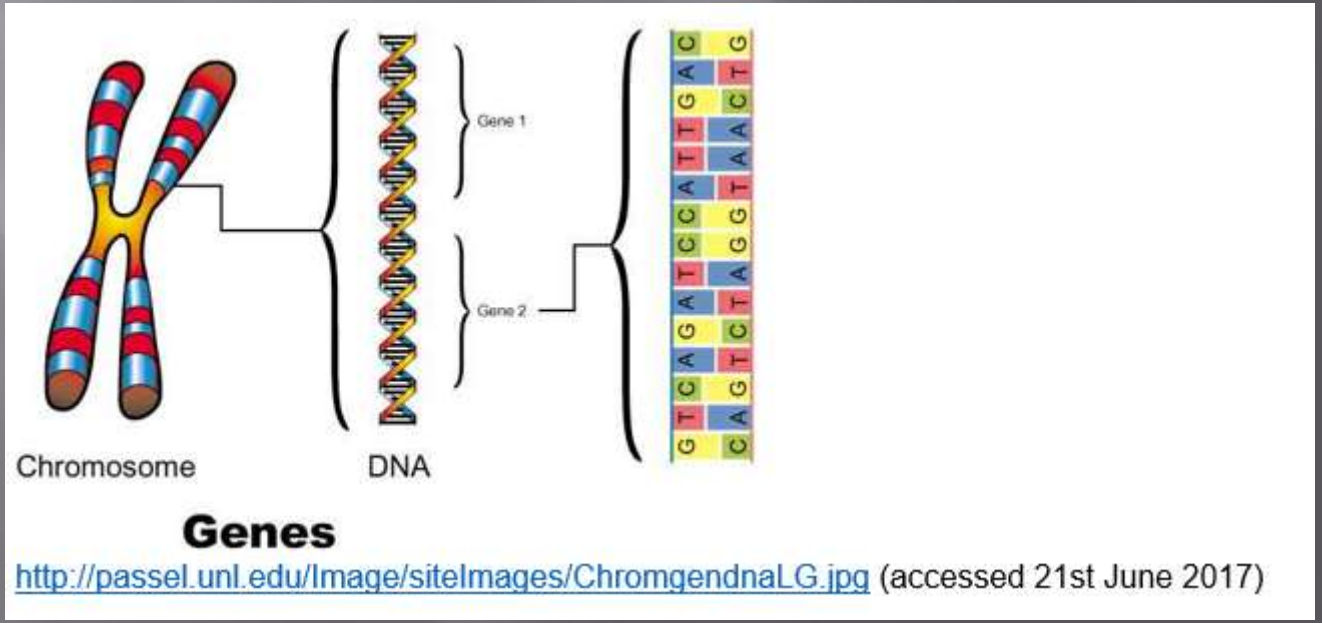
Genes

During cell replication, chromosomes are formed from the long threads of condensed DNA (and proteins).

A **gene** is a length of DNA that codes to produce a specific protein.

Different variants of genes account for many of the differences between individuals.

Chromosomes contain the genes and normal body cells contain two sets, one from each parent. A human cell contains 23 pairs of chromosomes.



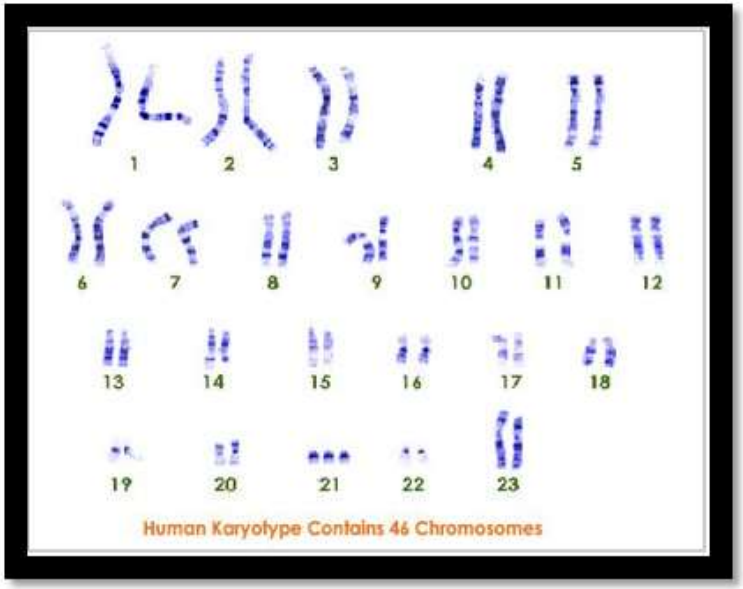
Genes

http://passel.unl.edu/Image/siteImages/ChromgendnaLG.jpg (accessed 21st June 2017)

Genes

Gametes (male or female germ cell) can unite with another in sexual reproduction to form a zygote. Gametes are haploid (containing only 23 chromosomes).

A karyotype is the number and appearance of chromosomes in the nucleus of a eukaryotic cell (or the complete set of chromosomes in an individual organism).

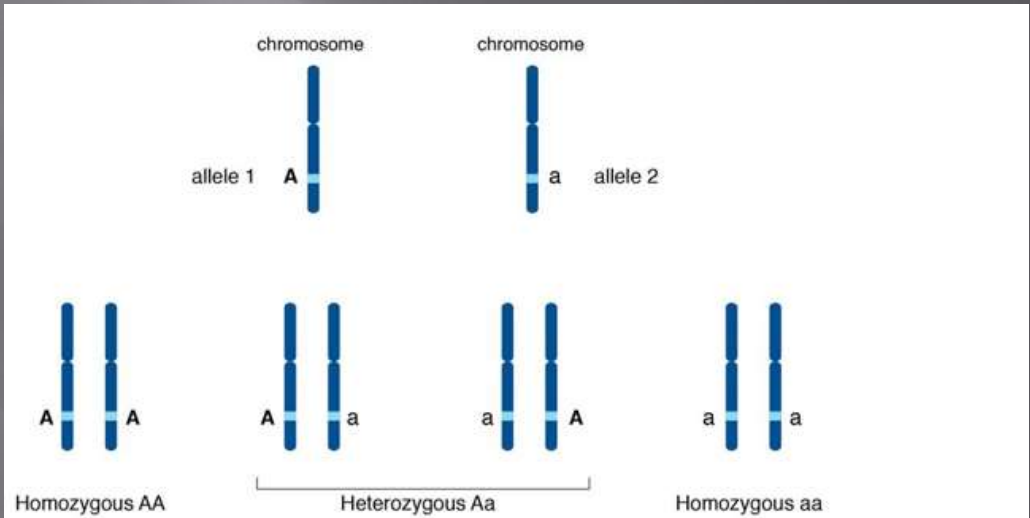


http://images.tutorvista.com/cms/images/123/human-chromosomes.jpeg (accessed 21st June 2017)

Inheritance

Homologous chromosomes (**chromosome** pairs that are inherited from each parent) have the same arrangements of genes (loci).

Alleles are gene variants / **different forms of a gene. They can be dominant or recessive.** If the alleles are identical the individual is **homozygous**, if they are different it is **heterozygous**. The alleles are given letters as symbols for example bB in this case.



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Genotype and Phenotype

The Genotype is the genetic makeup and it directly influences the code for the Phenotype (observed features) i.e. eye colour:

The dominant allele is always expressed BB (brown eyes).

The recessive alleles are expressed (bb) if there are no dominant alleles present.

Genotype	Phenotype
BB	Brown Eyes
Bb	Brown Eyes
bb	Blue eyes

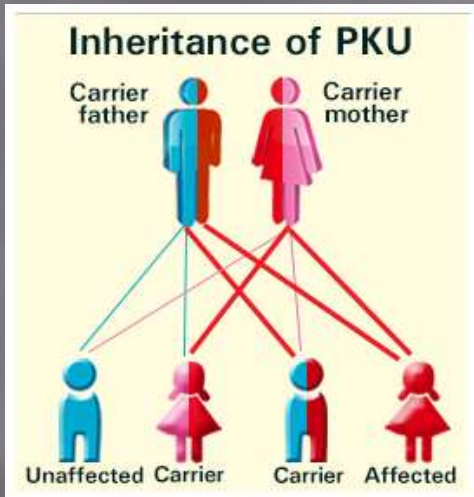
The Genotype interacts with the Internal and External Environment (water, nutrition, Temperature hormones) to influence development of Phenotype.

Identical twins share the same Genotype and placenta, However, different environmental conditions will effect the Phenotype.

Genetic disorders

The different forms of genes for eye colour are caused by changes (mutations) in the DNA code. There also may be a faulty version of a gene that results in a medical condition, and a normal version that may not cause health problems.

Many genes code for enzymes. **Phenylketonuria (PKU) is a rare, but serious, inherited disorder.** People with PKU can't break down (the amino acid) phenylalanine, which then builds up in the blood and brain. This can lead to brain damage.



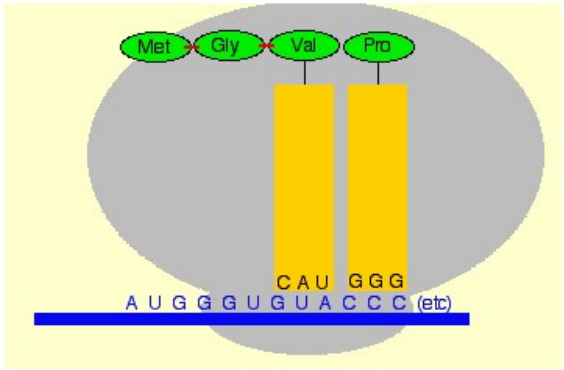
http://www.buzzle.com/img/articleImages/519138-41710-0.jpg (accessed 22nd June 2017)

Deoxyribonucleic Acid

DNA (and its four bases) – carries the code for 20 (essential and non-essential) amino acids. Three bases code for one amino acid (potentially 64 combinations can be found).

In replication, the code is carried and transcribed by mRNA. mRNA contains base molecule Uracil (instead of Thymine) so instead of U pairing with G, U pairs with A in mRNA.

Once created, the new RNA molecule migrates from the nucleus into the cells cytoplasm finding ribosomes on the Rough Endoplasmic Reticulum to form new proteins.



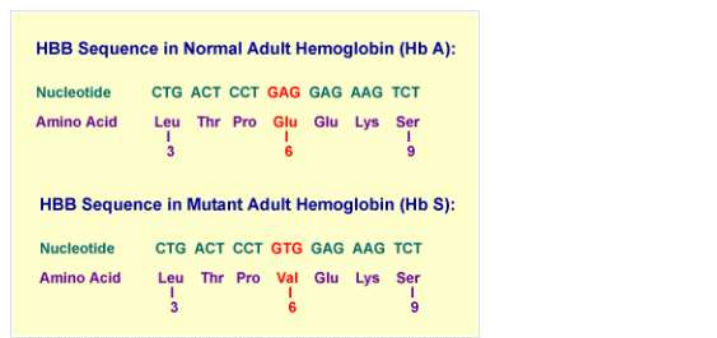
http://chemguide.co.uk/organicprops/aminoacids/dna5.html (accessed 22nd June 2017)

Free amino acids find their way to the ribosome and form peptide bonds. The new protein is made.

The amino acid sequence determines the shape of the protein.

Genetic disorders and mutations

Mutations may occur which in turn effect the amino acid sequence of a protein. This will affect its shape and may be nonfunctional. Here is an example: Sickle Cell Anemia (in Red Blood Cells, making them less effective in carrying oxygen around the body).

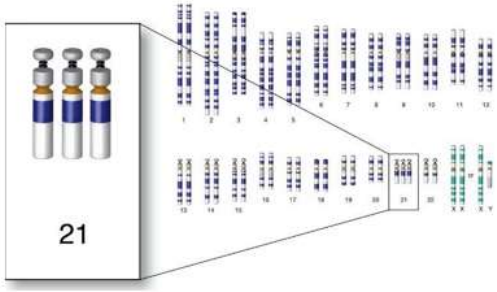


Glutamic acid is replaced by valine in mutant sickle cell betaglobin.

http://sicklecellanemiahonorsbio.weebly.com/genetic-cause.html (accessed 22nd June 2017)

This condition is inherited (chromosome No. 11) and the trait recessive.

Chromosome mutations such as Downs Syndrome (chromosome number 21 having one extra chromosome).



http://www.washington.edu/news/files/large-down-syndrome-trisomy.jpg (accessed 22nd June 2017)

Mutations produce genetic variation (alleles) and are exchanged between homologous chromosomes during meiosis and combine to form new gametes.

Future medicine

Understanding the genome has importance in the future of medicine for human diseases in individuals.

Genetic screening (diagnostic tests on genetic sequences) can identify inherited disorders and identify healthy siblings (potential donors of stem cells).

Increased understanding on cancer genomes will enable rapid diagnosis and treatment (i.e. cancer cells to be switched off).

Gene therapy: an experimental technique that uses genes to treat or prevent disease. Researchers are testing several approaches to gene therapy, including:

- Replacing a mutated gene that causes disease with a healthy copy of the gene.
- Inactivating, or “knocking out,” a mutated gene that is functioning improperly.
- Introducing a new gene into the body to help fight a disease.

The secret of how salamanders successfully regrow body parts is being unravelled by researchers in a bid to apply it to human limbs.

Reproduction

- Sexual – the fusion of two haploid gametes at fertilization to produce a zygote (homologous chromosomes swap genetic material ensuring that offspring are genetically different).

Flowering plants: For **fertilization** to take place, the plant must be pollinated (insects or wind) by a pollen grain of the same species (different or same flower). When the pollen grain lands on the stigma it creates a pollen tube through the style. This extends down to an ovule in the ovary, containing an ovum. The male gamete moves down the pollen tube and fertilizes the ovum to create a zygote (seed).

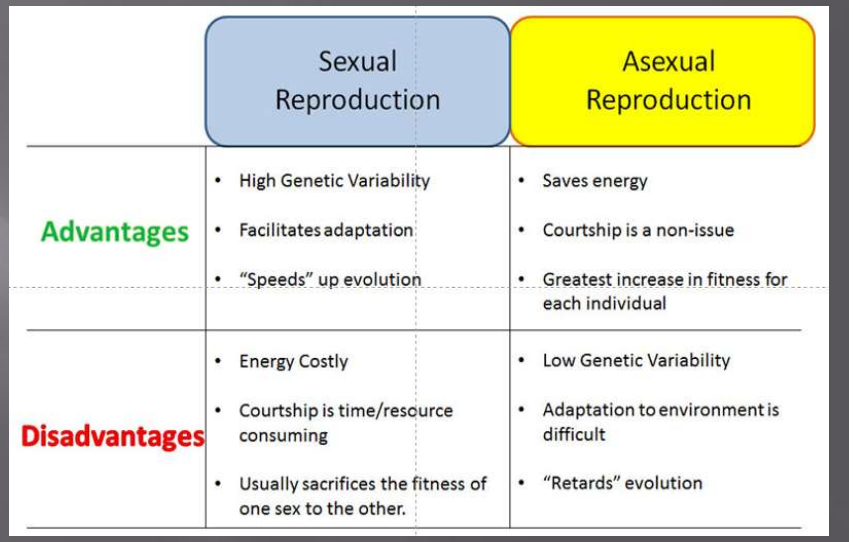
- Asexual – genetically identical daughter cells from one division resulting in a clone cell.

This type occurs in Protists (binary fission) and Fungi (sporation). In some green plants such as strawberry (*fragaria annanassa)*, potatoes, lady's mantle (alchemilla mollis) runners, underground stems and tubers form new daughter plants (vegetative propagation).

The lack of variation or genetic mixing, sometimes has its benefits. Large numbers of offspring can be generated faster to reduce competition for nutrients and water.

Differences: Sexual and Asexual reproduction

Asexual Reproduction	Sexual Reproduction	
Number of organisms involved	One parent needed	Two parents are required to mate
Cell division	Cells divide by Fission, budding, or regeneration	Cells divide by Meiosis
Types	Budding, vegetative reproduction, fragmentation, spore formation	Syngamy and conjugation
Advantages	Time Efficient; no need to search for mate, requires less energy	Variation, Unique., organism is more protected
Disadvantages	No variation - if the parent has a genetic disease, offspring does too.	Requires two organisms, requires more energy
Evolution	There is very little chance of variation with asexual reproduction. Mutations in DNA can still occur but not nearly as frequently as in sexual reproduction.	Sexual reproduction leads to genetic variation in new generations of offspring. This is fundamental to evolution.
Involvement of sex cells	No formation or fusion of gametes (sex cell)	Formation and fusion of gametes (sex cell) occurs
Found in	Lower organisms	Higher invertebrates and all vertebrates
Unit of reproduction	May be whole parent body or a bud or a fragment or a single somatic cell	Gamete
Time taken	Asexual reproduction is completed in a very short period of time.	Sexual reproduction can take several months to complete.
Number of offspring	Two or more	One or more

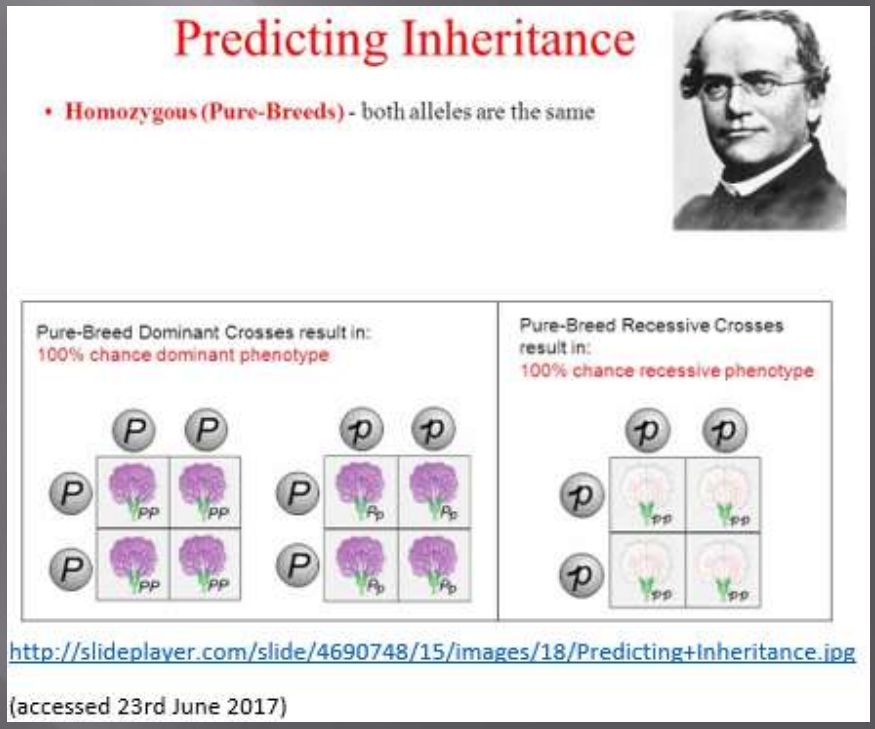


Inheritance

We have two sets of chromosomes in each cell, inherited by two sets of genes, each locus having two copies. There are three possible outcomes in a gene in dominated phenotype for example Brown (dominant allele) or Blue (recessive) eyes (slide 66).

In pure breeding: Dominant phenotype (homozygous RR) with recessive phenotype (homozygous rr). The dominant is expressed in offspring as Rr, but still carry a recessive gene, which may be passed to the next generation and so on.

	R	r
R	RR	Rr
r	Rr	rr



http://slideplayer.com/slide/4690748/15/images/18/Predicting+Inheritance.jpg

(accessed 23rd June 2017)

Inherited Diseases

Cystic fibrosis is caused by a faulty gene that is inherited from both parents. This can happen if the parents are "carriers".

It's estimated that around 1 in every 25 people in the UK are carriers of the faulty gene that causes cystic fibrosis. If both parents are carriers, there's a:

- 25% chance that each child they have will not inherit any faulty genes and won't have cystic fibrosis or be able to pass it on (FF).
- 50% chance that each child they have will just inherit one copy of the faulty gene from one parent and be a carrier (Ff).
- 25% chance that each child they have will inherit copies of the faulty gene from both parents and will have cystic fibrosis (ff).

	F	f
F	FF	Ff
f	Ff	ff

f is cystic fibrosis allele

The faulty gene affects the movement of salt and water in and out of cells. This, along with recurrent infections, can result in a build-up of thick, sticky mucus in the body's tubes and passageways – particularly in the lungs and digestive system. http://www.nhs.uk/Conditions/Cystic-fibrosis/Pages/Causes.aspx

Other inherited outcomes

In Co-dominance both alleles are dominant which leads to both alleles being expressed to a certain point. In some flowers, the cross is the same as the one above except the resulting heterozygous flower is co-dominated by the two colours, red and white, both colours are partially expressed resulting in pink flowers, resulting in three possibilities.

Another example of this is blood type. When two dominant alleles are present, A and B blood types, both are expressed. This results in the "AB" blood type (single gene inheritance).

Single gene inheritance: These traits are controlled by one gene, with other genes and outside factors having very little influence. Traits that are inherited in this way are typically discrete and are expressed as a few distinct phenotypes (either a person has the trait or they don't).

Multiple gene inheritance: height, hair colour, skin colour or risk of developing disease (heart / cancer) all can be found on multiple genes.

Sex related

An individual's sex is determined by the sex chromosomes. Most people have two sex chromosomes, one that is inherited from their mother and one that is inherited from their father. Females have two X chromosomes (XX) and males have one X chromosome and one Y chromosome (XY).

Conditions caused by changes ("mutations") in genes located on the X chromosome are considered X-linked.

Inheritance of sex is expressed:

	X	X
X	XX	XX
Y	XY	XY

Y – determines maleness on chromosome number 23.

Sex linked alleles are carried on the X chromosome (disease traits) such as colour-blindness and haemophilia A and B.

More than 100 X-linked inherited human disorders or traits have now been identified.

A brief history of Genetics

1865 – Gregor Mendel. He stated three generalizations about the way characteristics are transmitted from one generation to the next in pea plants by observing the behavior of chromosomes during meiosis and fertilization.

1910 – T H Morgan proved that genes are located on chromosomes, so could map the position of the genes on the chromosome.

He was interested in how traits were inherited and distributed in developing organisms, and he wondered what caused a fruit fly's eyes to deviate from the norm. The white-eyed fruit fly (normally red), helped to confirm the chromosome theory. In doing so, Morgan was the first person to definitively link the inheritance of a specific trait with a particular chromosome.

1928 – Griffiths was the first person to experiment suggesting that bacteria are capable of transferring genetic information.

Bacterial Transformation
Here's what Griffith did and what he observed -

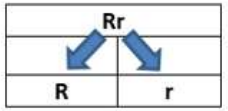
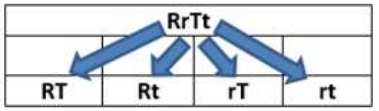
- He injected mice with the Type II-R strain and the mice survived.
- He injected mice with the Type III-S strain and the mice died.
- He heat killed the Type III-S strain and then injected the mice with the dead bacteria and the mice lived.
- He injected dead Type III-S strain and live Type II-R strain into the mice and the mice died.

He then detected the presence of live Type III-S strain bacteria with live Type II-R strain bacteria in the blood of the dead mice.

Mendel's Three Laws of Inheritance

Mendel's research produced three laws of inheritance that are true today.

Summary of the Three Laws

Law of Dominance (Dominate vs Recessive Alleles) In a cross of parents that are pure for contrasting traits, only one form of the trait will appear in the next generation. All offspring will be hybrid for a trait and will have only the dominant trait express the phenotype. The phenotype trait that is NOT expressed in the hybrid is called recessive.	Phenotype for **RR is Round.** Phenotype for **Rr is Round.** Phenotype for **rr is wrinkled.** Because round is the dominant allele over the wrinkled allele, the hybrid, Rr, will express the dominate trait of round.
Law of Segregation (regarding ALLELES) During the formation of gametes (eggs or sperm), the two ***alleles*** responsible for a particular trait separate from each other. Alleles for a particular trait are then "recombined" at fertilization, producing the genotype for the traits of the offspring.	
Law of Independent Assortment (regarding TRAITS) Alleles for different ***traits*** are distributed to sex cells (& offspring) independently of one another. (**Example**: the trait for height and the trait for color of peas do not depend on each other. These traits are independent of each other and can independently and randomly be distributed into the sperm or egg cells.) (**Note**: as long as any 2 traits are not on the same chromosomes then they can be distributed randomly and independently from each other into the sex cells.)	**R – Round** **T – Tall** **r – Wrinkled** **t – Short** 

http://ellsworthbiology.weebly.com/uploads/4/5/6/3/45636130/2-endel_three_laws_of_inheritance_ans.pdf
(accessed 23rd June 2017)

A brief history of Genetics

1944 – Avery McLeod and McCarty showed that a nucleic acid, deoxyribonucleic acid (DNA), known to be ubiquitous in organisms, was the chemical basis for specific and apparently heritable transformations in bacteria.

Hershey and Chase – used radioactive labels to trace genetic material.

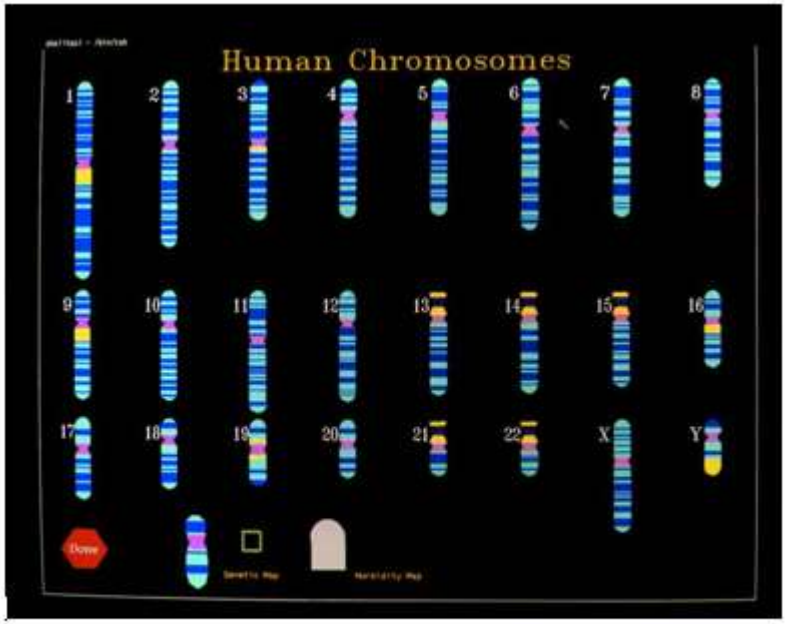
1950 - Erwin Chargaff discovers regularity in proportions of DNA bases for different species. In all organisms he studies, the amount of adenine (A) approximately equals that of thymine (T), and guanine (G) equals cytosine (C).

1953 - Francis Crick and James Watson discover that the chemical structure of deoxyribonucleic acid (DNA) meets the unique requirements for a substance that encodes genetic information.

They clearly modelled a 3-D double helix, DNA was the chemical substance of genes. In 1962 Crick and Watson were awarded the Nobel Prize in Physiology or Medicine.

1972 – Walter Friers sequence a gene. This lead the way for the human genome project which was completed in 2003.

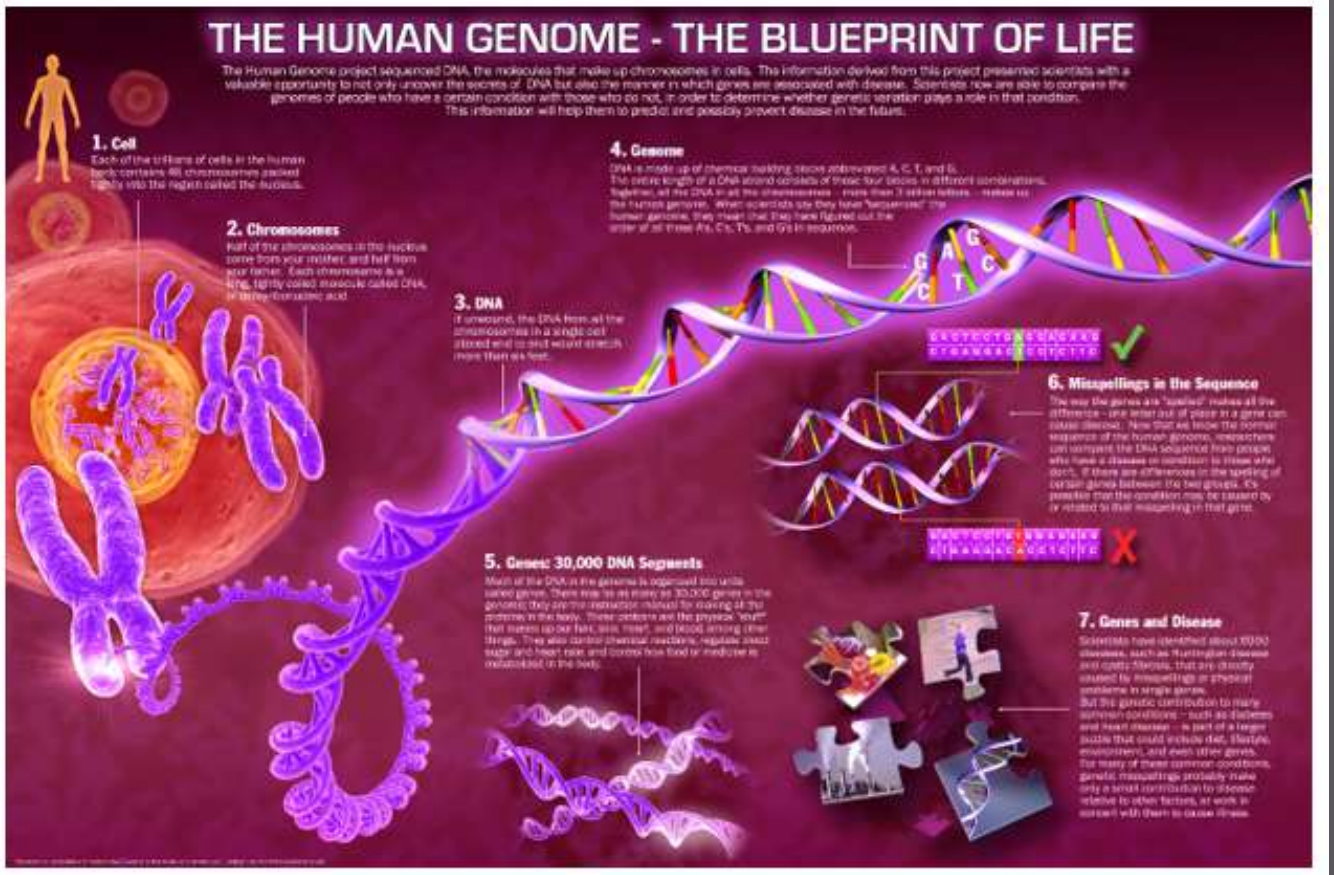
The Human Genome Project (HGP) was one of the great feats of exploration in history - an international research effort to sequence and map all the genes - together known as the genome of members of our species, *Homo sapiens*. The HGP gave us the ability, to read nature's complete genetic blueprint for building a human being.



http://turbulence.org/blog/images/2011/04/human-genome-project.jpg

(accessed 23rd June 2017)

http://www.infohow.org/wp-content/uploads/2012/11/The-Human-Genome.jpg (accessed 22nd June 2017)



Species variation

A difference between cells, individual organisms, or groups of organisms of any species. This can be caused either by genetic differences (genotypic variation) or by the effect of environmental factors on the expression of the genetic potentials (phenotypic variation) for example colour or camouflage.

Polymorphism, a discontinuous genetic variation resulting in the occurrence of several different forms or types of individuals among the members of a single species. It divides the individuals into two or more sharply distinct forms. Examples are: the different blood type, eye colour and gender in humans.

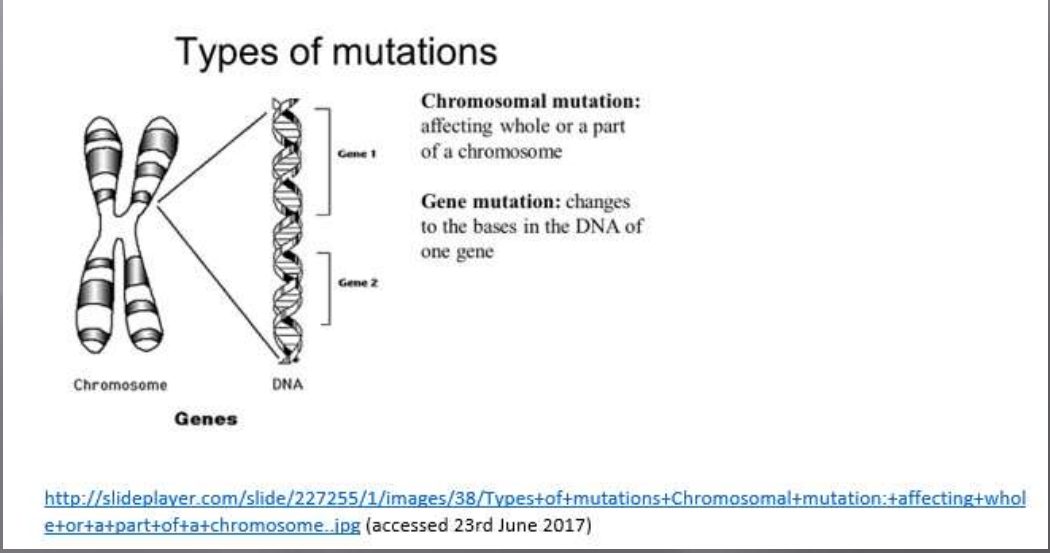
In continuous variation, the individuals do not fall into sharp classes but instead are placed amongst a wide range – i.e. the smooth graduation of height among individuals of human populations. Shoe size and weight also fall within the category.

Sexual dimorphism, the differences in appearance between males and females of the same species. For example colour (plumage in birds) and size. These are caused by the inheritance of one or the other sexual pattern in the genetic material.

Gene mutations

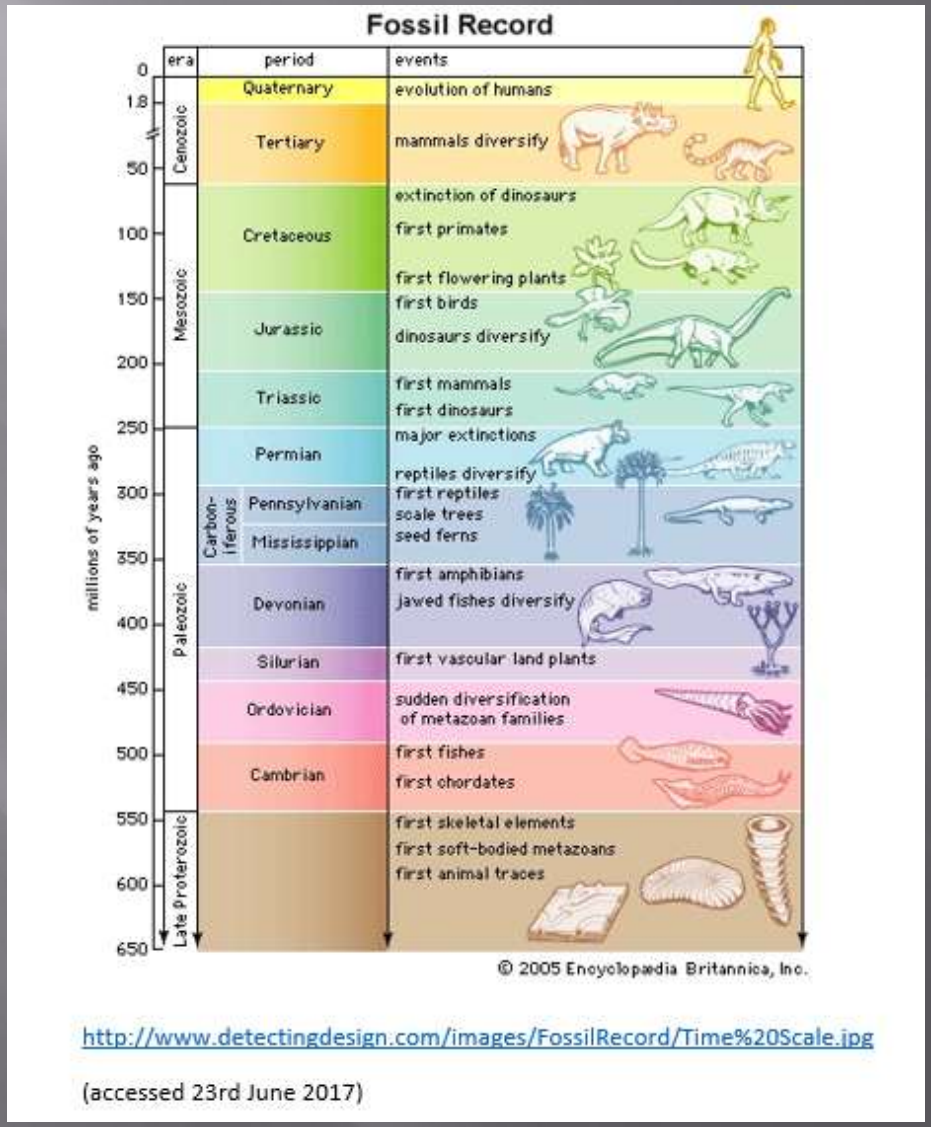
Single gene mutations in a base of the DNA can alter the amino acid sequence. These may involve substitution, insertion (some duplication of gene allows new genes to evolve doing no harm) or deletion (some mutations allow genes to be switched on or off).

Different Amino acid can completely alter the protein structure and shape, therefore the function, as an enzyme or metabolite will be changed. Non-functional proteins can produce harmful phenotypes.



http://slideplayer.com/slide/227255/1/images/38/Types+of+mutations+Chromosomal+mutation:+affecting+whole+or+a+part+of+a+chromosome..jpg (accessed 23rd June 2017)

Evidence of Evolution



http://www.detectingdesign.com/images/FossilRecord/Time%20Scale.jpg

(accessed 23rd June 2017)

Evolution

Biogeography is the study of the distribution of species and ecosystems in geographic space. Species (biological communities) on isolated islands are unique following adaptive radiation to new surroundings and niches by Natural Selection. It is important as it sheds light on the natural habitats around the world. It is also essential in understanding why species are in their present locations and in development of the world's natural habitat protection.

Homologies are evidence of evolution from common ancestors. A common example of homologous structures is the forelimbs of vertebrates, where the wings of bats, the arms of primates, the front flippers of whales and the forelegs of dogs and horses are all derived from the same ancestral tetrapod structure.

When comparing structures such as wings, we find that wings in insects (arthropods) are not the same as wings of vertebrates as they do not share a common ancestor.

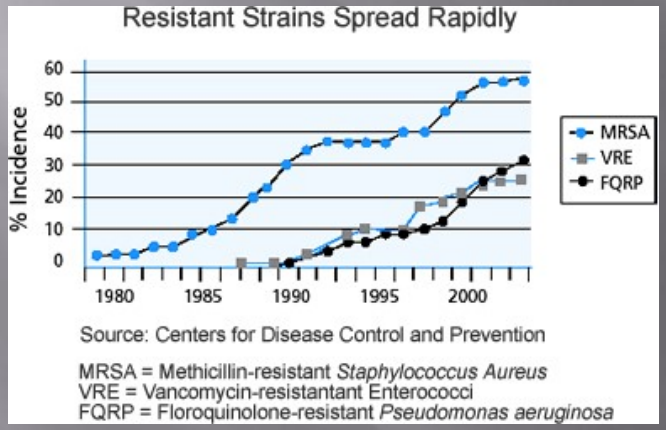
Arthropods (crustaceans, arachnids and myriapods) share common homologous structures such as segmented bodies, jointed limbs and exoskeletons.

Therapods show how wings and feathers evolved in birds (which also lost razor teeth and muscle tails).

Evolution

Pseudogenes are stable and inactive, long-term consequences of earlier mutations that occurred during the process of evolution and so damaged genes rendering them incapable of coding for proteins. Pseudogenes might be considered as analogues of fossils in geology.

Evolution occurs also in bacteria and simple organisms (DNA in plasmids), as discussed, this leading to “superbugs” which may be resistant against antibiotics.



Unwelcomed MRSA strains reproduce rapidly.

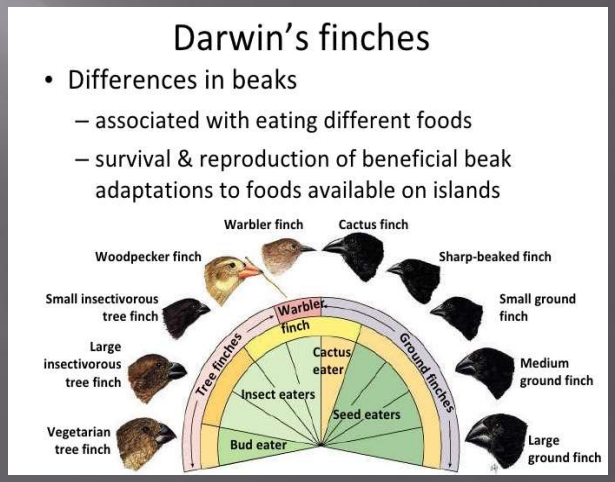
Endogenous retroviruses (ERVs) are elements of the human genome that potentially may act as either **genetic markers** for polymorphisms related to MS, or markers of environmental/endogenous stress.

Charles Darwin

Evolutionary biology explains homologous structures adapted to different purposes as the result of descent with modification from a common ancestor. Homology was explained by Charles Darwin's theory of evolution in 1859, but had been observed before this.

Darwin's theory of evolution explains how species of living things have changed over geological time. Darwin’s finches, although nearly identical in all other ways to mainland finches, had different beaks.

Their beaks had adapted to the type of food they ate to fill different niches on the Galapagos Islands.

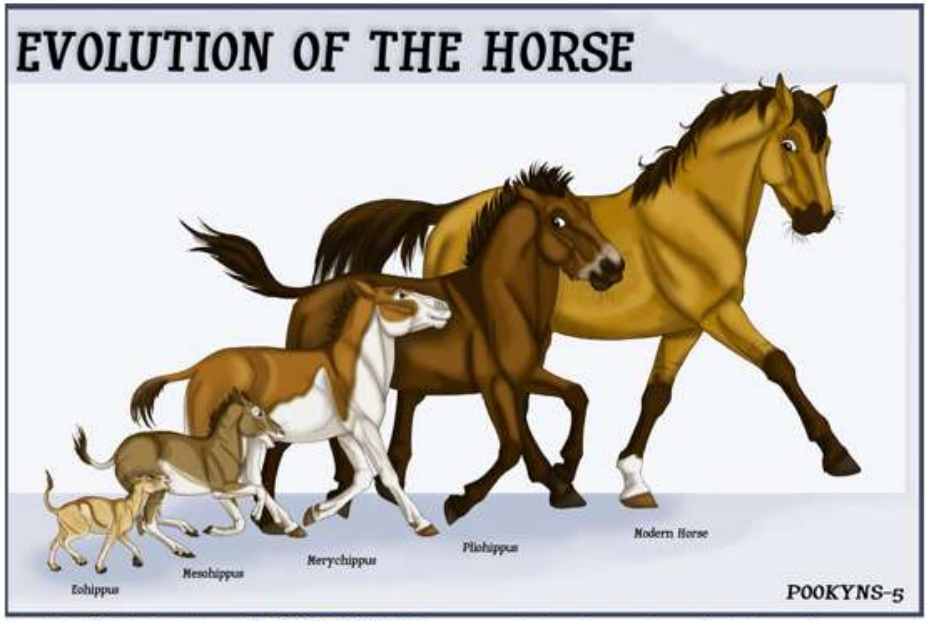


Their isolation on the islands over long periods of time made them undergo speciation. He explained his ideas about evolution in a book called On the Origin of Species, which was published in 1859.

Fossils

Rock layers (sediments) build up over millions of years, preserving bones, teeth, moulds and imprints by mineralisation. The older layers being far deeper and holding more primitive fossils.

Fossil records show how the common horse evolved (losing toes for hooves, developing taller and broader bodies and molar teeth to chew grass).

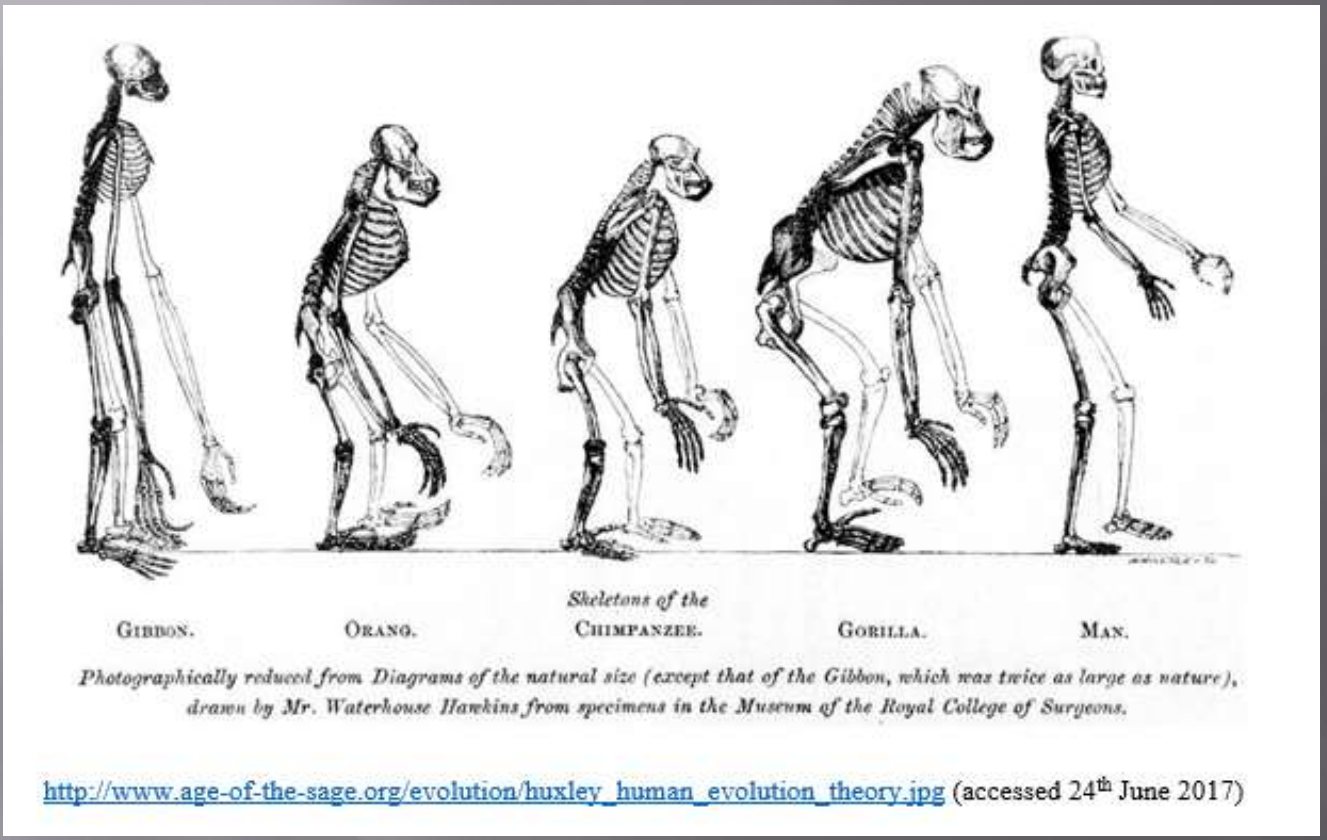


http://img08.deviantart.net/04a6/i/2012/092/7/f/horse_evolution_by_pookyns_5-d4utpxm.jpg
(accessed 24th June 2017)

http://geology.com/articles/green-river-fossils/fossil-horse-lg.jpg

(accessed 25th June 2017)

Evolution of Man



http://www.age-of-the-sage.org/evolution/huxley_human_evolution_theory.jpg (accessed 24th June 2017)

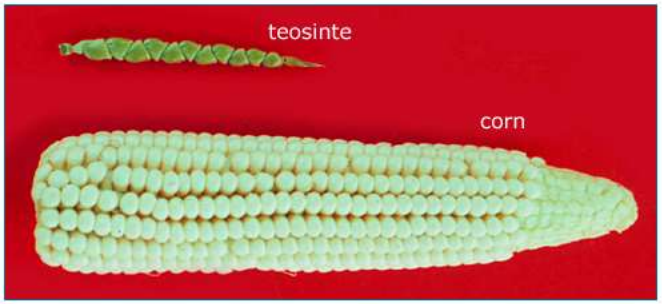
Note transitional forms:

upright posture, increased brain size, reduction in size of jaws and flattened face.

Artificial selection

Artificial selection – dogs being bred for favourable traits etc. is repeated over several generations before pure breed is created.

Wild tomatoes (left) and domestic tomatoes (right).



A "cob" of teosinte alongside a cob of modern corn.

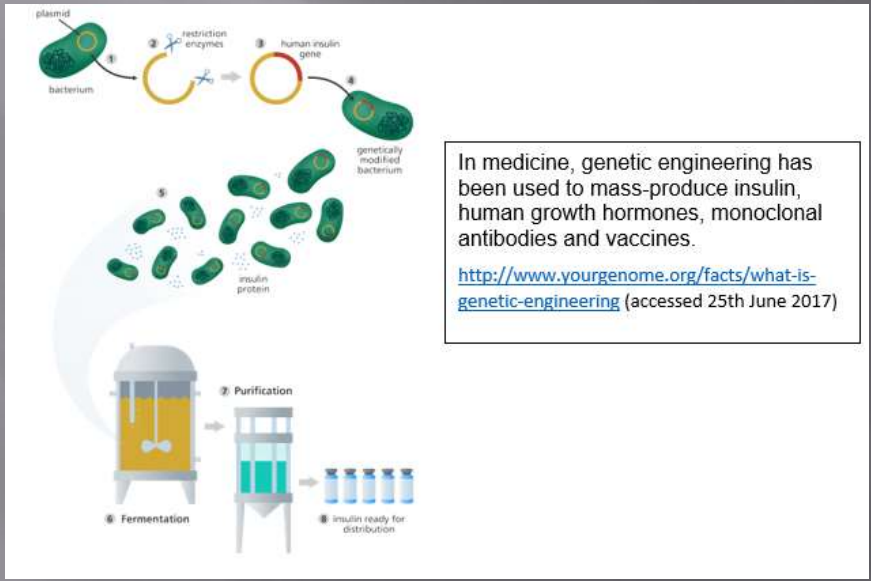
http://evolution.berkeley.edu/evolibrary/news/070201_corn (accessed 24th June 2017)

Crops also can be selected (from wild species) in this way to select for nutritional value, high yield and efficiency. But their low genetic diversity means that they are dependant on herbicides and pesticide application

Genetic Engineering

Genetic engineering has applications in medicine, research, industry and agriculture and can be used on a wide range of plants, animals and microorganisms.

In research, organisms are genetically engineered to discover the functions of certain genes.



In medicine, genetic engineering has been used to mass-produce insulin, human growth hormones, monoclonal antibodies and vaccines.

http://www.yourgenome.org/facts/what-is-genetic-engineering (accessed 25th June 2017)

Genetic engineering is also used in agriculture to create genetically-modified crops. GM plants could someday be used to produce recombinant vaccines i.e. the concept of an oral vaccine expressed in plants (crops) for direct consumption is being examined as a possible solution to the spread of disease in underdeveloped countries.

GM Implications

Potential health risks to humans include the possibility of exposure to new allergens in genetically modified foods, as well as the transfer of antibiotic-resistant genes to gut flora.

Gene transfer of pesticide, herbicide, or antibiotic resistance to other organisms would not only put humans at risk, but it would also cause ecological imbalances, allowing previously innocuous plants to grow uncontrolled, thus promoting the spread of disease among both plants and animals.

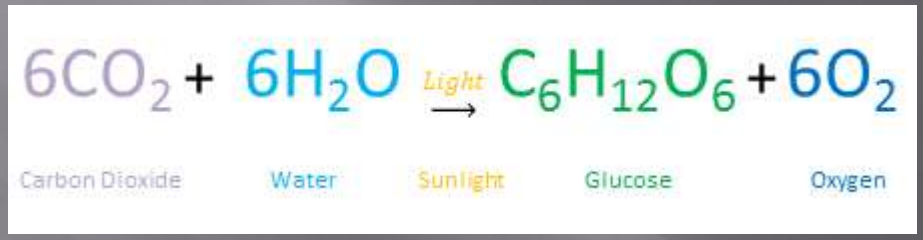
In contrast, the alarming consequences of gene transfer between GMOs and their wild-type counterparts have been highlighted by studying transgenic fish released into wild populations of the same species. The enhanced mating advantages of the genetically modified fish led to a reduction in the viability of their offspring. Thus, when a new transgene is introduced into a wild fish population, it propagates and may eventually threaten the viability of both the wild-type and the genetically modified organisms.

http://www.nature.com/scitable/topicpage/Genetically-Modified-Organisms-GMOs-Transgenic-Crops-and-732 (accessed 25th June 2017)

Producers and Photosynthesis

All green plants photosynthesize for primary production (ultimate biomass). It is the basis of food chains and life on earth.

It is an endothermic reaction – it uses light and heat from the sunlight (water and CO2) to produce chemical energy (Glucose and O2 are biproducts).



It releases oxygen, the air that we breath into the environment and absorbs harmful CO2, important to the carbon cycle and climate regulation.

Photosynthesis not only produces food (glucose, starch), but a variety of other products such as wood for building, paper, rubber and other materials.

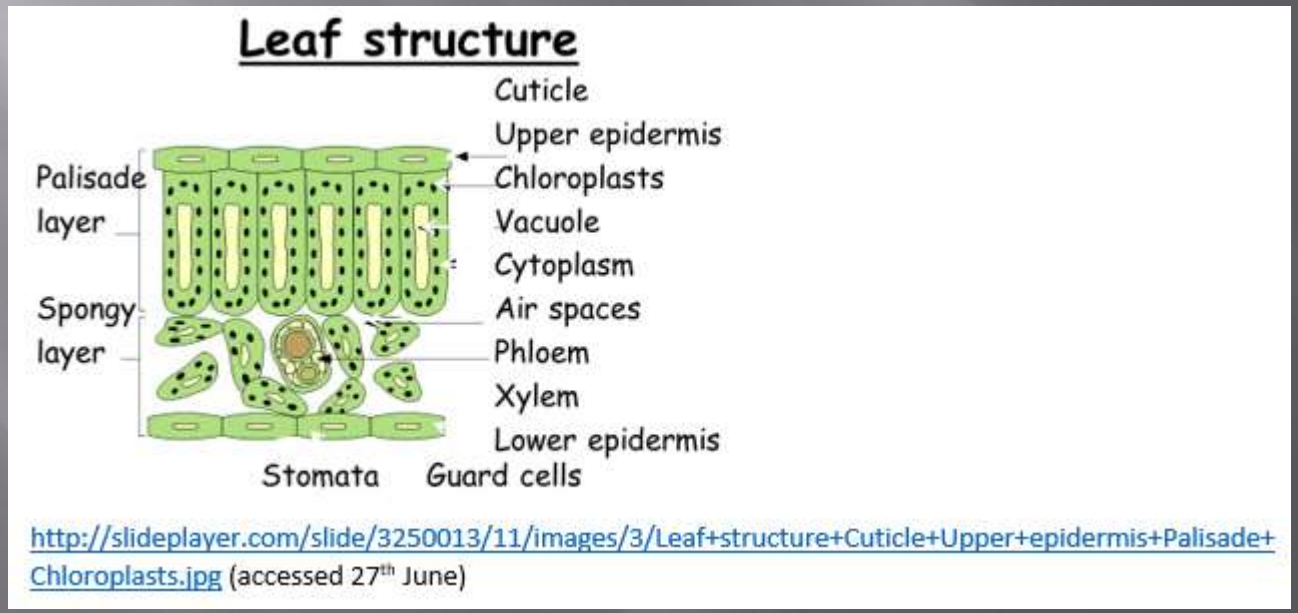
Ancient fossil (as result of prehistoric photosynthesis) fuels such as oil, coal and gas are used in energy / electricity production.

Photosynthesis and the Leaf

The structure of the leaf enables photosynthesis – adapted for maximum efficiency (flat, thin).

Chloroplasts are tightly packed in the palisade mesophyll layer (top of leaf) where light is directly hitting the surface.

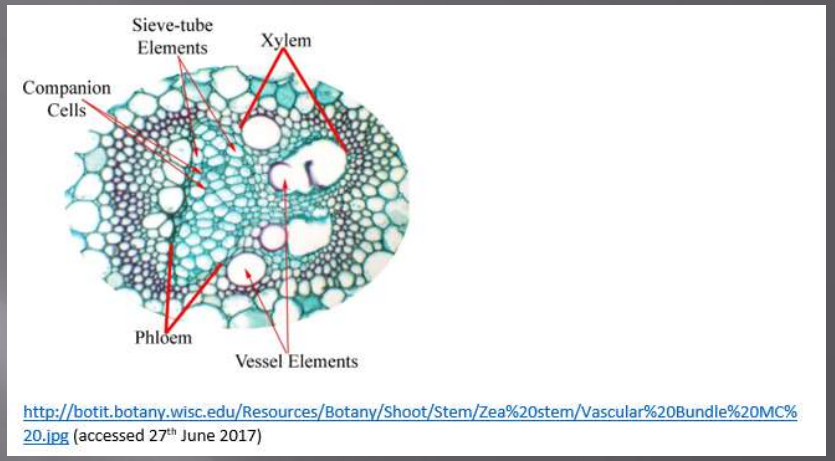
Stomata, guard cells and air spaces located in the lower epidermis enable gas exchange and water vapour movement in and out of the leaf.



http://slideplayer.com/slide/3250013/11/images/3/Leaf+structure+Cuticle+Upper+epidermis+Palisade+Chloroplasts.jpg (accessed 27th June)

Transport and Photosynthesis

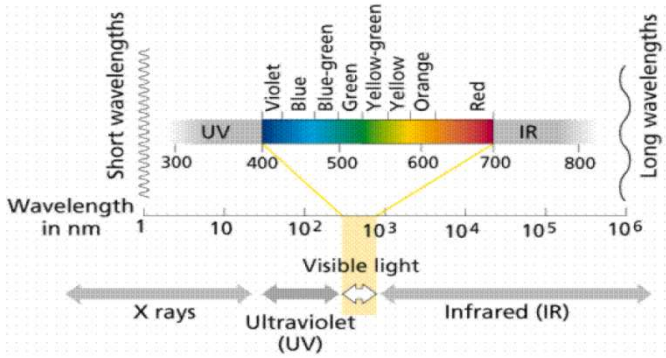
Vascular bundles (xylem and phloem) transport water, ions and food to all parts of the plant.



http://botit.botany.wisc.edu/Resources/Botany/Shoot/Stem/Zea%20stem/Vascular%20Bundle%20MC%20.jpg (accessed 27th June 2017)

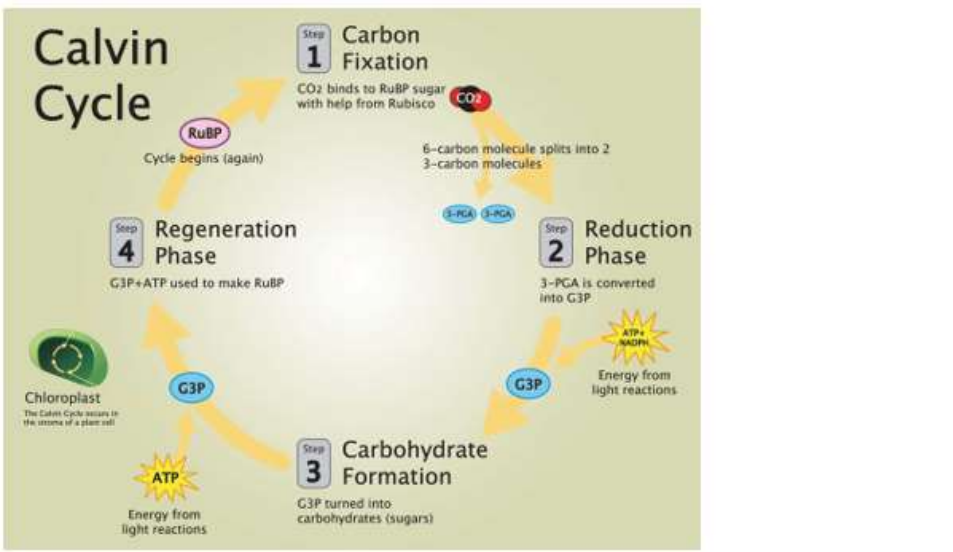
Some carbohydrate made during photosynthesis are stored and later used by plants themselves for respiration when needed.

The diagram below illustrates the range of light wavelength:



Photosynthesis occurs in plant cells of green leaves, specifically in the chloroplasts. The green pigment chlorophyll absorbs red and blue light at each end of the spectrum and reflects green light (making them look green).

Light and photosynthesis



http://media.nationalgeographic.org/assets/photos/000/274/27413.jpg (accessed 27th June 2017)

There are wo main stages to photosynthesis – Light reactions and the Calvin cycle.

Electrons from splitting water are used to reduce CO2 to carbohydrates.

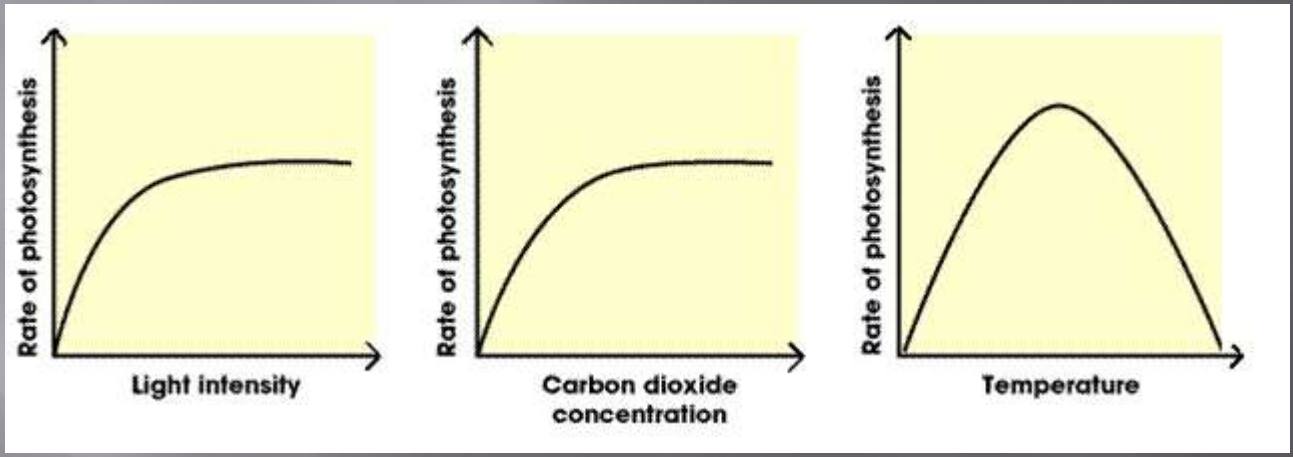
If CO2 is excluded from the leaf, no starch is present. Vascular bundles, root and tubers are all storage organs for starch.

In variegated plants (ivy, some shrubs), there are no chloroplasts and no starch is present in the white areas.

Chlorophyll can be extracted from a leaf with hot ethanol.

Limiting Factors

The rate of photosynthesis can be measured directly or indirectly and depends on limiting factors such as: light (very important), temperature and CO2. Water, soluble ions and nutrients are also needed.



In crop production, greenhouses accommodate plant growing conditions well and the limiting factors can be controlled to achieve optimum yield.

Importance of plants (photosynthesis)

Primary productivity varies in different ecosystems, the highest levels are in rainforests, where there is a high biomass, and the least occurs in desert or arid environments.

Starch and sugars are stored in fruiting bodies (berries, nuts and seeds) and tubers. These are eaten by heterotrophic consumers (herbivores and omnivores). Nectar and pollen is necessary for insects and pollinators such as bees.

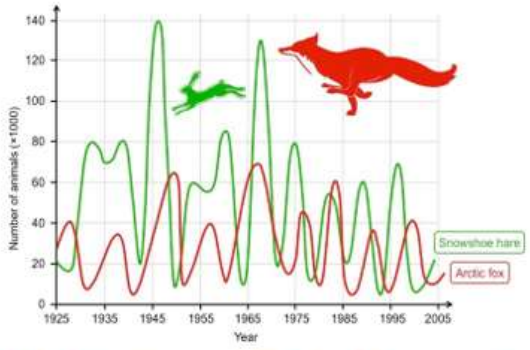
Burning fossil fuels (coal / oil and gas) releases CO_2 and NO_2 into the atmosphere which has a direct impact on climate, ocean acidification and human health.

Biology and Ecosystems

Ecology: The study of organisms (interactions) within an environment.

A community is a group of living species within a habitat, all interacting with each other in a way that without one, the system would struggle. This is an Ecosystem. Such interactions include; predation, competition and symbiosis. Ecology can be affected by abiotic factors (micro climate, topography, soils etc.) and biotic factors (predation and competition, human intervention).

Symbiosis: is a type of close and long-term biological interaction between two different biological organisms.



http://ib.bioninja.com.au/_Media/predator-prey_med.jpeg (accessed 28th June)

Predator / Prey relationships: If a predator population increases in relation to food (prey) and there is insufficient supply, the predator numbers drop (starvation, migration) to a sustainable level until the prey populations rise again.

Biology and Ecosystems

Habitat: A place where organisms live. Types of habitat include forest, woodland, marshland, grassland, heathland or mosaic (mixed).

Different species are adapted to certain habitats i.e. badgers prefer woodlands and newts prefer wet / marshland.

Biodiversity: is the measure of variation and number of species in an ecosystem. The higher the biodiversity (i.e. rainforest), the more significant / important it is.

Biomass: is derived from photosynthesis in plants which are then eaten by primary consumers (herbivores) and so on (the dry weight at each trophic level).

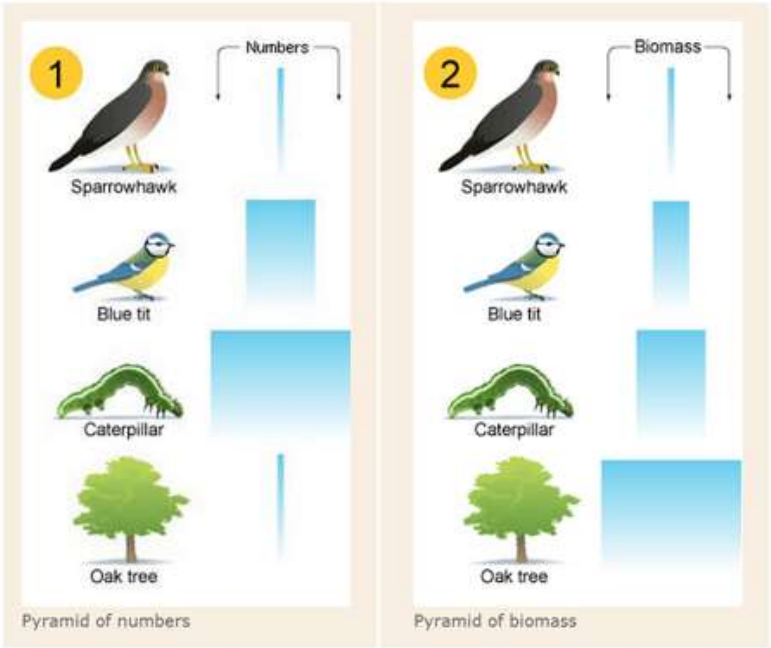
We can find out about species abundance (through quadrats) and species distribution (using transects and quadrats to observe change).

Other ways to measure abundance in animals are pitfall traps, nets and monitoring via tracking devices for larger animals.

Pyramid of biomass

The flow of energy within an ecosystem can be illustrated in a food web. In food chains, energy is lost (movement, respiration and heat) and is transferred from one trophic level upwards.

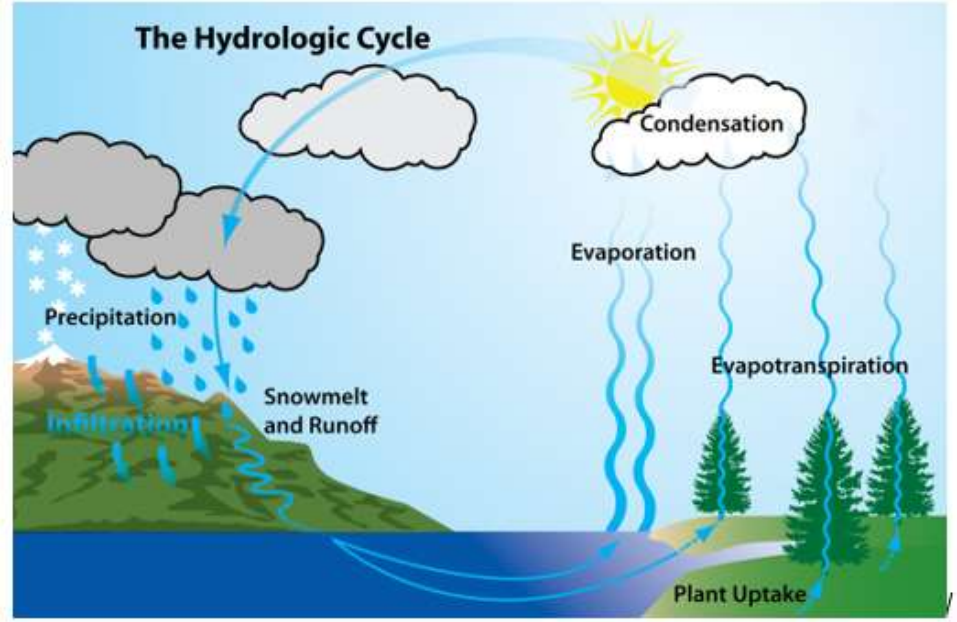
This is described as the pyramid of biomass.



http://3.bp.blogspot.com/-zzCv3pWvvCM/UylbJO_ZxDI/AAAAAAAAC-c/aZ9fRjUbd8Q/s1600/pyramids+of+numbers,+biomass.jpg (accessed 28th June 2017)

Natural Cycles

Water cycle:



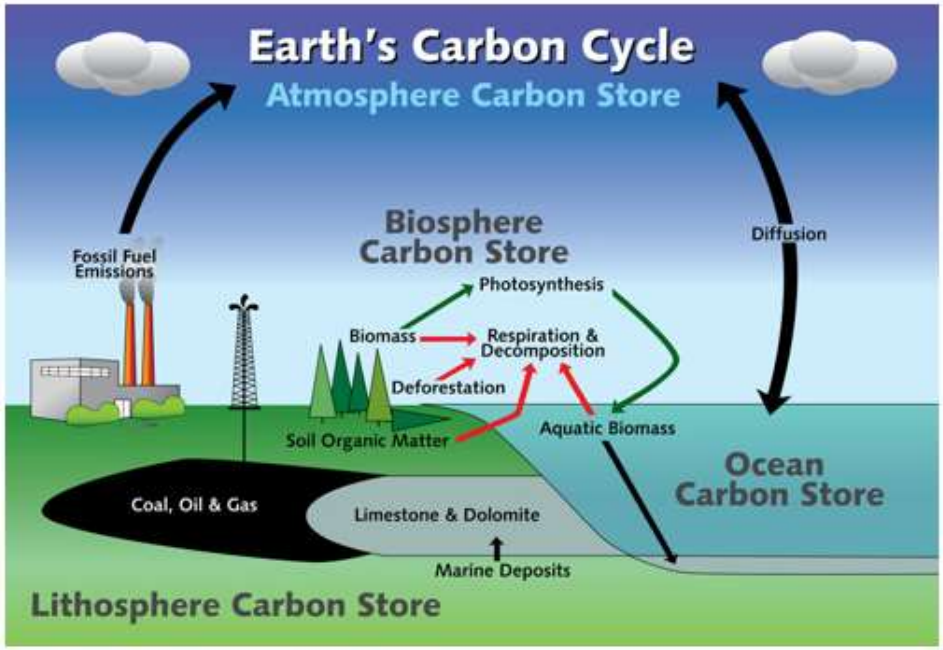
http://www.nj.gov/drbc/library/images/hydrocycle2.jpg (accessed 28th June 2017)

Water has properties that make it essential to living organisms. It is the single most important molecule on the planet's surface (70% earth surface is water – oceans, lakes and rivers) and without it life could not exist.

Water is the most abundant compound on this planet. It is the most important component of the human body (and other animals) making up over two thirds of total bodyweight as our cells composition is around 80% water.

Natural Cycles

Carbon cycle:



http://www.dec.ny.gov/images/administration_images/carboncycle.jpg (accessed 28th June 2017)

All cells contain carbon (in proteins, fats, simple sugars and carbohydrates). Plant cell walls (made of cellulose).

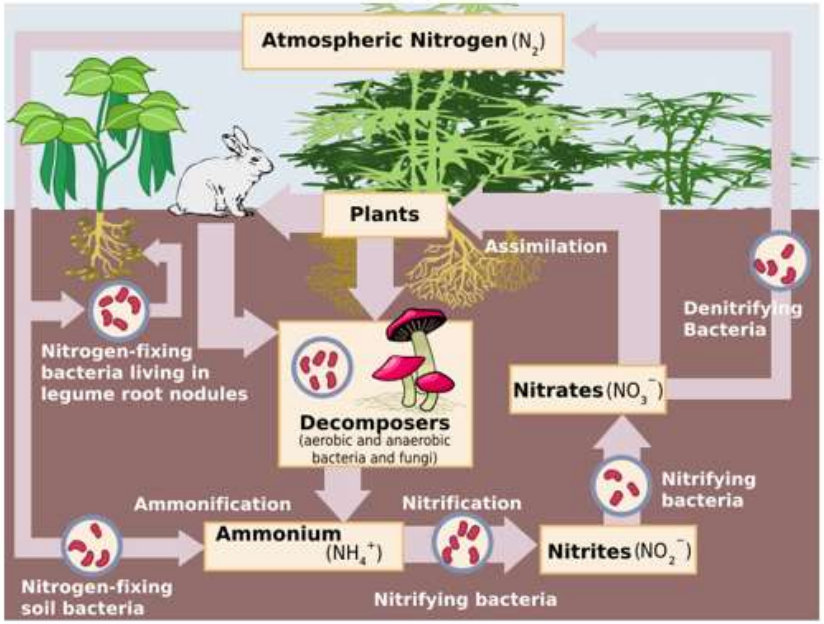
Microorganisms are important in the carbon chain for the processes of biodegradation and decomposition under aerobic and anaerobic conditions.

Carbon is passed from the atmosphere, to plants and organisms through food chains returned to the atmosphere as carbon dioxide again.

Huge stores of carbon are locked up/trapped in non-renewable Fossil Fuels (oil, gas and coal) as a result of ancient photosynthesis.

Natural Cycles

Nitrogen cycle:



https://upload.wikimedia.org/wikipedia/commons/thumb/f/fe/Nitrogen_Cycle.svg/800px-Nitrogen_Cycle.svg.png (accessed 28th June 2017)

Nitro fixing bacteria (found in leguminous plants) also help convert Nitrogen gas into ammonium ions back into soils.

Nitrogen - an inert gas in the atmosphere. Nitrogen is important for plant growth, in animals and for the synthesis of proteins (amino acids).

Nitrifying bacteria helps convert ammonia to nitrites and nitrates which is taken up by plants. Denitrifying bacteria removes nitrates from soils and converts them to nitrogen gas.

Pollution caused by man

Burning fossil fuels, vehicle emissions, deforestation, poor agricultural practices, chemical and industrial processes emitting harmful bioproducts to air and water.

Air pollution can cause short and long term effects on health (estimated 29,000 deaths per year linked to poor air quality), especially in very young or old people.

Eutrophication: the enrichment of waters with nutrients (surface runoff of fertilizers). This causes growth of plants and algae, which results in oxygen depletion and natural balances are lost. Fish die, the ecosystem is ruined.

Toxic substances such as heavy metals, chlorophenols, PCBs and other persistent chemicals get into food chains and bioaccumulate as they are not easily broken down by any means.

Acid rain (H_2SO_4) and NOx emissions kill large areas of vegetation and forests.

The rise in greenhouses gases (methane) can be linked to intensive cattle farming, landfills and removal of peat bogs.

CFCs destroy the ozone which protects everyone living on earth from harmful UV radiation from the sun.

Pollution caused by man

Plastic pollution on land and in our seas causes animals to suffocate or be strangled to death and can be swallowed. Chemicals in plastic cause hormone imbalances and toxification leading to death.

DDT, herbicides (glyphosate), pesticides, neonicotinoids are just a few chemicals that are sprayed on crops. They kill pollinating insects and other beneficial organisms. They are hard to break down and bioaccumulate in food chains.

Desertification: Areas of desert are created by the destruction of natural vegetation. Causes of desertification include: Removal of vegetation cover, overgrazing, unsustainable farming practice, loss in fertility of soil and excessive tree felling.

The world is undergoing the 6th Mass Extinction in the 4 billion year history of the planet – this is down to human activity.

Habitat destruction, deforestation, poor land use leading to soil erosion and floods, intensive (mono) agriculture, intensive meat production (methane), land swallow up for development and infrastructure (roads, houses, HS2), over fishing, eutrophication of our waters. . . . just to name a few.

What can we do?

Example: Shale Gas Extraction (fracking) operations are completely unsustainable. It generates toxic wastes, emission of methane into the atmosphere and ground contamination (water).

Major efforts need to be developed and **maintained** for greener energy.

It was recorded this summer that 25% of UK energy was generated from solar power alone. Wind and other clean energy creates a vast amount of energy. This illustrates the potential of green, clean energy and is crying out for innovation and investment from a (pro environmental) government.

Plant more trees . . . . Create habitats . . . . . Enjoy wild flowers. . . .

Work hand in hand with Nature . . . Reduce waste (Reuse and Recycle) . . . . Bus journeys or walk . . . Be Energy (Electricity) efficient (switch off when not in use) . . . . .

Be innovative

Transforming techniques to work with the Environment.

Claim: a farming method formulated to encourage beneficial species which will lead to increased farming output by up to 20% without high application of chemicals.

Monoculture is the agricultural practice of producing or growing a single crop or plant species over a wide area and for many consecutive years. This is a factor affecting all pollinating bees and other beneficial insects. The removal of biodiversity and plants to forage; Poor nourishment equals sick bees. An unhealthy environment following poor crop yields is therefore impacting on the farming economy.

For a couple of years, I kept my bees on some local farmland. Having had a few bad years, I decided to move them out of the field and into a garden / open space habitat.
Honey bees appear to do much better in areas of greater plant diversity and where the use of chemicals is sensitively managed.

Can we develop a complex practice which introduces a new method of Multi - cropping? Yes, the practice which has been formulated is called The Tri-culture Method.
It is a farming concept that has been composed to introduce flowering crops into the system that are pollinator magnets, encouraging beneficial insects to farmland for the reason of its improved plant diversity status.

This has been developed to be practiced in existing large fields of 7 hectares and above. It involves dividing the field up into 3 equally shared sectors. Whereas monoculture practices crop farming with one species, the "Tri – culture" method practices the cultivation of three different crop species sown and harvested starting from the Outer zone, the Inner zone followed by the final Core zone according to the order of harvest - one crop is yielded, a later crop is then planted (winter cover crop).

Triculture Farming:

Increased plant diversity = Increased pollinating insects = increased production.

Compound Eco Perimeter Hedgerow*

- **A healthy and robust perimeter hedgerow (incorporating some preferred species - Hawthorne, Hazel, Crab apple, Red currant, Raspberry canes) will provide a habitat environment and the blossom, an early food source for beneficial species such as bees, ladybirds, lacewings, hoverflies (predators of aphids) and breading space for earthworms. Will also provide berry's and fruits, a sustainable food source for human consumption. Borage, comfrey, hyssop (deters cabbage white butterflies), sages, lavender and herbs can form part of the lower hedgerow.**
- **Perimeter hedgerows and their strips offer protection to soil by means of sustaining the important microorganisms for example mycorrhizal fungi which principally improves soil biology and associated soil chemistry.**
- **Hedgerows bestow physical properties for example soil water retention and protection in the event of flooding through interception by roots and foliage of shrubs and trees, they also provide a windbreak for delicate crops – situated closest to the perimeter, the outer zone could be designated for this purpose.**

Conclusions;

- **The method needs to be practiced over the next few years to gather enough information possible to adapt and continually improve the method and achieve optimum outcome.**
- **Farmland is required for Tri-culture (and monoculture) research to proceed ideally across the board to account for regional variations and farming techniques.**
- **Experienced growers / farmers required to put some thought into suitable crop rotations for the new farming method – It is important that farmers have a say in the crops that they plant within the system, but to embrace the idea of the Tri-culture method to improve plant diversity, improve soil and encourage beneficial species.**
- **Our current farming methods (as well as the pesticide issues) need adapting to suit nature and be more environmentally responsive and sustainable - to incorporate "bee & pollinator friendly" farming and restrict the current monoculture system.**

Be aware

The *State of Nature 2016: England* report is a collaboration between the conservation and research organisations listed below:

GCSE Biology

Thank you for taking part and hope you have learned some interesting facts along the way!!

Don't forget to read the follow up presentation:

Practical Biology

Which will follow shortly!!!

Thank you