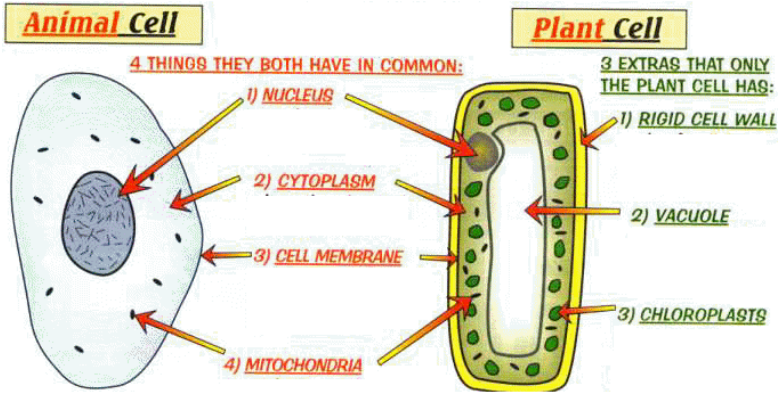
B2 PLANT AND ANIMAL CELLS

The structure of cells can be studied using a light microscope. Image is magnified by lens (made bigger) and the different parts of a cell can be seen.



Plant and animal cells have some features in common:

- *Cell membrane:* separates the contents of the cell and its surroundings
  controls the movement of substances (e.g oxygen, glucose, carbon dioxide) in and out
- *Cytoplasm*: where many of the cell's chemical reactions take place and it contains many organelles (tiny structures that carry out specific jobs)
- *Nucleus*: an organelle that contains DNA (the genetic material) and controls all the activities of the cell
- *Mitochondria:* organelles in which aerobic respiration (i.e respiration in the presence of oxygen) takes place

Plant cells also have some extra structures:

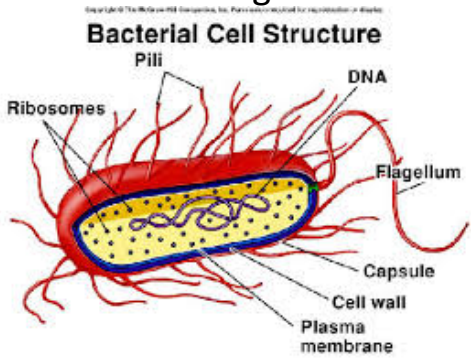
- Cell wall: made of tough cellulose, which supports the cell and gives it shape
- Large permanent vacuole: filled with cell sap - helps support plants by keeping cells turgid (i.e filled with water)
- Chloroplasts: organelles that contain chlorophyll – a green substance that absorbs light energy used for photosynthesis

INSIDE BACTERIA

- Light microscopes can magnify more than 1500 times allowing us to see inside bacteria.
- Bacteria are single-celled organisms that are much smaller than animals or plant cells. Bacteria do not have nuclei.
- In the 1930s the electron microscope was invented - this uses a beam of electrons to magnify specimens up to about 2,000,000 times!
- Electron microscopes have shown us more detail about the structure of bacterial cells
- 1. Bacteria cells have two types of DNA
    - Chromosomal DNA – giant loop of DNA containing most of the genetic material
    - Plasmid DNA – comes in small loops and carries extra information

  2. Bacteria Cells have a cell wall
    - It's different to the cell wall in plants – it is not made of cellulose, and it is more flexible
    - However, it does a similar job (i.e provides support and shape)

  3. Some Bacteria cells have flagella on the outside:
    - These are long, whip-like structures that bacteria can use to move themselves along



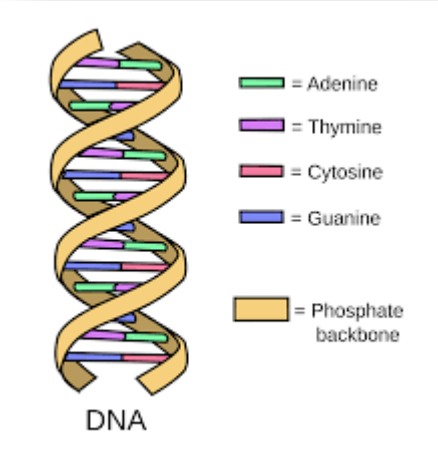
Questions – Plant and Animal Cells

- What would you use to see the structure of a cell? What part magnifies the cell?
- Name the part of the cell where the chemical reactions occur.
- What is an organelle?
- What does a cell membrane do?
- Name three substances that move in and out of the cell
- What process happens inside mitochondria?
- Name 3 extra structures that a plant cell has that an animal cell doesn't have. What does each structure do?

Questions – Inside Bacteria

- What type of microscope has allowed us to see even more detail of bacteria cells?
- What are the magnifications of a light microscope and of an electron microscope?
- Name the two types of DNA a bacterium cell has and what each types does.
- Give one reason why bacteria cell walls are similar to a plant cell wall and one reason why they are different.
- What is the name given to a ‘whip like’ structure that can make a bacterium cell move.

DNA



Chromosomes

Inside nuclei (plural of 'nucleus') chromosomes contain the genetic material made of DNA

- Sections of DNA are called genes:
  - Each gene codes (i.e carries instructions) for a specific protein
  - Often, genes work together to produce what is needed for a particular feature: e.g. eye colour is determined by lots of different proteins that are coded by several different genes

The structure of DNA:

- A DNA molecule consists of two strands that are coiled together to form a spiral known as a 'double helix'
- The two strands of DNA are linked together at regular intervals by chemicals called 'bases'
- Bases always pair up in the same way because they have complementary (i.e matching) shapes:
  - Adenine (A) always pairs with thymine (T)
  - Guanine (G) always pairs with cytosine (C)
  - The matching bases are known as 'complementary base pairs'
- Base pairs are joined together by weak hydrogen bonds
- The order of the bases in DNA (i.e the 'DNA sequence') determines the proteins that are made in the body
- We each have a slightly different order of bases in our DNA/genes as all of us are made from slightly different proteins – this is what makes us all different

DNA DISCOVERY

- In the 1950s,Rosalind Franklin was investigating the structure of DNA. She directed beams of x-rays at purified DNA and used photos to record how the DNA molecules scattered the x-rays
- At the same time, Watson and Crick were trying to build a 3D molecular model of DNA, using data obtained by other scientists. The detailed x-ray images from Franklin gave Watson and Crick the clues they needed to come up with their double helix model
- Watson and Crick published their findings and Franklin was barely mentioned
- Eventually, though, it became clear that all 3 scientists (i.e not just Watson and Crick) were key to the discovery of the structure of DNA and they were all (except for Franklin, who died beforehand) awarded Nobel Prizes

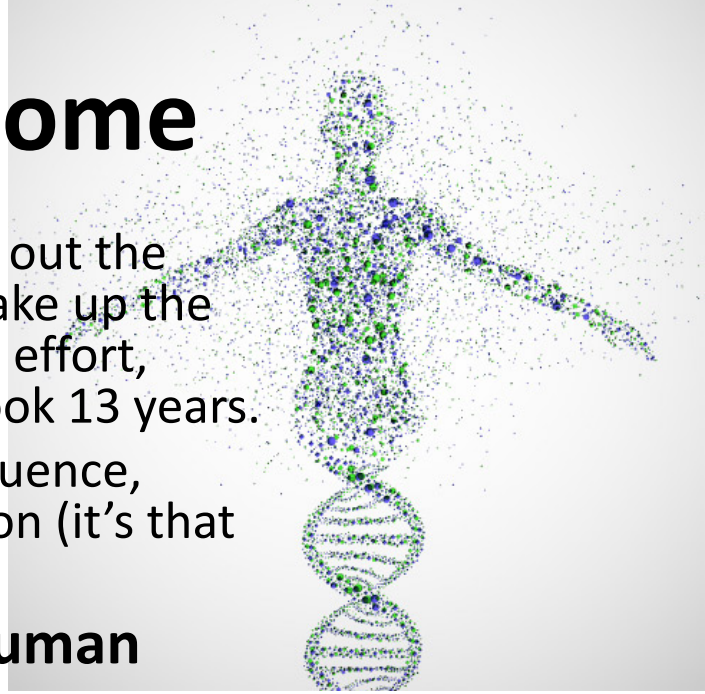
Questions – DNA

- Name the organelle found in a nucleus that contains the genetic material.
- What is a gene?
- What does ‘a gene codes for’ mean?
- What does a double helix look like?
- How are the strands held together?
- Which bases pair up? Why are they complementary?
- What type of bonding holds the bases together?
- What is the ‘DNA sequence?’ Why is it important?
- Why are we all different?

Questions – DNA Discovery

- In which decade was the structure of DNA discovered?
- Who discovered DNA structure and what particle was used?
- What were Watson and Crick using to build a 3D model of DNA?
- Who published their findings first?
- Who got awarded a Nobel prize?

The Human Genome



The human genome project (HGP) involved finding out the sequence (order) of the 3 billion base pairs that make up the human genome. The HGP was a huge international effort, involving scientists in 18 different countries and took 13 years.

Although each human being has a unique DNA sequence, everyone has at least 99.9% of their DNA in common (it's that 0.01% that makes us different)

What can we do with the results of the Human Genome project?

- We can find new ways of finding genes that may increase the risk of certain diseases
- We can find new treatments and cures for disorders e.g gene therapy, where scientists try to replace faulty genes that cause a disorder with normal genes
- We can find new ways of looking at changes in the genome over time – i.e how humans have evolved
- We can personalise medicines - find medicines that work best (i.e are more effective and have fewer side-effects) on certain people

GENETIC ENGINEERING

- **Genetic engineering' occurs** when a scientist removes a gene from one organism and inserts it into the DNA of another organism **e.g production of human insulin by genetically modified bacteria**
- Scientists can insert the gene for human insulin into bacterial plasmid DNA in the following 5 stages:
  1. Bacterial plasmid DNA is removed from bacteria
  2. Bacterial plasmid DNA is cut by 'cutting enzymes'
  3. Bit of the chromosome that contains the human insulin gene is cut by 'cutting enzymes'
  4. The human insulin gene is stuck onto the bacterial plasmid DNA by 'sticking enzymes'
  5. The bacterial plasmid DNA, with the additional human insulin gene, is reinserted into bacteria

- The genetically modified (GM) bacteria now have the human insulin gene in their plasmid DNA and can make human insulin, which is used by people with diabetes. These bacteria are now called GMO – genetically modified organisms

How was Human Insulin made in the past?

insulin used to be extracted from dead cattle and pigs and though similar is not the same as human insulin. The supply of the animal insulin could be affected by animal diseases or by the numbers of animals slaughtered.

What are the advantages of making Human insulin by GM Bacteria?:

- It is the same as the insulin produced by body cells in the pancreas
- It can be used by vegans (vegans don't eat any animal products and would not take animal insulin
- It can be made in vast quantities and more cheaply

What are the disadvantages? o

Different bacteria produce insulin slightly differently and this may not suit everyone

Questions – The Human Genome Project

- What is the HGP?
- How many base pairs make up a human being?
- How many countries worked together and for how long?
- What percentage of our DNA is the same as everyone else's? What percentage is different?
- Name four applications of the results of the Human genome project.

Questions – Genetic Engineering

- What is genetic engineering?
- Describe the 5 stages for inserting the gene for human insulin into bacterial DNA.
- What is a GMO?
- Give three advantages of using genetically modified bacteria to make human insulin.
- Give one disadvantage.

e.g. 2 beta-carotene in golden rice to reduce vitamin A deficiency in humans

- Lack of vitamin A can cause the immune system to stop working properly and can lead to death and blindness
- Beta-carotene is needed by humans to make vitamin A
- Two extra genes can be inserted into normal rice plants to make them produce beta-carotene in their grains and are called 'golden rice plants' and they make yellow rice

- **Disadvantages of this process**
  1. Some people are concerned that the GM rice will crossbreed with wild rice plants and contaminate the wild rice DNA
  2. Others worry that eating GM organisms might be harmful
  3. Some people say the levels of beta-carotene in golden rice are not high enough to make much of a difference
  4. GMOs can be expensive

e.g. 3 production of herbicide-resistant crop plants:

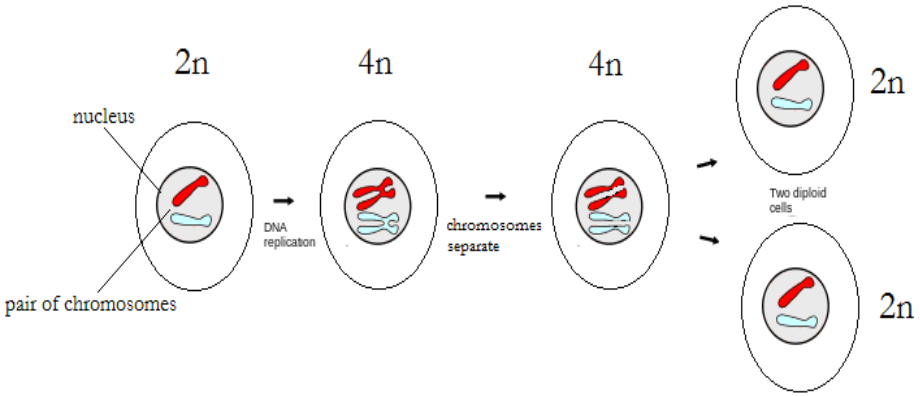
- Herbicides are used to kill weeds and Scientists have added genes to some plants to make them herbicide resistant. This means farmers can use one large spray of herbicide rather than several smaller doses and it reduces the amount of crop spraying needed
- **Disadvantages of this process:**
  1. Cross-pollination can take place between plants and weeds (i.e they fertilise each other)
     - some weeds may inherit the herbicide resistance genes
     - weeds can become herbicide resistant (i.e they're no longer killed by herbicides)
  2. Fewer weeds survive and a loss of food and shelter for animals

Mitosis: All human body cells (i.e all cells except sperm and egg cells) contain two sets of 23 chromosomes (=46 in total) in their nucleus. One set of 23 chromosomes comes from the father and the other set of 23 chromosomes comes from the mother . The human body cells contain two copies of each chromosome = 'diploid'

To make more cells during growth and/or to repair damaged cells, body cells divide by a process called mitosis:

1. Chromosomes first make copies of themselves - DNA replication
2. The copies of the chromosomes separate and the cell divides
3. This division produces two daughter cells, which are diploid and genetically identical.

- Note: n = 23 chromosomes in nucleus…→2n = 46 , 4n = 92



- Diploid cell has 46 chromosomes→2n
- 1st stage: diploid cell replicates→46x2 = 92 chromosomes→4n
- 2nd stage: chromosomes separate but no further division occurs→still 4n
- 3rd stage: cell divides to form two diploid daughter cells, each containing 46 chromosomes (2n)

Questions – Genetic Engineering examples

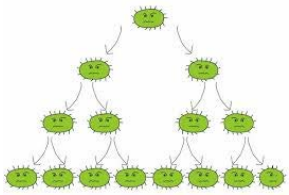
- What vitamin deficiency occurs in humans without beta-carotene?
- What crop have scientists injected genes into to make more beta carotene and what colour is the crop?
- Give four disadvantages of this
- What is a herbicide?
- Why would a crop that resists herbicides be beneficial?
- Name one disadvantage

Questions on Mitosis

- How many pairs of chromosomes does every human cell contain?
- Where do 23 pairs come mitosis?
- What two processes occur by mitosis?
- What do diploid and haploid mean?
- Describe the 3 stages of mitosis.

Asexual reproduction (A means without)

- As well as in growth and repair, cell division by mitosis also occurs in asexual reproduction. Asexual reproduction is when organisms reproduce by themselves (i.e without a partner)
- Bacterial cells often reproduce asexually by splitting in half
- Some plants can also reproduce asexually



Sexual reproduction:

- Sex cells (i.e sperm cells and egg cells) are called 'gametes' which are different to body cells as they only contain one set of chromosomes in their nucleus (so have a total of 23 chromosomes). Gametes are ***haploid*** cells – they have **ha**lf the number of chromosomes.
- When a sperm cell fertilises an egg cell, the gametes fuse to produce a **di**ploid body cell (d for double -with 46 chromosomes – two sets of 23) called the zygote.
- The zygote develops into a ball of cells called the embryo, which then develops to form a new individual

Meiosis

Meiosis is the form of cell division needed to make gametes.

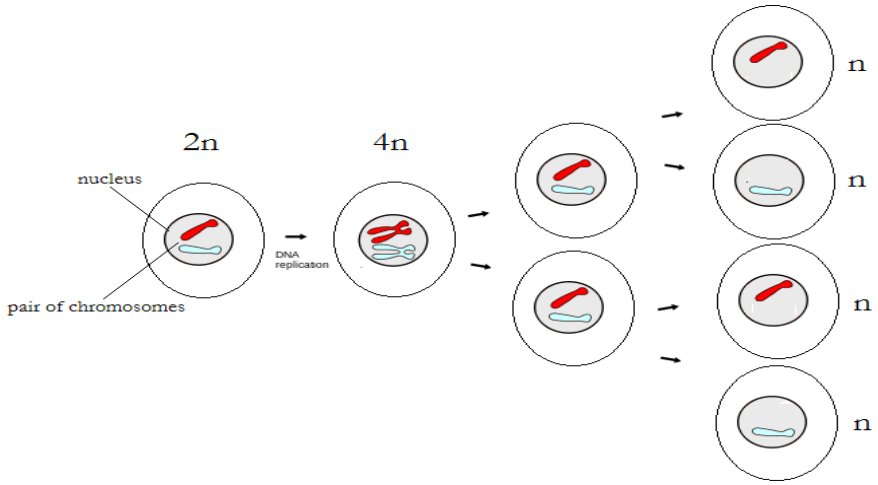
1. First step is DNA replication (this first step is the same as in mitosis)
2. This is followed by two cell divisions - i.e the cell is first divided into two and then divided again into four
3. This produces 4 haploid daughter cells, each containing one set of (23) chromosomes

Chromosome pairs in a diploid cell contain the same genes but may have different versions of the genes (i.e different 'alleles') because they come from different parents so the chromosomes in a pair are slightly different

- In meiosis, these slightly different chromosomes are split between the daughter cells in a random way so they are genetically different from each other

.

- Note: <u>n = 23 chromosomes in nucleus</u>…→2n = 46 , 4n = 92



Questions on Asexual and Sexual Reproduction

- What does asexual mean?
- Name three processes that use mitosis
- Give two organisms that reproduce asexually
- What is the collective name for sex cells?
- Gametes are haploid …explain
- Zygotes are diploid….explain
- What is the common name for a zygote?

Questions on Meiosis

- What is meiosis?
- What is first step of meiosis?
- How many cell divisions follow?
- Why is this different from mitosis?
- If you start with one cell, after meiosis how many daughter cells are there?
- Is the daughter cell haploid or diploid?
- Why are the daughter cells genetically different?

CLONES

Clones are individuals that are genetically identical (i.e that have the same DNA sequence)

Cloning means producing an identical individual and is an example of asexual reproduction.

Risks of cloning mammals

Cloning animals isn't easy because it's not possible to make a whole new animal from an arm or a leg

It wasn't until 1996 that the first large animal (a sheep called Dolly) was cloned

- Unfortunately…very few embryos produced during cloning develop successfully (Dolly was the only lamb produced after 237 attempts!)
- Dolly grew older much more quickly than normal and died young…Scientists aren't sure whether this was due to health problems caused by the cloning or whether it just happened by chance.

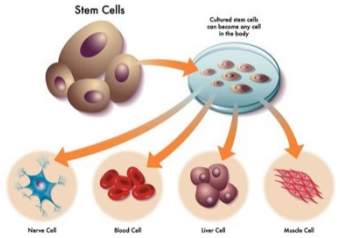
Benefits of Cloning

- It can be used to make a genetically identical copy of an adult organism that has a desirable trait e.g bulls whose sperm produces high quality calves are valuable and worth cloning.
- This can be a desirable genetically engineered trait - e.g cows engineered to produce human insulin in their milk can be cloned…two clones can then be bred together so that their offspring will also have this engineered trait

How to clone a mammal

1. A diploid nucleus is removed from a body cell of the animal that is going to be cloned
2. The diploid nucleus is inserted into an enucleated egg cell (i.e a cell that has had its nucleus removed)
3. The egg cell is stimulated to start dividing by mitosis
4. It is then implanted into the uterus (womb) of a surrogate mother where it will develop into a new individual . The 'surrogate mother' hosts the embryo but isn't actually the mother because the organism being produced doesn't have any of the surrogate mother's DNA/genes

Stem Cells



Stem cells are cells that have not specialised yet. There are two types of stem cells: :Embryonic stem cells – these can develop into nearly all types of cells and adult stem cells - these can develop into only a few types of cells

The ability of embryonic stem cells (in particular) to develop into lots of different types of cells means they could be used to treat many medical problems...

Two steps: 1. Embryonic stem cells first need to be extracted (see below for problems associated with this) 2. They are then put wherever in the body they are needed so that they can develop into the appropriate specialised cell

General risks of using stem cells:

- If stem cells are put into the body, they could produce the wrong kind of cells or even create cancer cells therefore more research is needed to make sure stem cells are safe
- People may try to use embryonic stem cells to produce human clones – this is illegal

Problems associated with extracting embryonic stem cells

One way of extracting embryonic stem cells is to use leftover embryos created for couples having fertility treatment however, extracting the embryonic stem cells kills the embryo. This is controversial because some people think that because embryos go on to develop into people, destroying embryos is the same as murder

Two ways scientists are trying to solve this issue: **1.** Use adult stem cells to make cloned embryos - the embryonic stem cells could then be extracted from the clones without any natural embryos having to be killed **2.** Turn specialised body cells into stem cells by reprogramming them – if this works, it will help to completely avoid the ethical problem of using embryos

Treating leukaemia:

Due to the ethical issues associated with extracting embryonic stem cells, most established methods use adult stem cells, which are easier to extract

e.g adult stem cells are used in bone marrow transplants to treat leukaemia (a cancer of white blood vessels)

Adult stem cells can't develop into as many different types of cells so the number of diseases they can treat is limited.

Questions on Clones

- What is a clone?
- Is cloning sexual or asexual reproduction?
- Who was dolly and when was she cloned?
- Did Dolly have a long and happy life?
- Name one benefit and one risk of cloning?
- What are the four steps you would take to clone a mammal?

Questions on Stem Cells

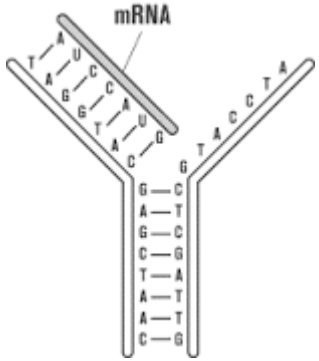
- What are stem cells?
- What two types of stem cells are there?
- Describe the two steps to turn a stem cell into a specialised cell.
- What risks are there for using stem cells?
- What problems are associated with extracting stem cells?
- Give two ways that scientists are trying to solve the problems above.

PROTEIN MANUFACTURE (SYNTHESIS)

Protein synthesis takes place in two stages – transcription and translation…

Transcription:

- Transcription takes place inside the nucleus
- The DNA is first unzipped by breaking the weak hydrogen bonds between the bases in the double helix – this separates the two strands of DNA
- One of the DNA strands then acts as a template…:
  - RNA bases that are complementary (i.e that match) to the bases on the DNA strand link together
  - This forms a strand of messenger RNA (mRNA) that is complementary to the DNA template strand - see diagram below
- RNA vs DNA:
  - RNA only has one strand (not two like DNA has)
  - RNA has a base called uracil (U) instead of thymine (T)…→
    - in RNA: adenine (A) bases pair with uracil (U) bases
    - in DNA: adenine (A) bases pair with thymine (T) bases
    - In the diagram an adenine (A) base on the strand of DNA is matched by a complementary uracil (U) base on the mRNA strand
    - a thymine (T) base on the strand of DNA is matched by a complementary adenine (A) base on the mRNA strand



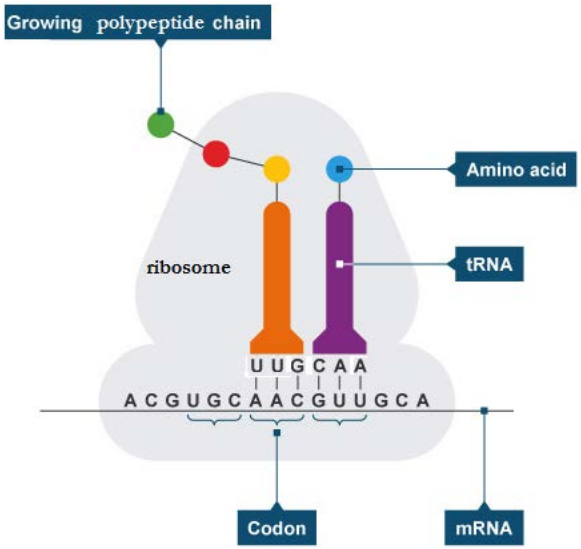
Translation

- Translation takes place on ribosomes (an organelle found inside the cytoplasm)
- mRNA is small enough to leave the nucleus, enter the cytoplasm and then attach itself to a small structure called a ribosome
- In the ribosome are also transfer RNA (tRNA) molecules which have attached a triplet of bases (i.e 3 bases) and an amino acid
- The triplet of bases on the tRNA controls which amino acid is attached (tRNA like mRNA contains uracil (U) bases instead of thymine (T) bases)
- Process:
- The ribosome moves along the mRNA, decoding it in groups of 3 – these base triplets on the mRNA strand are known as 'codons'
- As the ribosome moves along the mRNA, the tRNA with complementary triplet of bases lines up with the codon

- The tRNA then releases the amino acid it was carrying…

  The amino acid joins on to the growing amino acid chain

  The tRNA is now free to collect another amino acid. The ribosome then moves onto the next codon and the process continues until the chain of amino acids is long enough



Questions on Protein Manufacture

- Name the two processes in protein manufacture
- Where does transcription occur?
- What bonds break when the DNA breaks apart?
- What do we call the strand that is made that joins to the single strand of DNA?
- What is the difference in coding in the mRNA?

Questions on Translation

- Where does translation occur?
- How does mRNA reach the ribosomes?
- Describe transfer RNA and its purpose
- What does the triplet of bases on tRNA code for?
- What is a codon?

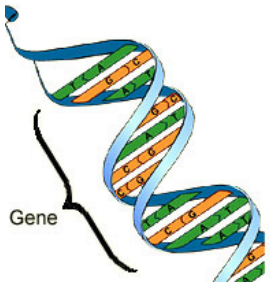
Mutations

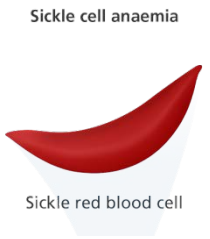
Each protein is made up of a different sequence (number and order) of amino acids.

This sequence affects the way the polypeptide chain folds up, giving the protein its specific 3D shape. Some proteins form long fibrous molecules (eg. keratin – found in human hair and nails), and others have a round 'globular' shape (eg. insulin, haemoglobin, enzymes)

The shape helps the proteins with their function eg. round haemoglobin helps it move around the body easily. eg. enzymes are specific to one reaction, and their shape determines which reaction this is.

A mutation is a change in the sequence of bases in the genetic code of DNA. Some mutations have no effect on the amino acid sequence so the shape of the protein is not affected. Other mutations result in one amino acid being replaced by another so the protein folds up differently so affects the shape and the way proteins work. Eg. Sickle cell anaemia – mutations in the gene that produces haemoglobin causes red blood cells to become pointy, reducing the oxygen carrying capabilities of the cell.





Aerobic Respiration

All cells in the body need energy – it is released by respiration. More active cells need more energy eg. muscles contract having to cause movement – this requires a lot of energy.

This process occurs inside organelles called mitochondria.

Aerobic respiration just means with a plentiful supply of oxygen.

This released energy can be used by the cells.

Glucose and oxygen are carried around the body by blood. Blood also takes away waste carbon dioxide. Diffusion is how these substances move into the blood, through a 1-cell-thick wall.

Respiring cells produce lots of carbon dioxide – less than in the blood – so it diffuses down a concentration gradient into the bloodstream.

They use up oxygen and glucose so they diffuse down the concentration gradient into the cells from the blood.

Questions on Mutations

- What is a protein?
- Why is the sequence of proteins significant?
- Why is the shape of a protein important?
- What is a mutation?
- Describe an example of a common mutation of red blood cells.

Questions on Aerobic Respiration

- How does a cell get energy?
- Where does respiration occur?
- What is the symbol equation for aerobic respiration?
- How do the reactants and products get into the cell?

Gas Exchange

Alveoli – tiny air sacs in the lungs – are surrounded by capillaries. Here is where gas exchange takes place.

The oxygen diffuses into the blood, waste carbon dioxide diffuses out.

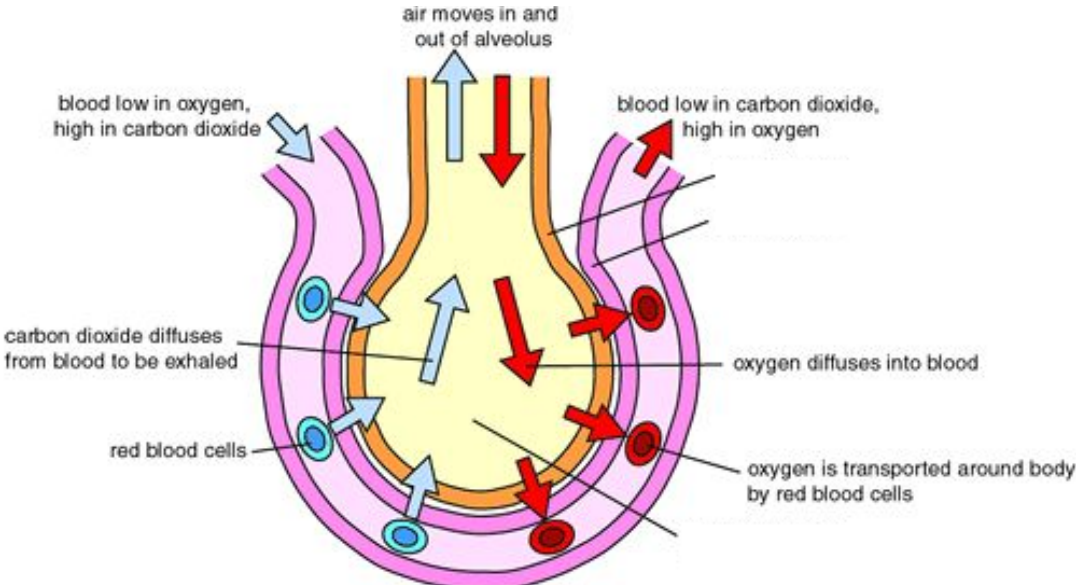
Arriving at the alveoli blood has a high concentration of carbon dioxide and a low concentration of oxygen.

The carbon dioxide is removed by exhaling.

Breathing in allows oxygen to enter the alveoli.

Blood leaving the alveoli has a high concentration of oxygen and a low concentration of carbon dioxide.

Oxygen is transported in the blood stream via red blood cells to be used for respiration



Exercise and Anaerobic Respiration

The amount of blood pumped out by the heart in one minute is called the 'cardiac output' The cardiac output depends on the:

- Heart rate – beats per minute
- Stroke volume – volume of blood pumped out of the heart each beat
- The higher the stroke volume and the heart rate, the higher the cardiac output
- cardiac output = stroke volume x heart rate

During exercise:

- Muscles need more energy, they need more oxygen from respiration
- 1. the heart rate and stroke volume increase
- 2. breathing rate also increases to get more oxygen into the blood
- So more oxygen reaches muscle cells faster - faster rate of aerobic respiration in muscle cells - more energy released

During intense exercise:

- even increasing the heart rate and the breathing rate isn't enough to supply oxygen to muscle cells quickly enough
- anaerobic (less oxygen) respiration starts to happen (alongside aerobic respiration) inside muscle cells

Anaerobic respiration breaks down glucose without using oxygen - the waste product lactic acid is produced:

- glucose → lactic acid (+ energy released)
- The energy released by anaerobic respiration is less than the energy released by aerobic respiration

The waste lactic acid produced during anaerobic respiration is toxic so it must be broken down as soon as possible. Lactic acid can be broken down by oxygen into carbon dioxide and water:

(the lactic acid can't be broken down during exercise because there isn't enough oxygen available - it is being used in aerobic respiration)

The extra oxygen needed after exercise is obtained by keeping the breathing rate and the heart rate high for a few minutes after exercise (i.e until the oxygen has broken down all the lactic acid produced into carbon dioxide and water). The time taken for the heart rate to return to normal (resting) after exercise is the 'recovery time' - the faster the recovery time, the fitter the person

Questions on Gas Exchange

- What are alveoli?
- What is the difference between the blood arriving and leaving at the alveoli?
- How is carbon dioxide removed from the blood?
- How does oxygen reach the cell?

Questions on Anaerobic Respiration

- What is the cardiac output? What is it calculated from?
- How does the respiratory system change during exercise?
- Why does anaerobic respiration occur?
- What is the equation for anaerobic respiration?
- Why does lactic acid need to be broken down?
- How is lactic acid broken down?

PHOTOSYNTHESIS

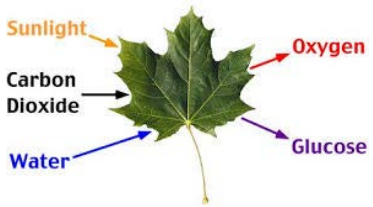
- Plants (like animals) have mitochondria in their cells where respiration occurs
- Plants need a supply of glucose for respiration
- In animals/humans, glucose needed for respiration is obtained from the breakdown of starch
- Unlike animals/humans, plants can make their own glucose by a process called photosynthesis
- Equation for photosynthesis:

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

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

- Photosynthesis takes place inside plant cell organelles called chloroplasts which contain a green substance called chlorophyll. Plants cannot photosynthesise without chloroplasts.
- Chlorophyll absorbs sunlight, transferring the light energy into stored chemical energy in glucose

Leaf adaptations:



- The leaf is the main plant organ in which photosynthesis occurs.
- Leaves are adapted for photosynthesis as they have chloroplasts containing a substance called chlorophyll that absorbs light energy from the sun. They are broad and flat and therefore have a large surface area to absorb as much light energy as possible
- On the underside of leaves are microscopic pores called stomata where gases enter and leave the leaf
- Air spaces inside the leaf give cells a large surface area to volume ratio – this makes gas exchange through the stomata more efficient

Gas exchange in the stomata

- Carbon dioxide from the atmosphere diffuses into the leaf through the stomata and is used for photosynthesis
- Oxygen produced in photosynthesis diffuses from the inside of the leaf into the atmosphere through the stomata
- Water produced during respiration can evaporate from cells inside a leaf and diffuse out of the leaf through the stomata
- Stomata open when it's light to allow gas exchange and photosynthesis to occur . They close when it's dark
- When it's dark, stomata close for two reasons:
    1. Photosynthesis can't take place so gas exchange is not necessary
    2. Plants still respire in the dark, producing water vapour

Note:

- Water needed for photosynthesis does <u>NOT</u> enter through stomata in the leaf - it is taken up in the roots and then transported to the leaf in xylem vessels

Questions on Photosynthesis

- Where does plant respiration occur?
- Where does the glucose come from for plants to respire?
- Write the word equation for photosynthesis
- Write the symbol equation for photosynthesis
- In which organelle does photosynthesis occur?
- Name the chemical that absorbs sunlight

Questions on Leaf Adaptations

- What is the main organ of a plant?
- How is the shape of a leaf adapted for photosynthesis?
- What is the name of the small pores on the underside of a leaf that allow gases in and out?
- What do air spaces inside the leaf do?
- Which gas diffuses into a leaf and why?
- Name two substances that leave the leaf –one by diffusion and one by evaporation.
- Give two reasons why stomata close in the dark

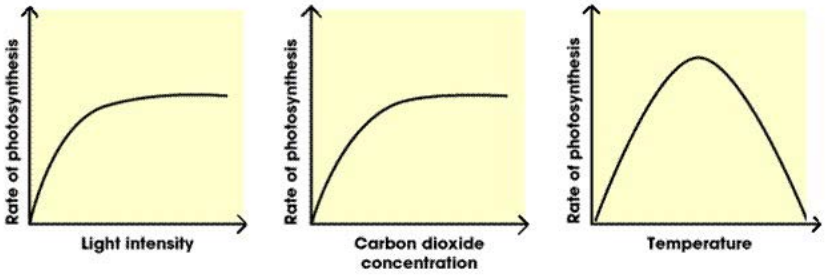
LIMITING FACTORS

The higher the rate of photosynthesis, the more glucose that is produced which is needed by plants for growth and for respiration

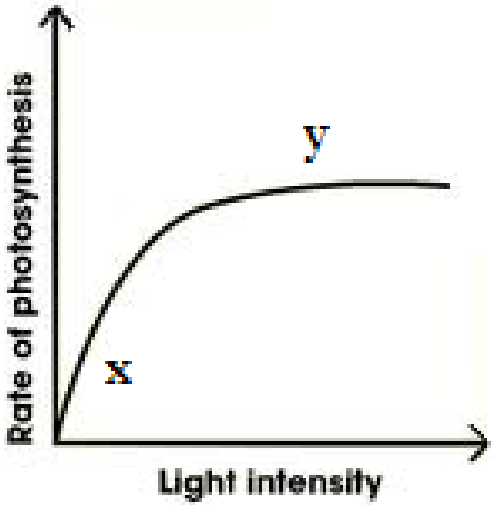
Factors affecting the rate of photosynthesis:

- Concentration of carbon dioxide
- Water
- Light intensity
- Temperature (reactions in photosynthesis are catalysed by enzymes so can also affect the rate of photosynthesis)

- The process of photosynthesis is affected by several factors so the maximum rate at which the process can occur is controlled by the factor that is in the shortest supply – the factor in the shortest supply is the 'limiting factor' that will slow the rate of photosynthesis down
- If a plant has lots of carbon dioxide, lots of water, is grown at the right temperature but in dim light, it will photosynthesise slowly. Increasing the concentration of carbon dioxide, or giving the plant more water or increasing the temperature will not increase the rate of photosynthesis
- Only increasing the amount of light will increase the rate of photosynthesis so in this example, the limiting factor is light (intensity)



Limiting Factors -Graphs

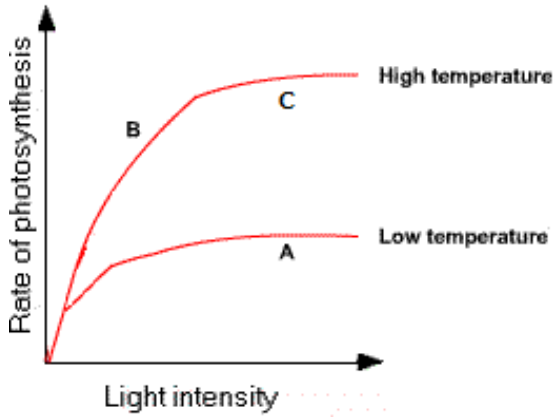


At point x:

- Increasing light intensity increases the rate of photosynthesis…
- initially light intensity is the limiting factor

At point y:

- Increasing light intensity doesn't increase the rate of photosynthesis any further…
- another factor (i.e temperature, CO_2 concentration or water) must be limiting the rate of photosynthesis at this point



At point **A** – increasing the temperature increases the rate of photosynthesis (the high temperature trace at the same light intensity has a much higher rate of photosynthesis)the limiting factor at this point is temperature

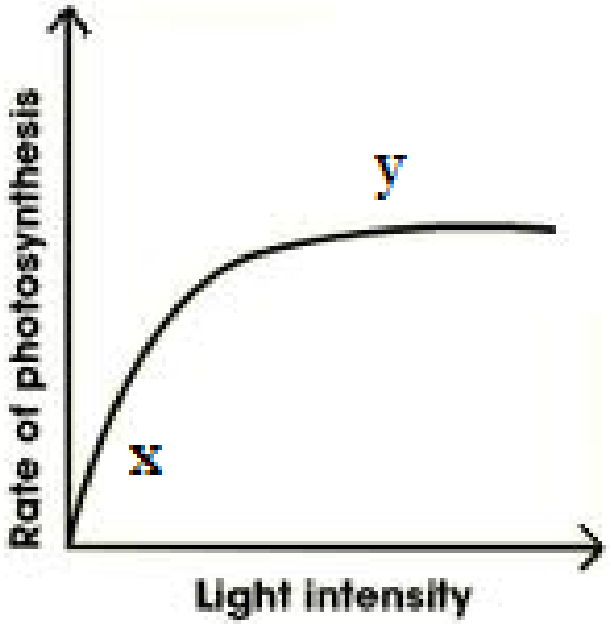
At point **B** – increasing the light intensity increases the rate of photosynthesis - the limiting factor at this point is light intensity

At point **C** – increasing temperature or light intensity doesn't increase the rate of photosynthesis any further -the limiting factor at this point could either be the amount of carbon dioxide or water available to the plant

Questions on Limiting Factors

- Name four factors that can affect the rate of photosynthesis
- Explain how temperature can affect the rate of photosynthesis.
- What do we call the factor that is in shortest supply?

Questions on Limiting Factors



Explain this graph.
What happens when light intensity increases?

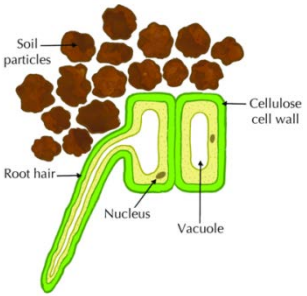
Why doesn't the rate of photosynthesis keep increasing?

WATER TRANSPORT

- Roots anchor plants to the ground and take up water and mineral salts from the soil
- 'Root hair cells' are present in roots – they have adaptations that help them take up water and minerals from the soil:
  1. long, thin extensions that reach into the surrounding soil
  2. large surface area
- Water enters the root hair cells by osmosis

  Water moves from a region of higher water concentration to a region of lower water concentration until 'equilibrium' is reached (i.e until the water concentration is the same on both sides)

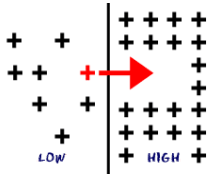
  Sucrose molecules can't move because they are too big to fit through the gaps in the partially permeable membrane



Dissolved minerals

The concentration of minerals dissolved in soil water is very low compared to the concentration of minerals in the plant. For minerals dissolved in soil water to be taken up into the roots, they must be absorbed against the concentration gradient –from an area of lower concentration to an area of higher concentration. Minerals help plants grow.

- Absorbing particles against a concentration gradient is called 'active transport' which requires energy from respiration.



- Once water and minerals have entered the root cells, they need to get to all the plant's tissues
- Xylem vessels transport the water needed for photosynthesis and dissolved mineral salts
- The glucose made in the leaves during photosynthesis is converted to sucrose and then transported to other parts of the plant by phloem vessels and then stored as starch
- Transpiration is the pulling up of water against gravity, so water produced during respiration can evaporate from cells inside a leaf and diffuse out of the leaf through the stomata
- As the rate of evaporation of water increases the faster the loss of water through stomata and the increased rate of transpiration
- Rate of evaporation determines the rate of transpiration, warm and windy day, the rate of transpiration will be greater

Questions on Water Transport

- Describe two jobs of plant roots.
- Describe two adaptations of root hair cells
- Name the process that allows water to move into root hair cells.
- Why don’t sucrose molecules move into the root hair cell?

Questions on Dissolved Minerals

- What is the process called where plants absorb minerals against a concentration gradient?
- What do xylem vessels do?
- What happens to the glucose made during photosynthesis?
- What is transpiration?
- What effect will a wet day have on the rate of transpiration? What about a windy day?

ORGANISMS AND ENVIRONMENTAL FACTORS

Biodiversity means the different species of animals and plants in a habitat (the place where an organism lives). Scientists want to know: Where particular organisms are found (their 'distribution') in the habitat and how many individuals of each species (the 'population size') there are in a habitat

SAMPLING

It takes too long to study the whole habitat so ecologists usually look at just a small portion of an area – this is called 'sampling'

Random sampling - every point within an area has an equal chance of being selected so the sample is likely to be representative of the whole area

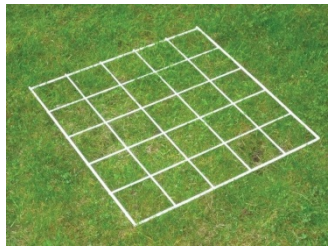
Sampling techniques:

- **Pooter** - used to catch small invertebrates. It has two tubes which are connected to a container and you suck on one of the tubes and any small invertebrates are sucked up into the container through the other tube (called the 'inlet tube')

- **Sweep net** – this is used in areas of long grass to catch some of the organisms present
- **Pond net** – can be used to sample aquatic (i.e water) habitats

- **Pitfall traps**-Useful for trapping small animals such as spiders, beetles and woodlice and they can be set up and left overnight so can catch nocturnal animals (i.e animals that are only active at night)

- **Quadrats** - these are square frames, typically used to sample the number (population) of different plant species in a habitat: The quadrat is placed at random locations (e.g by throwing) – at each location, the number of plants of each type within the quadrat are counted. For spreading plants (e.g clover), the % of the quadrat area covered by the plant is estimated. The mean number of a particular type of plant found in each quadrat can be used to estimate the population size of that plant in the area



Environmental factors

Different conditions can sometimes be found within a habitat
(e.g at different points in a field) which can affect the distribution of organisms.

Light intensity varies in a habitat and explains the distribution of different species of plants. Some species of plant may need lots of light so you will only find them in the part of the field that receives the most sunlight. Other species of plants may be able to survive with less light so you might find some in darker, more sheltered parts of the field

Other factors such as temperature or soil/water pH may also have an effect on the distribution of organisms in a habitat

When investigating changes in a habitat caused by one environmental factor, it's sometimes useful to carry out 'systematic sampling' along a line.

- Using systematic sampling makes it easier to spot patterns and to see the effect that the environmental factor is having on the distribution of organisms in a habitat
- Systematic sampling can be done by placing quadrats at regular intervals along a straight line

Questions on organisms and environmental factors

- What is biodiversity?
- Explain the words habitat and distribution.
- Why is random sampling better?
- Describe 5 sampling techniques.
- Which technique would you use for nocturnal animals?
- Which techniques would you use for a pond?

Questions on Environmental factors

- How does light intensity affect the distribution of organisms?
- Name three other factors that will affect the distribution of organisms.
- When is systematic sampling useful?
- Describe what piece of apparatus you would use for systematic sampling and what you would do with it?

FOSSILS AND EVOLUTION

- Fossils are the preserved remains of organisms that lived on the Earth thousands or millions of years ago
- The collection of fossils from different periods in the Earth's history is known as the 'fossil record'
- Studying the fossil record can reveal details about how organisms have changed gradually through time (i.e how they have evolved) and the fossil record is one of the strongest pieces of evidence in support of evolution

Gaps in the fossil record:

The fossil record has many gaps in it for 3 main reasons

1. Soft-bodied organisms leave little fossil evidence behind because soft tissues decay (→don't usually form fossils)
2. Sometimes, the hard parts of organisms are destroyed and fossils don't form
3. Many fossils are buried deep in the earth and have not yet been found

The gaps in the fossil record mean that scientists must interpret how organisms changed over time from incomplete data.

The same set of data could be interpreted differently by different scientists

As more fossils are discovered, scientists can predict more accurately how an organism may have looked like and how it may have evolved

Computers can now be used to model how the organism may have looked

GROWTH

Growth is an increase in size, length or mass.

Percentiles can be used to compare a certain characteristic (e.g mass) against the total population

- The 20th percentile indicates that 20% of the data points are the same or lower than this value
- The 50th percentile indicates that 50% of the data points are the same or lower than this value and the 50th percentile is the **median** value of the sample

Growth in plants

Plants have special areas called 'meristems' found on the tips of roots and shoots – these are the sites of plant growth

Stages in Plant Growth

Cell division: cells in meristems keep dividing constantly (each division doubles the number of cells)

Elongation: once the cells have divided, they get longer – this is called 'elongation'

Differentiation: as a plant continues to grow, the older meristem cells start to develop into specialised cells – this process is called 'differentiation'. A meristem can differentiate (develop) into any type of plant cell (so they're like the equivalent of embryonic stem cells in animals) e.g. a meristem cell in the root can develop into a specialised root hair cell

Growth in animals:

Growth in animals also involves cell division but unlike plants, animals stop growing when they become adults

In an animal, cells that can differentiate to form many different types of specialised cells are called stem cells:

- Embryonic stem cells can differentiate and form almost any type of cell in the body
- However, adult stem cells can only develop into a limited range of cells. This is why most animals can't re-grow a damaged limb or body part, but plants can grow new shoots, roots and leaves

Questions on Fossils

- What is a fossil
- What do we call the collection of fossils from different periods in the Earth's history?
- How does the fossil record support the theory of evolution?
- Suggest 3 reasons why the fossil record has gaps in it.
- Why is the gap in fossil records a problem for scientists?

Questions on Growth

- Define growth.
- What would the 40th percentile line mean?
- In plants what is a meristem?
- Name the three stages in plant growth.
- How is growth in animals different from growth in plants?
- Explain why plants can grow new shoots but animals can’t grow new limbs?

BLOOD

Blood contains many different types of specialised cells which all have differentiated from blood stem cells.

Blood is made up of four main components plasma, red blood cells, white blood cells and platelets.

Plasma (55% of the blood): Plasma is the liquid (yellow colour) component of the blood which transports dissolved substances such as carbon dioxide, food substances and hormones

Red blood cells (45% of the blood): Red blood cells contain the red pigment haemoglobin and when blood in capillaries arrives at the alveoli it contains little oxygen.

The oxygen diffuses from the alveoli into the red blood cells. In the red blood cells, oxygen combines with haemoglobin to form oxyhaemoglobin (the reaction is reversible ↔)

haemoglobin + oxygen ↔ oxyhaemoglobin

Oxyhaemoglobin is then transported in red blood cells around the body to supply cells with oxygen for respiration. The oxyhaemoglobin splits, releasing oxygen (which diffuses into respiring cells) and haemoglobin.

When red blood cells return to the alveoli, haemoglobin will be able to combine with new oxygen molecules and the process repeats

Red and White Blood Cells

Structure of RBC: Biconcave disc (cells have a dimple on both sides) which gives red blood cells a large surface area to volume ratio for oxygen to diffuse into and out of the cell.

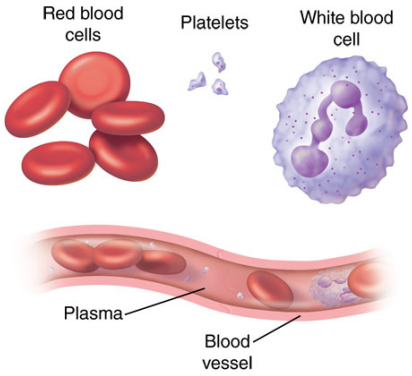
No nucleus which means there's more room for more haemoglobin so they can transport more oxygen.

Structure of White blood cells (less than 1% of blood): All white blood cells have a nucleus. White blood cells are bigger than red blood cells

Function: White blood cells are part of the body's defence against - part of the body's 'immune system'. Some white blood cells make antibodies which are proteins that bind to microorganisms that cause disease and destroy them. Other white blood cells destroy any foreign cells that enter the body by surrounding ('engulfing') them

Platelets (less than 1% of blood): Platelets are tiny fragments of cells that don't have nuclei.

Function: Platelets are important in clotting blood (when blood vessels are damaged). The clot dries out and forms a scab – this stops microorganisms getting into the body



Questions on Blood

- Name the four components of blood
- What is the role of plasma?
- What pigment do red blood cells contain?
- What is the reversible reaction that occurs in red blood cells?
- What are alveoli?
- Why do cells needs oxygen?

Questions on White and Red Blood Cells

- What is a bi- concave disc and why is it a useful shape for a red blood cell?
- Is it an advantage or disadvantage that the RBC has no nucleus?
- What are the differences between a RBC and a WBC?
- Describe an antibody and its function.
- Explain how a scab forms and the important part of the blood involved in the process.

The Heart

Blood coming in from the tissues is low in oxygen ('deoxygenated'). It is pumped by the heart to the lungs where haemoglobin in red blood cells picks up oxygen (i.e combines to form oxyhaemoglobin). Blood becomes 'oxygenated' and returns to the heart where it is then pumped around the body to the tissues and cells (so that cells receive oxygen for use in aerobic respiration).

The heart is split into right and left sides and each side is split into two chambers – an atrium (atria – plural) and a ventricle. A vein called the vena cava brings deoxygenated blood from the body into the right atrium.

1. Superior vena cava – brings deoxygenated blood from upper body Inferior vena cava – brings deoxygenated blood from lower body. When the right atrium is full, muscles in the wall contract and the deoxygenated blood is forced through valves and into the right ventricle. Valves are flaps of tissue that prevent backflow of blood (i.e stop blood going back the way it came).Valves are prevented from turning inside out by tendons

2. When the right ventricle is full of blood, the muscles of the ventricle wall contract and the blood is forced out through some other valves into the pulmonary artery. The pulmonary artery carries the deoxygenated blood to the lungs where it picks up oxygen and becomes oxygenated

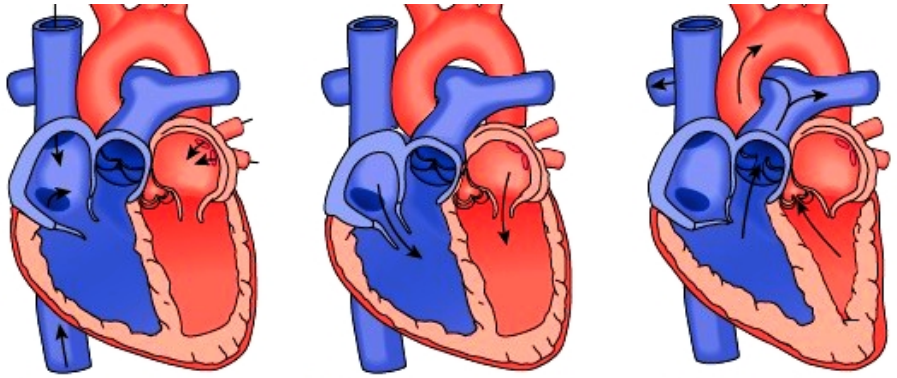
3. The oxygenated blood is then transported by the pulmonary vein from the lungs to the left atrium of the heart . When the left atrium is full, it contracts and the oxygenated blood is forced through valves and into the left ventricle

4. Once the left ventricle is full of oxygenated blood, the muscles of the ventricle wall contract and the blood is forced out through some other valves into an artery called the 'aorta'

5.The aorta carries oxygenated blood around the body (supplying cells with oxygen for use in aerobic respiration).The cycle then repeats (note: right and left sides of the heart work together, filling and emptying at the same time – it's just easier to explain the way the heart works by looking at each side in turn)

a. the left ventricle has to pump blood all the way round the body and the right ventricle only has to pump blood to the lungs therefore the muscle wall of the left ventricle is thicker than the muscle wall of the right ventricle

b. The septum separates the right and left sides of the heart. The right side of the heart (i.e the right atrium and right ventricle) pumps deoxygenated blood. The left side of the heart (i.e .the left atrium and the left ventricle) pumps oxygenated blood. the septum is important so that the oxygenated blood and deoxygenated blood do not mix



Atria fill with blood

Contraction of atria pumps blood into the ventricles.

Contraction of ventricles pumps blood into aorta and pulmonary artery

THE CIRCULATORY SYSTEM

Cells, Tissues and Organs

Groups of specialised 'cells' working together are called 'tissues e.g. muscle tissue is made of a group of specialised muscle cells

Tissues that work together (to carry out a particular function) form 'organs'

Groups of organs that work together are called 'organ systems e.g: The heart is an organ…blood vessels are also organs; The heart and blood vessels form an organ system called the 'circulatory system'

Blood vessels

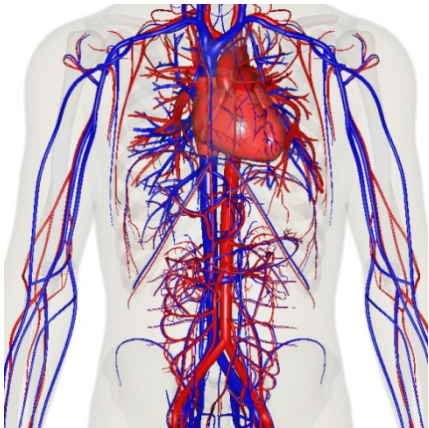
Blood vessels are tube-shaped organs that carry blood. There are 3 types of blood vessels – arteries, veins and capillaries

1. **Arteries** (e.g pulmonary artery, aorta): Carry blood away from the heart. Blood in arteries has to be under high pressure so that it can reach all parts of the body (remember that aorta carries blood all around the body. Arteries have strong, thick walls

2. **Veins** (e.g pulmonary vein, vena cava):Carry blood towards the heart. Blood in veins travels slowly and at low pressure, veins have thin walls and a wide, large passage for blood to flow

3. **Capillaries** Allow substances to diffuse into and out of the blood, into or out of cells and tissues. e.g oxygen diffuses from alveoli into capillaries in the lungs.

To help substances diffuse faster, capillaries have very thin walls (only one cell thick).



Questions on the Heart

- What does deoxygenated and oxygenated mean?
- Where does deoxygenated blood come from?
- Describe the structure of the heart.
- Why are the walls of the heart different thicknesses?
- What does the septum do?

Questions on the Circulatory System

- What do we call a group of cells working together? Groups of tissues? Groups of organs?
- Name the three types of blood vessel.
- Why do arteries have thick walls?
- Describe how the blood flows in veins?
- Why are capillary walls so thin?

The Digestive System

Food contains a lot of large insoluble molecules that have to be broken down into small soluble molecules before they can pass into the blood and be used by cells e.g starch must first be broken down into glucose which can then pass into the blood, where it's then transported to cells for use in aerobic respiration. Food is broken down in a process called 'digestion' which takes place in an organ system called the 'digestive system'

Alimentary canal – i.e the route the food takes from the mouth to the anus

1. Mouth: The mouth is where food enters the body. During chewing, teeth break up food into small pieces 1. It's easier to swallow 2. It also increases the surface area of the food and digestive enzymes in the mouth can break down the molecules in food more quickly. The tongue helps to form the chewed food into a ball called a 'bolus'. The bolus gets coated in saliva, which lubricates it and makes it easier to swallow. Saliva also contains an enzyme that starts to break down the starch in food.

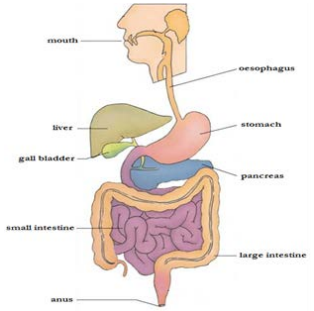
2**. Oesophagus**: The oesophagus is a muscular tube that connects the mouth to the stomach. As food passes down the oesophagus, muscles in its wall contract in waves and squeezing the food (bolus) down towards the stomach. This pushing of the food along the alimentary canal by muscular contractions is called 'peristalsis'

3. Stomach: The stomach is a muscular bag that makes acid and some enzymes (particularly enzymes that break down proteins into amino acids). The enzymes and acid present in the stomach – together with the use of peristalsis – help the stomach to churn the food up

4. Small intestine: The small intestine is a long, coiled, muscular tube where most of the large insoluble molecules are broken down into smaller soluble molecules. To do this, it contains lots of digestive enzymes (many are made by the pancreas but it makes some of its own, too). The small soluble molecules of food are then absorbed into the blood through finger-shaped projections called villi. Food is moved along the small intestine by peristalsis

5. Large intestine: Undigested food (i.e food which isn't broken down in the small intestine) passes into the large intestine. The large intestine is a wide, thin-walled tube. In the large intestine, water diffuses back into the blood leaving the waste material (faeces) behind

6. Anus: This is where the undigested food (faeces) is passed out of the body



Other important organs of the digestive system

Pancreas: makes digestive enzymes and releases them into the small intestine

Liver: Once digested food in the small intestine passes into the bloodstream, it is taken up into the liver to be processed.

Some molecules are broken down even more. Some are built up into larger molecules. The liver also <u>makes</u> bile, which helps digest fats

Gall bladder: The gall bladder is a small organ that <u>stores</u> bile made by the liver. It releases the bile into the small intestine when needed (i.e after a fatty meal when there is fat that needs to be broken down).

BREAKING DOWN FOOD

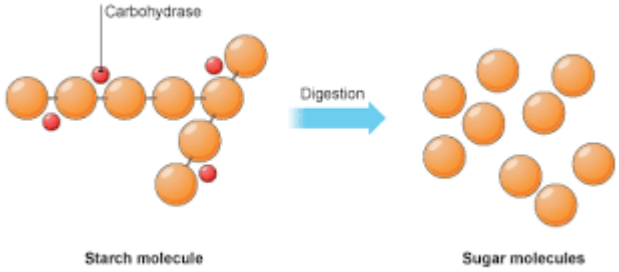
The chemical breakdown of food (from large insoluble molecules into small soluble molecules) depends on the action of digestive enzymes. Different types of digestive enzymes break down the three main types of food molecules – carbohydrates, proteins and fats

Digesting carbohydrates

Digestive enzymes that break down carbohydrates are called 'carbohydrases'

e.g amylase in saliva.

Amylase breaks starch down into sugars. The sugars can then either be absorbed by the small intestine or be broken down into glucose (a 'simple sugar') by other carbohydrases.



Digesting proteins

Protease enzymes break down proteins into shorter polypeptide chains and then into amino acids.

Pepsin is a protease produced in the stomach. The contents of the stomach are acidic so pepsin has an optimum pH of around pH2 or pH3 which means pepsin works best (breaks down proteins fastest) in acidic conditions

Some other proteases are produced by the pancreas and then released into the small intestine. The contents of the small intestine are weakly alkaline proteases that are released into the small intestine have an optimum pH of around pH8.

Digesting fats

Lipases are enzymes that break down fat molecules into fatty acids and glycerol. However, fats are insoluble and form large globules in the watery digestive juices. Large globules have a small surface area to volume ratio and lipases would only be able to break down the fat molecules very slowly

Role of bile

After a fatty meal, bile is released by the gall bladder into the small intestine

1. Bile breaks down large fat globules into tiny droplets, forming an emulsion (i.e bile 'emulsifies fats') and then the smaller droplets have a larger surface area so lipases can break down the fat molecules more quickly
2. Bile is alkaline and neutralises stomach acid and produces a slightly alkaline environment for protease enzymes of the small intestine to work best in

Questions on the Digestive System

- Name an insoluble molecule and what it gets broken down into so that it is soluble in the blood.
- Explain two reasons why chewing food is useful.
- What is peristalsis?
- What get removes from the food in the large intestine?
- Explain the purpose of the gall bladder, pancreas and liver.

Questions on Breaking Down Food

- What does carbohydrase do?
- Name the enzyme that breaks down proteins and fats.
- Name a protease enzyme and explain what its optimum pH is.
- Describe the role of bile
- Is bile acidic or alkaline? Why is this useful?

VILLI

Once food molecules are broken down in the small intestine, they pass into the blood by diffusion.

- The lining of the small intestine contains millions of folds called villi
- The structure of villi allows efficient absorption of soluble food molecules from the small intestine into the blood.

1. Large surface area: Villi are finger-like (i.e long and thin) projections that have a very large surface area so more diffusion can take place

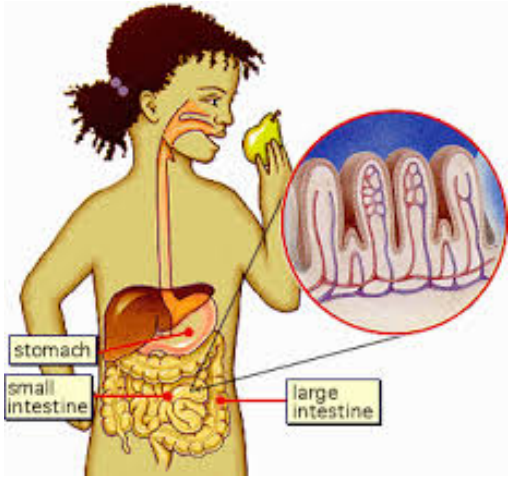
2. Large capillary network: The large capillary network that surrounds villi means soluble food molecules are constantly moved away in the blood and delivered to cells where they are needed

There's always a lower concentration of soluble food molecules in the blood than inside the small intestine. This steep concentration gradient means soluble food molecules can rapidly diffuse from the small intestine into the blood.

3. Single layer of cells: There is only a single layer of cells between the small intestine and the blood vessels (capillaries) in the villi and there's only a short distance over which the soluble food molecules need to diffuse

Evidence for the importance of villi – coeliac disease:

- In coeliac disease, villi may be lost -People affected with coeliac disease cannot absorb the products of digestion properly and become very thin
- This shows the importance of villi in ensuring that the products of digestion are efficiently absorbed into the bloodstream so that they can then be transported to cells that need them



PROBIOTICS AND PREBIOTICS

The digestive system contains millions and millions of bacteria – some can cause problems, but most provide health benefits e.g. they can help break down food and protect against disease-causing microorganisms**. F**oods that claim to make people healthier (e.g yogurt) are called 'functional foods'. Bacteria in the digestive system that have health benefits are called 'beneficial' bacteria

Probiotics

Probiotics contain live 'beneficial' bacteria – these are usually Lactobacillus and Bifidobacteria, which produce lactic acid in the gut. The makers of foods containing probiotics (e.g yoghurt) claim that they will make you healthier by: improving your digestive system helping your body protect itself against disease:;reducing allergies. However a study in 2010 by the European Food Safety Agency concluded that there wasn't enough evidence to support these health claims

Prebiotics

Prebiotics are substances that the body can't digest – they provide food for the beneficial bacteria in the gut and encourage their growth

Tomatoes, bananas, onions and asparagus all contain oligosaccharides – a common form of prebiotic

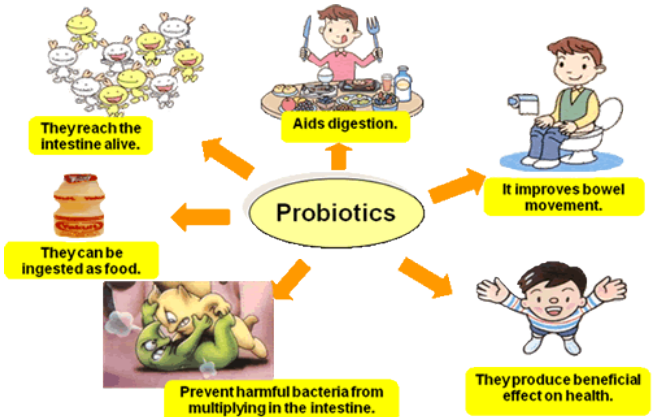
There is good evidence that prebiotics can increase the number of beneficial bacteria in the gut (by promoting their growth)→help maintain good health

Plant Stanol Esters

Plant stanol esters are oily substances found in plants and scientists have discovered that these oily substances can stop the small intestine absorbing cholesterol and therefore lower the cholesterol levels in the blood.

High cholesterol levels in the blood are linked to raised risk of heart disease and plant stanol esters could reduce the risk of heart disease.

There is clear evidence for this effect! Plant stanol esters are now used in many foods - e.g. yogurt



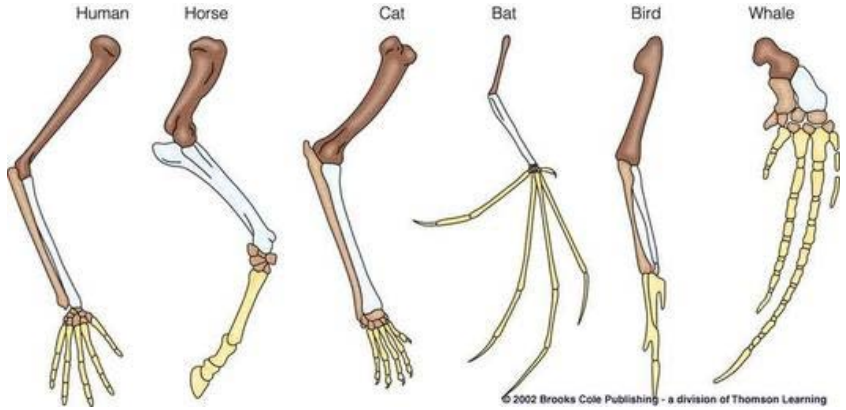
Questions on Villi

- What are villi?
- How does the large surface area of villi increase the efficiency of absorption?
- What keeps the rate of diffusion so high in the villi?
- Give evidence that Villi are important.

Questions on Probiotics and Prebiotics

- What is a functional food?
- Name a probiotic and list three things the manufacturers claim about them.
- What is a prebiotic?
- What are the advantages of plant stanol esters?

More evidence for evolution



- All vertebrates have the same five-fingered 'pentadactyl' limb structure
- From fossils, we know that even limbless vertebrates living on Earth millions of years ago had a pentadactyl limb structure
- This suggests that all vertebrates evolved from one common ancestor hundreds of millions of years ago
- The pentadactyl limb has evolved differently in different vertebrates, to adapt to different ways of living and moving

Questions on Evolution

- Name something all vertebrates have in common.
- How do we know that vertebrates had the same feature millions of years ago?
- Why has this feature evolved differently in different vertebrates?