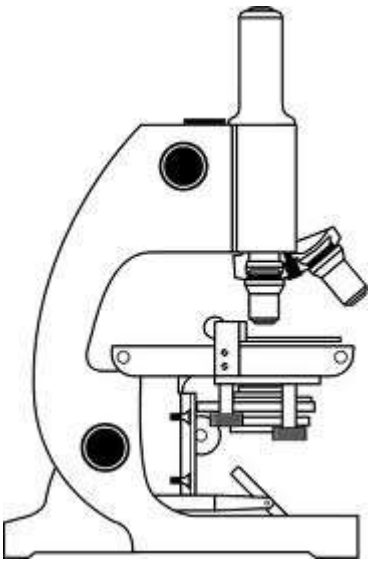
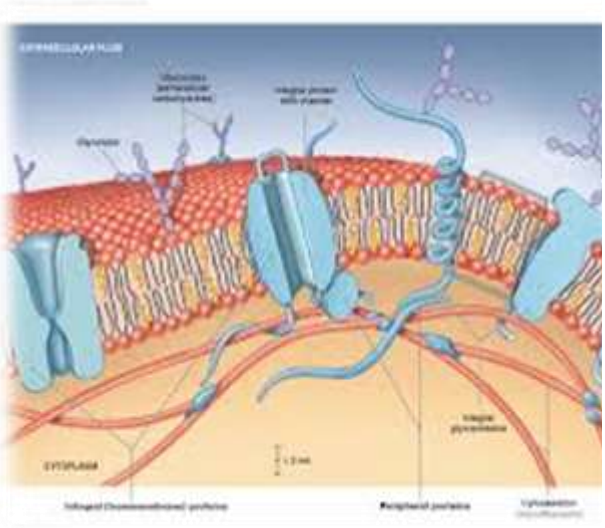
Cell Biology





Section 1 Cell structure

Learning Outcome

- For plant, animal, fungal and bacteria cells, know cell ultrastructure and functions to include: cell walls, mitochondria, chloroplasts, cell membrane, vacuole, nucleus, ribosomes and plasmids.

All living organisms are made up of one or more cells. Cells are the 'building blocks of life'. Unicellular organisms are made of one cell: Multicellular organisms are made up of many cells. The organisation of a cell when seen using a powerful (electron) microscope is known as **ultrastructure**.

Comparing plant, animal, fungal and bacteria cells.

[See next page for diagrams of typical plant, animal, fungal and bacteria cells.]

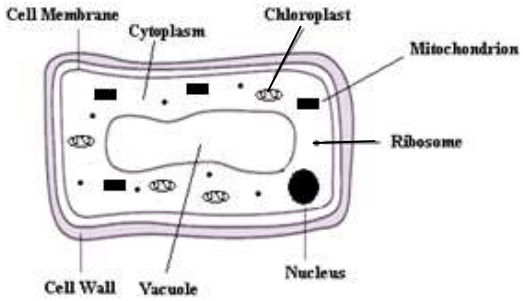
Plant, animal, fungal and bacteria cells contain a cell membrane, cytoplasm and ribosomes. The **cell membrane** is selectively permeable and controls the entry and exit of materials. The **cytoplasm** is a jelly-like substance which is the site of most of the cell's chemical reactions. At the **ribosomes** proteins are produced, being assembled from amino acids.

Apart from bacterial cells, all cells contain mitochondria and a nucleus. **Mitochondria** provide energy from aerobic respiration. The **nucleus** contains DNA and controls the activities of the cell. Although bacterial cells do not contain a nucleus they do possess a structure called a **nucleoid** which is a large "ring" of DNA. In addition, bacterial cells also possess **plasmids** which are small "rings" of DNA.

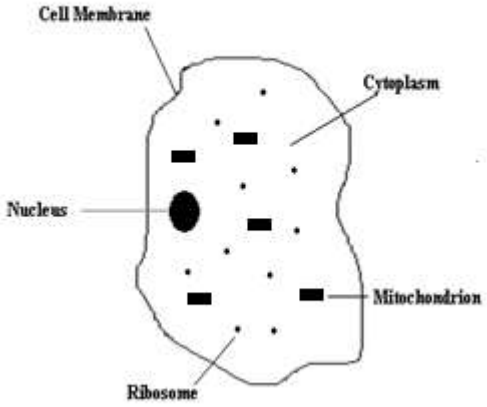
Apart from animal cells, all cells are surrounded by a **cell wall** which strengthens the cell and gives it support. (Plant cell walls are made of cellulose; fungal cell walls are made of chitin. Bacteria cells walls have a different chemical structure to that of plants and fungi).

Plant cells possess two additional structures – a vacuole and chloroplasts. The **vacuole** is filled with cell sap (a dilute solution of salts and sugars) which provides support. **Chloroplasts** contain the green pigment chlorophyll which is needed to trap light energy for the process of photosynthesis.

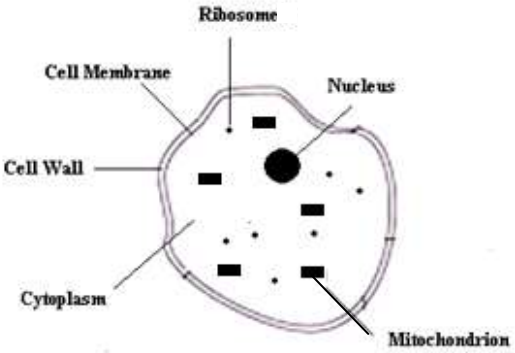
PLANT CELL



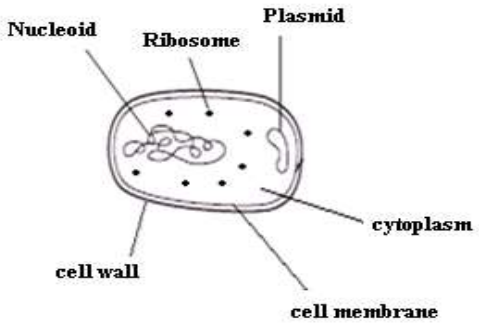
ANIMAL CELL



FUNGAL CELL



BACTERIA CELL



Activity 1

- Copy the heading: **Comparing plant, animal, fungal and bacteria cells.**
- Glue diagrams of cells (plant, animal, fungi, bacteria) into your jotter and label all cell structures.
- Copy and complete the following table using the information on the previous pages.
  [In the 'Organism' column use P = plant; A = animal; F = fungi; B = bacteria]

Cell structure	Organism (P, A, F, B)	Function (what is does)
		Contains DNA. Controls the activities of the cell.
Cytoplasm	P A F B	
Cell membrane		Is selectively permeable. Controls the entry and exit of materials.
		Contains chlorophyll. Involved in photosynthesis.
Vacuole		
Cell wall		
		Production of protein from amino acids.
Mitochondria		
		Large "ring" of DNA. Controls some of the activities of the cell.
		Small "ring" of DNA. Controls some of the activities of the cell.

- Answer the following questions (in sentences) in your jotter.

1. What structures are common to plant, animal, fungal and bacteria cells?
2. What structures do only plant cells have?
3. Which type of organism has a similar **cell structure** to plants and animals but has a different cell wall structure?
4. Which type of organism has a different **cell wall** structure to plant and fungal cells?

Activity 2

- Using a microscope, examine fresh and prepared slides of cells from a range of organisms
  - plant, animal, fungi, bacteria

  Make labelled drawings in your jotter. (Remember to include the magnification)

Section 2 Transport across cell membranes

2a Cell Membrane

Learning Outcome

- Know that the cell membrane consists of lipids and proteins

Investigating the chemical nature of the cell membrane

Activity 1

- Copy the above heading and carry out the following experiment.

Introduction

Cell membranes are thought to be composed of a protein component and a lipid (fat) component. If either of these are damaged, the cell membrane will no longer be intact and materials will move out of the cell easily.
Proteins are denatured (broken down) by temperatures greater than 45^0C. Lipids (fats) dissolve in alcohol.
If cell membranes contain protein, the membrane will be damaged and cell contents will leak out when the cell is at temperatures of 45^0C or above. Similarly if cell membranes contain lipids the membrane will be damaged and cell contents will leak out when the cell is placed in ethanol.
In this experiment plant cells which have a dark coloured pigment in the vacuole are used. Damage to their cell membranes can be detected as pigments will be seen if they leak out of the cell.
Your task is to confirm, from the experimental observations, that the cell membrane is composed of lipids and proteins.

Equipment and materials.

Materials required by each group;

eye protection	thermometer
cork borer	$10cm^3$ syringes
white tile	labels or marker
3 boiling tubes	timer
$60cm^3$ bottle ethanol	

Materials to be shared;
2 water baths, one at 25^{0}C one at 60^{0}C (thermometer in each to check temp)
Beetroot, colour chart

Method

1. Using the cork borer, cut three cylinders of equal length and thickness from a beetroot.
2. Wash cylinders thoroughly in cold running water.
3. Place one cylinder in each of the three boiling tubes.
   Label the boiling tubes with t he condition the beetroot cylinder is being placed in.
4. Using a syringe add 10cm^{3}water to two of the boiling tubes.
5. Place one of these boiling tubes in a 25^{0}C water bath and one boiling tube in a 60^{0}C water bath.
6. Using another syringe add 10cm^3 of ethanol to the third boiling tube and place it in the 25^{0}C water bath. [Wear eye protection and ensure there are no sources of ignition as ethanol is flammable].
7. After 15 minutes note any colour leakage from the cylinders in each of the boiling tubes, using the colour chart.

Optional work
Write a brief description of how the experiment was carried out. This can be done **after** you have noted down your results.

Results
Present your results in a table and as a bar graph.

Conclusion

Copy and complete the following sentence.

The cell membrane consists of _____ and _____.

Evaluation

Answer the following question (in sentences).

Why was it necessary to wash the cylinders?

Why was it necessary to wash the cylinders in **cold** water?

Why were the cylinders of beetroot the same length and diameter?

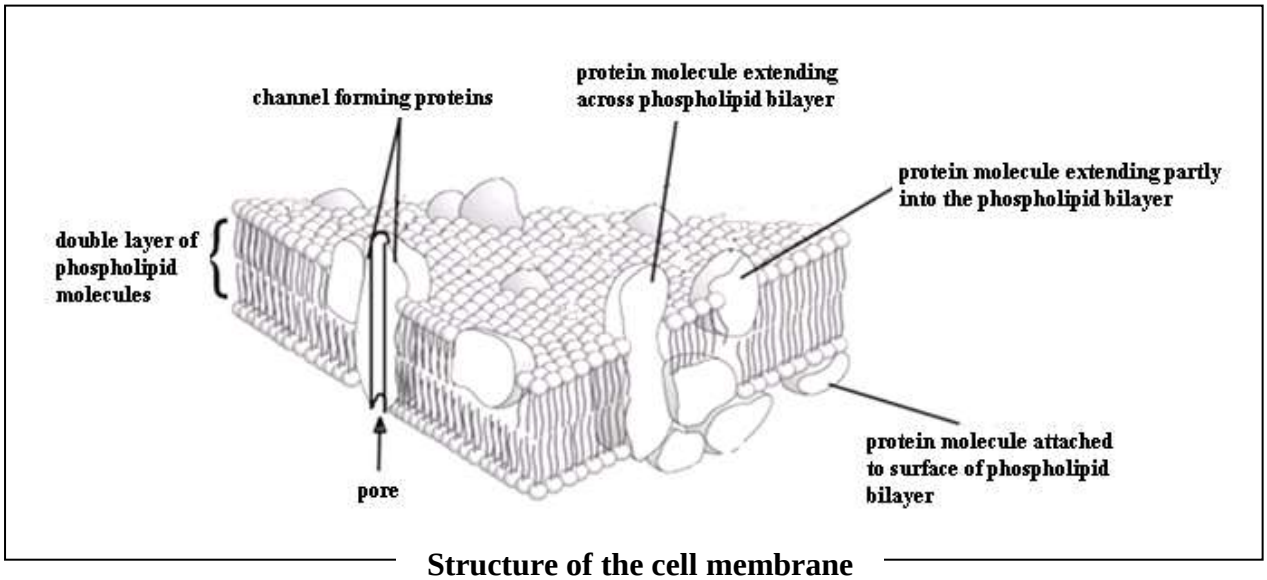
Why was beetroot used?

How could the reliability of the results be increased?

Structure of the cell membrane

You have just confirmed that the cell membrane consists of lipids (phospholipids) and proteins. As shown in the diagram below, the phospholipid molecules form a double layer (bilipid layer) with some of the protein molecules extending partly into the bilipid layer and others are extending across it from one side to the other. Some of the protein molecules can form channels (pores) which can allow the movement of molecules into or out of the cell.

It is thought that the layers of phospholipid molecules are constantly moving (**fluid**) and that they contain the protein molecules as a patchy (**mosaic**). This structure of the cell membrane is known as the **fluid mosaic model**.



Structure of the cell membrane

Activity 2

- Copy the heading: **Structure of the cell membrane**
- Glue a copy of the above diagram into your jotter and label all the parts.
- Describe the function of channel-forming protein molecules.

2b+c

Diffusion and its Importance

Learning Outcomes

- Diffusion is the movement of molecules from an area of high concentration to an area of low concentration down a concentration gradient.
- A cell membrane allows small soluble molecules to pass through but does not allow large insoluble molecules to pass through. The membrane is said to be selectively permeable.
- Diffusion is passive. This means it does not require energy to take place.
- Diffusion is important in cells as the mechanism of the exchange of materials e.g. glucose, oxygen and amino acids into the cell and carbon dioxide and other wastes out of the cell.

Diffusion in Unicellular Organisms

Diffusion can be described as the movement of molecules from an area of high concentration to an area of low concentration, down a concentration gradient. Single celled organisms rely on diffusion to keep them alive. Oxygen and glucose diffuse *into* the cell, from a high concentration in the surrounding environment *outside* the cell. They are used by the organism to survive. As a consequence the organism is constantly making carbon dioxide and other wastes resulting in the concentration of these substances being higher *inside* the cell, they therefore diffuse *out of* the cell. Diffusion is always from a high concentration to a low concentration down a concentration gradient. A concentration gradient can simply be defined as the difference in concentration between and area of high concentration of a substance and an area of low concentration of a substance.

Activity 1 Copy the heading and definition of diffusion into your jotter then copy and complete Figure 1 below adding arrows to show the direction of movement of the molecules.

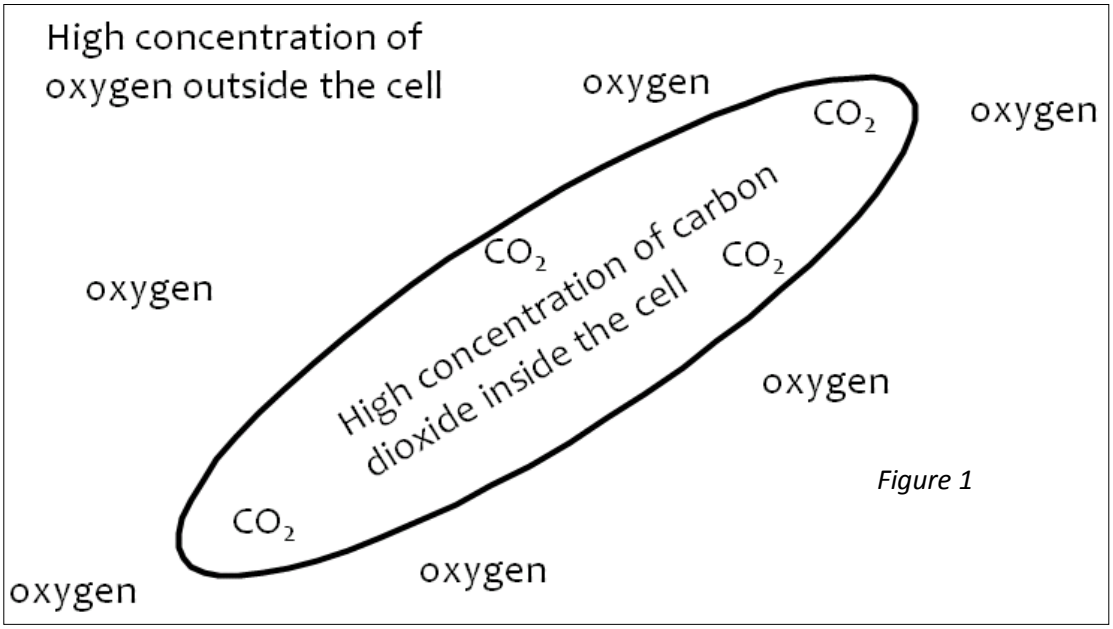


Figure 1

Diffusion in Multicellular organisms

Diffusion plays a very important role in multicellular organisms.
It is essential for;

1. The exchange of respiratory gases between the lungs and capillaries
2. The exchange of gases between capillaries and respiring cells.
3. The movement of dissolved food from the small intestine into the blood capillaries
4. The movement of dissolved food from the blood capillaries to respiring cells
5. The movement of urea from cells into the bloodstream.

Activity 2

Copy and complete the following figure 2 below.

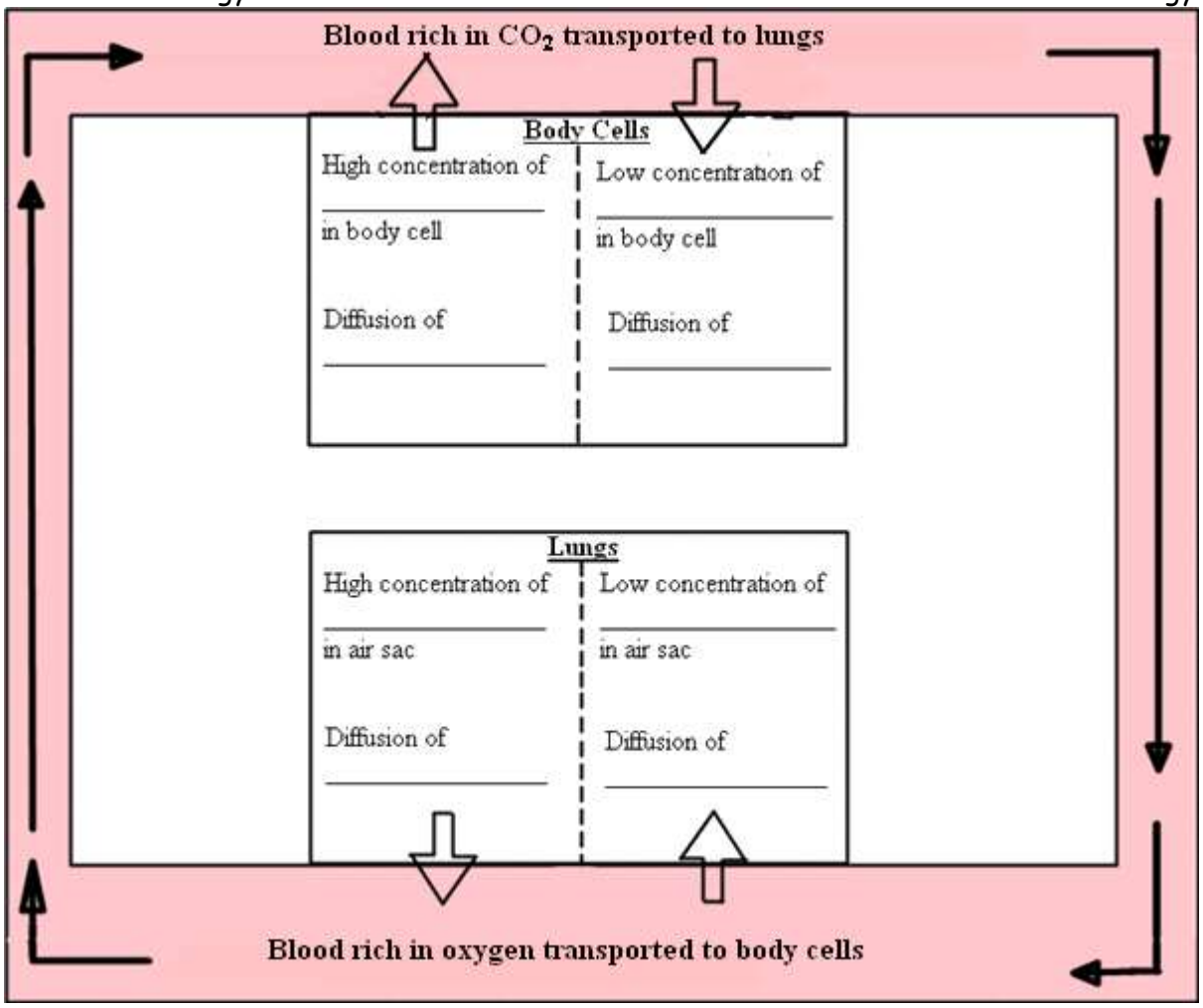


Figure 2

Answer the following questions in a sentence.

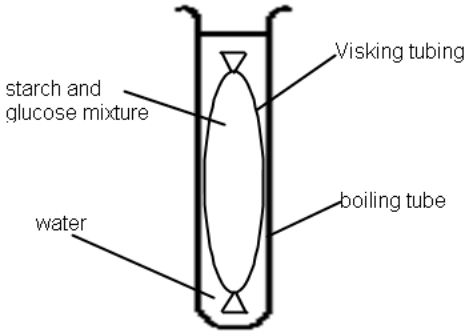
1) What is meant by diffusion?
2) Does diffusion require energy to take place?
3) Why is diffusion important in single celled organisms *and* multicellular organisms?

Activity 3

Visking tubing can be used to demonstrate diffusion and the selective permeability of the cell membrane. Complete the following experiment and record your results in your jotter.

Apparatus

One length of visking tubing
Mixture of starch and glucose (made from 1% starch suspension and 5% glucose solution)
Boiling tube
Distilled water
Iodine solution
Benedict's solution
Water bath (for testing for simple sugars)
Dropper



Method

1. Tie a knot in one end of a length of visking tubing which has been soaking in water.
2. Using a dropper fill the visking tubing with the glucose and starch mixture.
3. Tie the other end of the visking tubing and rinse it under the tap.
4. Place the filled visking tubing into a boiling tube and fill the tube with distilled water.
5. Leave the experiment for 15 minutes to allow diffusion to take place.
6. Test the water in the boiling tube for starch (using iodine solution) and sugar (using Benedict's solution).
7. Record your result.

Conclusion

1. What does the visking tubing represent?
2. What was detected in the water surrounding the visking tubing?
3. What was not detected in the water surrounding the visking tubing?
4. Why were these chemicals detected/not detected?

Evaluation Questions

1. Why was it necessary to rinse the filled visking tubing before placing it into the boiling tube?
2. Why was it necessary to leave the experiment to run for 15 minutes?
3. How could the experiment have been made more reliable?

2c+d

Osmosis and its effect on cells

Learning Outcomes

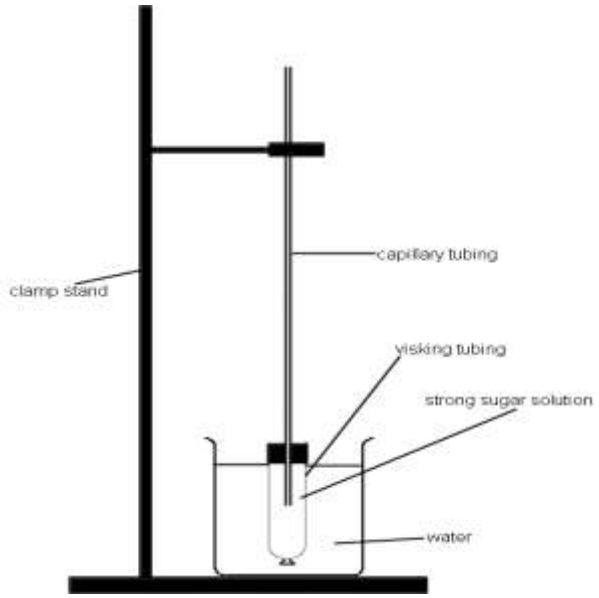
- Osmosis is the movement of water molecules from an area of high water concentration to an area of low water concentration through a selectively permeable membrane.
- In solutions of different concentrations animal cells can burst, shrink or remain unchanged.
- In solutions of different concentrations plant cells become turgid, plasmolysed or remain unchanged.
- Solutions can be described as hypertonic, isotonic or hypotonic when compared to another solution.
- Hypertonic solutions have the lower water concentration.

Osmosis

Osmosis is the movement of water molecules from an area of high water concentration to an area of low water concentration through a selectively permeable membrane. An osmometer can show osmosis occurring. As have discovered visking tubing has a selectively permeable membrane, osmosis takes place through a selectively permeable membrane. The osmometer is set up as shown below.

Activity 1 - Copy the heading **Osmosis** and copy out the definition.

Activity 2 - Osmometer



- Stick the two diagrams into your jotter. On the first diagram mark the starting level of the sucrose solution. On the second diagram mark the level of the sucrose solution after 20 minutes.
- Write a short conclusion which should include what was observed and the reasons why.

Solutions of Different Concentrations

Solutions can have different concentrations. The concentration inside a cell may not be equal to the liquid surrounding it. When we compare the differing solutions we use the following words;

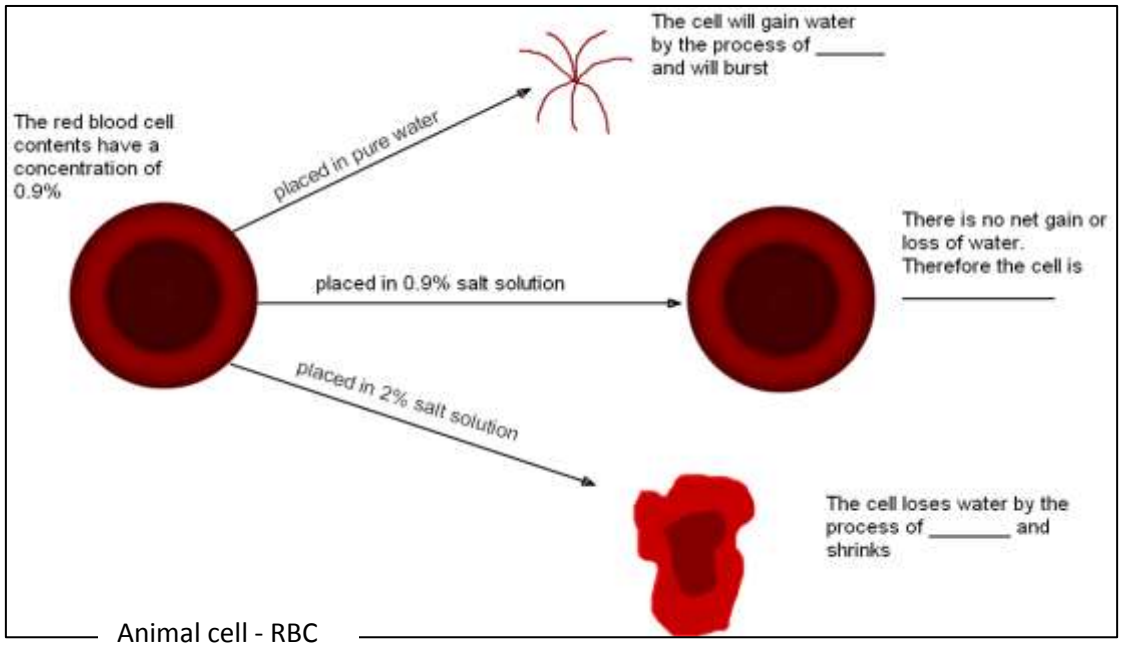
Hypotonic – This describes solutions that have the higher water concentration.

Isotonic – This describes solutions that are of equal concentration.

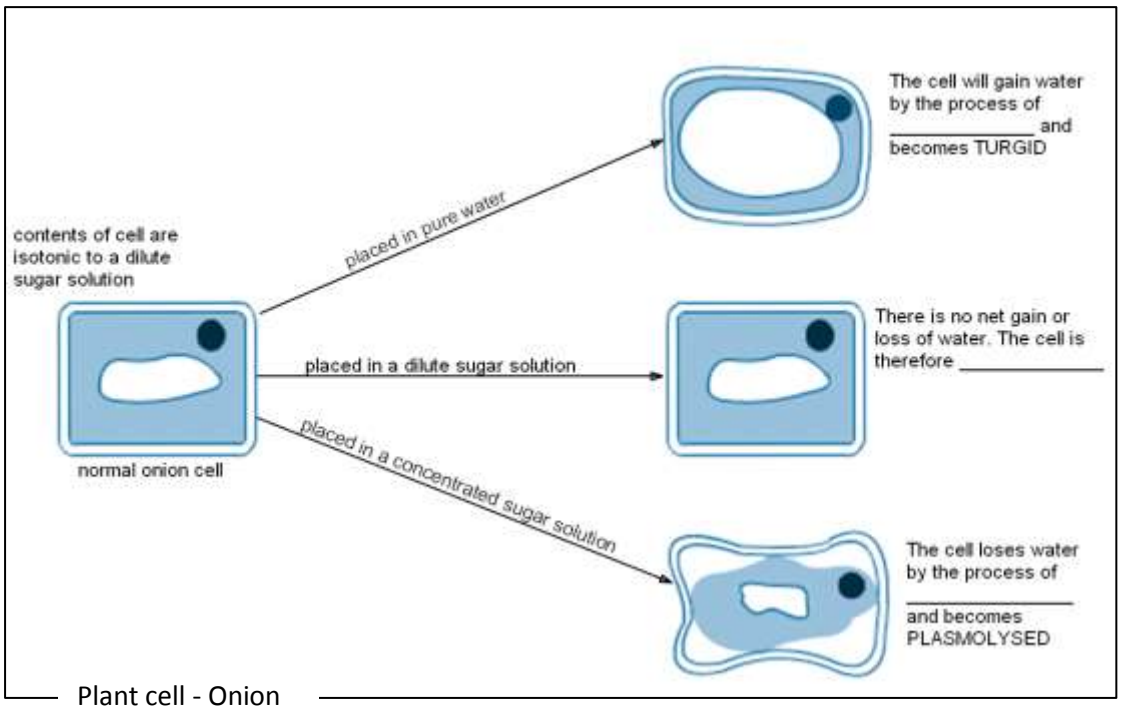
Hypertonic – This describes solutions that have the lower water concentration.

Activity 3

When cells are immersed in solutions of different water concentrations they react differently. Copy and complete the following figures. Using the words hypertonic, isotonic, and hypotonic add a description of each solution the cells are being placed in under each arrow. Below your diagram write the definitions of **hypertonic, hypotonic, isotonic**, **turgid and plasmolysed**.



Animal cell - RBC



Plant cell - Onion

2f Active Transport

Learning Outcomes

- **Active transport is the movement of molecules (and ions) across the cell membrane from a low to a high concentration (i.e. against the concentration gradient).**
- **Active transport is carried out by membrane proteins.**
- **Active transport requires energy (supplied by ATP).**
- **Temperature, availability of oxygen and concentration of respiratory substrate (e.g. glucose) affect the rate of active transport (because the rate of respiration and energy production are affected).**
- **Examples of active transport are a) sodium and potassium in nerve cells and b) iodine in seaweed.**

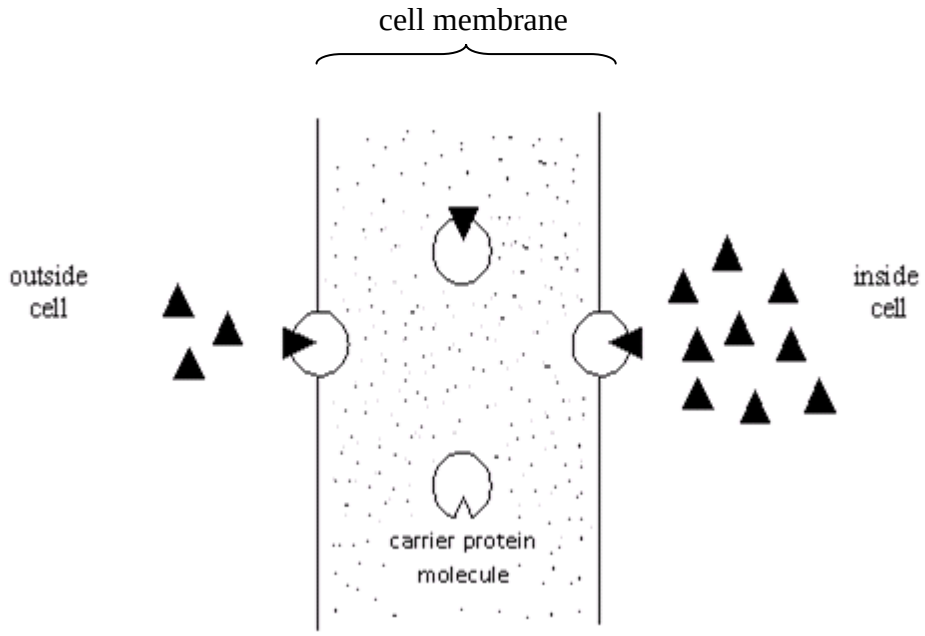
Active transport is the movement of molecules across the cell membrane against the concentration gradient i.e. molecules move from a **low** concentration to a **high** concentration. This is the opposite direction to the passive process of diffusion and requires **energy**, which is supplied by respiration. Factors, therefore, which affect the cell's respiration rate, also affect the rate of active transport – temperature, oxygen concentration and concentration of glucose.

The movement of molecules across the cell membrane during active transport is carried out by **protein** molecules (carrier protein molecules) present in the cell membrane.

Nerve cells transport **sodium** and **potassium** by active transport. The concentration of **iodine** inside the cells of **seaweeds** is much greater than that of the surrounding sea water due to active transport.

Activity 1

- Copy the heading: **Active transport**
- Copy the following diagram to show active transport of " ▲ " molecule



- Write on your diagram '**high concentration**' or '**low concentration**' beside one of the groups of molecule "▲" to show the concentrations outside and inside the cell.

- Draw an arrow across the cell membrane to show the direction of the active transport of molecule "▲" [Write along the arrow '**active transport**']

- Draw arrows between each carrier protein molecule to show the direction of movement of the carrier protein molecule. [Hint: clockwise or anticlockwise direction.]

- Answer the following questions (in sentences).
  1. Define the term **active transport.**
  2. Explain how **active transport** is different from diffusion.
  3. Name the type of substance which moves molecules across the cell membrane during active transport.
  4. Name the factors which may affect the rate of active transport. Explain your answer.
  5. Give two examples of active transport.

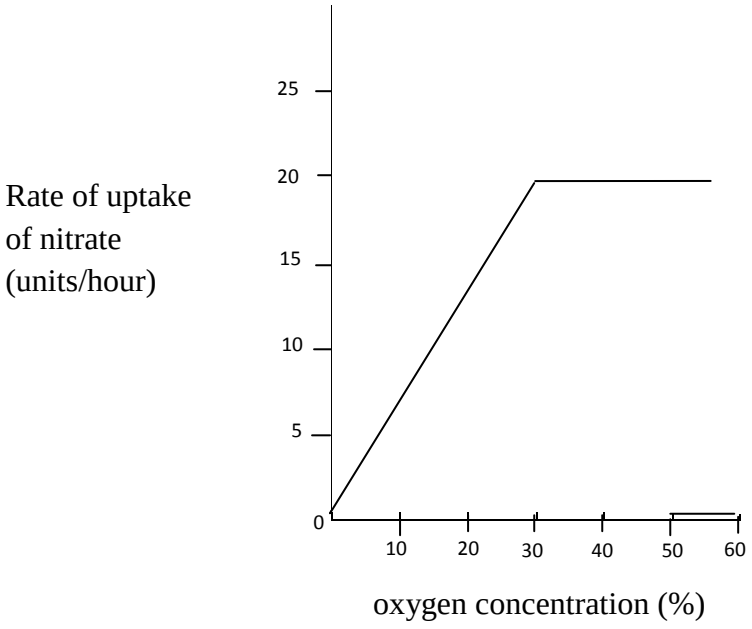
Activity 2 – Extra Questions

1. The table below shows the results of an experiment carried out to analyse the concentrations of potassium and sodium found in sea water and in the sap of cells of seaweed.

liquid	concentration (units)	
	potassium	sodium
seawater	0.02	0.59
cell sap	0.56	0.03

Write a conclusion for the experiment assuming that active transport is taking place.

2. The graph shows the effect of oxygen concentration on the rate of uptake of nitrate ions by barley roots.



a) Why does oxygen concentration affect the rate of uptake of nitrate from 0 to 30%?

b) Suggest a reason why the rate of uptake levels off at oxygen concentrations greater than 30%.

Section 3 Producing new cells

3a Mitosis

Learning Outcomes

- The sequence of events of mitosis.
- Mitosis maintains the diploid chromosome complement of cells.
- Diploid cells have two matching sets of chromosomes, which are replicated during mitosis.

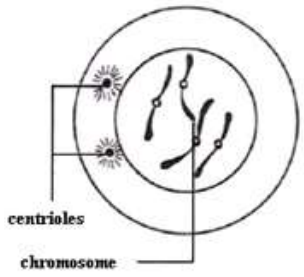
Cell division, or **mitosis** as it is called, is the process by which new cells are produced from existing cells. Mitosis is controlled by the nucleus of a cell which contains thread-like structures known as **chromosomes**.

Every species of plant and animal has a characteristic number of chromosomes (the chromosome **complement**) present in the nucleus of each of its cells. The chromosome complement of all cells (apart from sex cells) consists of **two** matching sets of chromosomes – the cell is therefore said to have a **diploid** chromosome complement.

Chromosomes carry all the genetic information necessary to control all aspects of the structure and function of an organism. Therefore, when a cell divides, a new set of chromosomes must be made (**replicated**) so that vital genetic information is passed into the two new cells and is not lost.

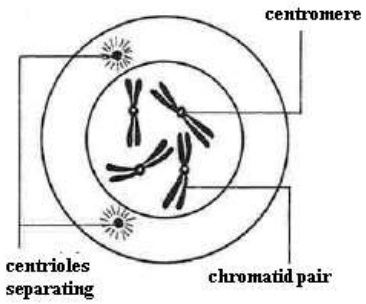
The **sequence of events** occurring during mitosis is shown on the next page.

Stage 1



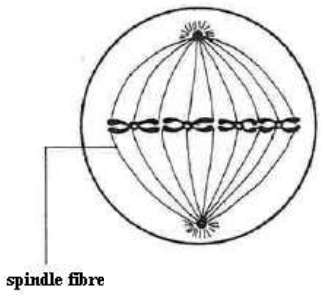
Chromosomes appear in the nucleus. Two structures called centrioles are seen outside the nucleus.

Stage 2



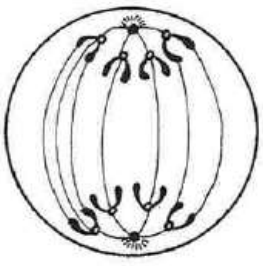
Each chromosome makes a replicate (a copy) of itself. These replicates or chromatids are joined at a centromere.

Stage 3



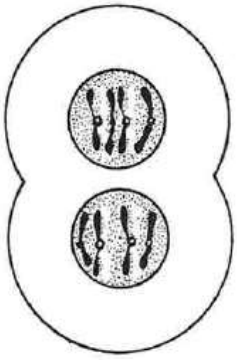
The membrane round the nucleus disappears. The centrioles move to opposite ends (poles) of the cell and produce spindle fibres. The chromatid pairs line up at the equator attached to the spindle fibres

Stage 4



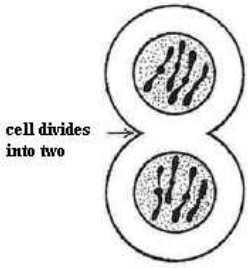
The chromatid pairs are pulled apart and move to opposite poles of the cell.

Stage 5



New nuclear membranes form around each clump of chromatids.

Stage 6



The cytoplasm divides, new cell membranes form, producing two identical cells (which go through a period of growth) before mitosis starts again in each cell

Activity 1

- Copy the heading: **Producing new cells – Mitosis**
- Collect **Information sheet – Stages of Mitosis**
- Collect **Stages of Mitosis – Description**
- Cut and paste the correct description with the correct stage of mitosis in the correct sequence.

Activity 2

- Using a microscope, examine prepared root tip slides.

Activity 3

- Copy and complete the following statement using the wordbank.

replicated	**chromosome**	**diploid**

Mitosis maintains the diploid _____ complement of cells.
_____ cells have two matching sets of chromosomes which are _____ during mitosis.

Section 4 DNA and Protein Production

4a

The Structure of DNA

Learning Outcomes

- **DNA is a double stranded helix**
- **DNA contains 4 types of bases**
- **DNA bases are Guanine, Cytosine, Adenine and Thymine**
- **DNA bases pair up in the following order;**
  - **Guanine and Cytosine (and vice-versa)**
  - **Adenine and Thymine (and vice-versa)**

DNA

DNA is found in the nucleus of every cell and is composed of two strands twisted around itself (figure 1). Each strand is a chain of bases. DNA contains the genetic information of the whole organism.

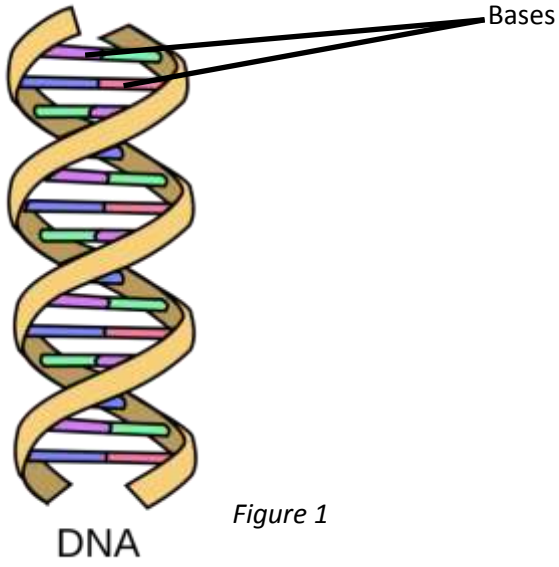


Figure 1

The two strands are held together by bonds between the bases. Each base has a specific shape so that it can only fit one other type of base (shown in figure 2).

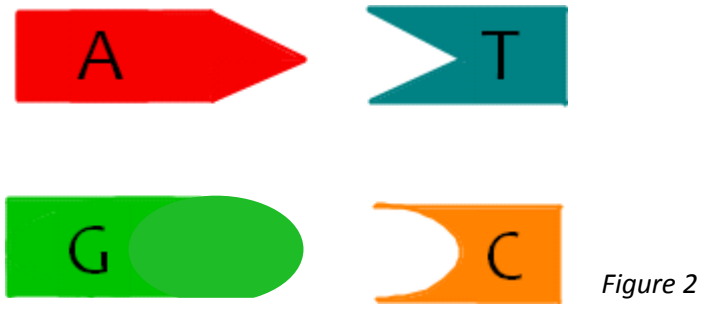


Figure 2

Activity 1

Answer the following questions in a short paragraph.

1) What is DNA?
2) What are the bases in DNA?
3) In what order do the bases combine?
4) Figure 3 below represents one strand of DNA. Copy this into your jotter and complete a second strand showing the bases which match.

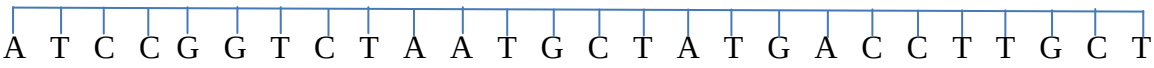


Figure 3

4b mRNA

Learning Outcomes

- **Messenger RNA (mRNA) is a molecule which carries a copy of the code from DNA , in the nucleus, to a ribosome.**
- **A ribosome is a structure in the cytoplasm which 'reads' the mRNA and matches it to specific amino acids**
- **Proteins are assembled from amino acids at ribosomes.**

Production of Protein

Proteins are long chains of amino acids. The sequence of these amino acids determines the final structure of the protein.

As previously mentioned, DNA contains genetic material. DNA carries this information on genes. Genes are sections of DNA which carry specific information, for example, there are genes for eye colour, hair colour or the ability to roll your tongue. Genes may be hundreds or thousands of bases long. These genes code for proteins but the DNA is too large to pass out of the nucleus to the ribosomes (in the cytoplasm) where proteins are made. This problem is solved by mRNA. mRNA makes a 'mirror image' copy of the gene, but unlike DNA it is only composed of one strand. As mRNA is a one stranded copy of a gene it is small enough to pass out of the nucleus and move into cytoplasm towards a ribosome.

Each group of **three** bases along the DNA strand represents a 'code-word' for an amino acid. The mRNA copies this code and the ribosomes 'read it' and match it with a specific amino acid. The amino acids joins up in chains to form proteins. Therefore it can be said that the order of bases in the DNA determines the order of amino acids. This is shown in figure 4 below.

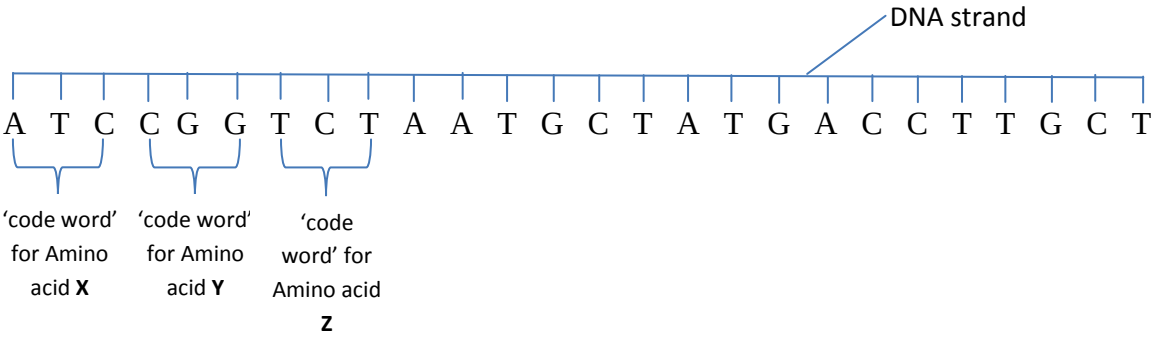


Figure 4

Activity 1

Complete the following questions in a short paragraph.

1) Why is mRNA required?
2) Where is mRNA made?
3) Where does mRNA travel to?
4) What happens when mRNA reaches its destination?
5) What is formed by a chain of amino acids?
6) Copy and complete the figure 5 by inserting the correct amino acid letter. Use the information in table 1 to help you;

Table 1

DNA Code	Amino Acid
GCA	Amino Acid M
CGC	Amino Acid N
AAC	Amino Acid O
CCC	Amino Acid P
GGA	Amino Acid Q

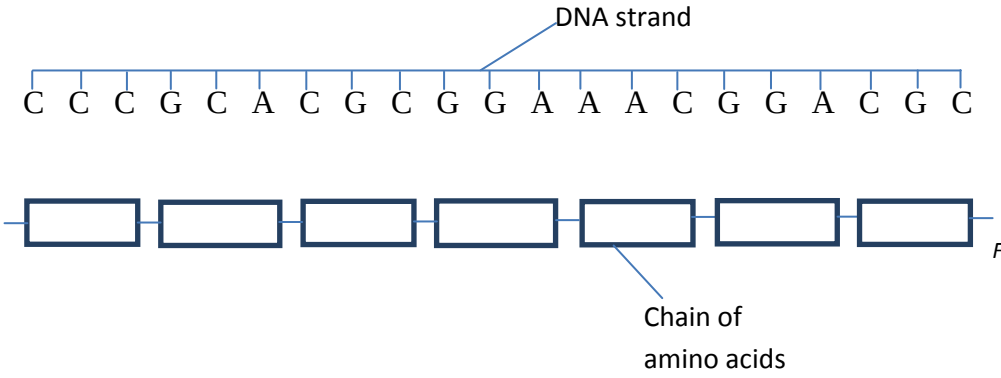


Figure 5

Section 5 Proteins and Enzymes

5a Variety of Protein Shapes

Learning Outcomes

- **The variety of protein shapes and functions arises from the sequence of amino acids.**
- **The sequence of amino acids leads to coiling and folding which determines the final shape and function**
- **Examples of protein shapes are;**
  - **Structural Proteins**
  - **Enzymes**
  - **Hormones**
  - **Antibodies**

In the previous section it was shown how the order of the bases in DNA determines the order of the amino acids when a protein is formed in a ribosome. The order of these amino acids determines the folding and coiling and this gives the protein its specific shape and therefore its specific function. An example of the formation of the enzyme amylase is shown in figure 1 below.

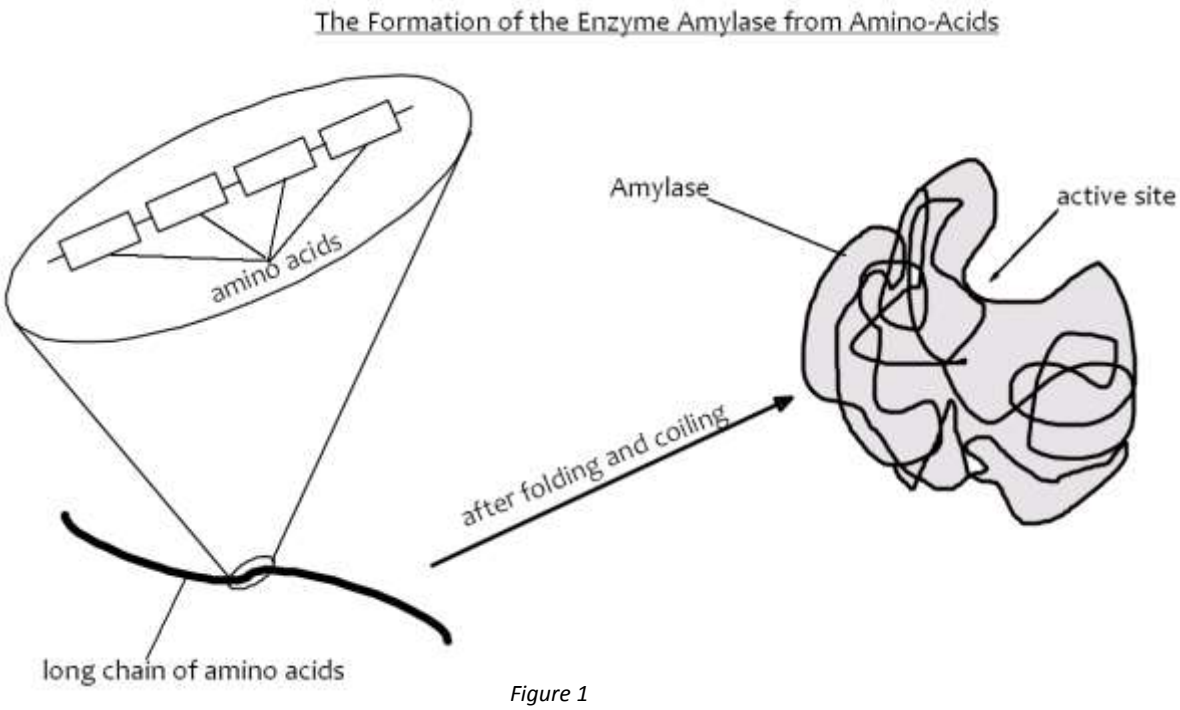
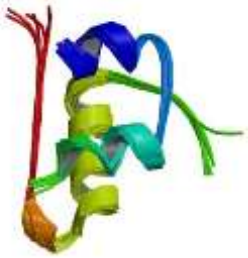
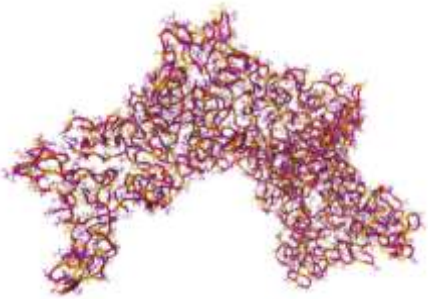


Figure 1

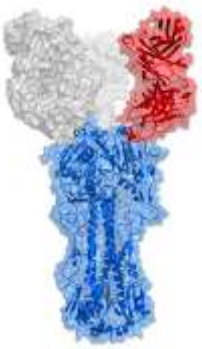
The previous example showed the formation of an enzyme after long chains of amino acids have been formed. It is not only enzymes that are assembled in this way. Structural proteins, hormones and antibodies are formed in the same process of folding and coiling. Their shapes are shown below.



Structural Protein



Hormone



Antibody

5b Functions of proteins

Learning Outcome

- **Know the functions of proteins to include: structural, enzymes, hormones and antibodies.**

Proteins have a **variety of functions**. Some of these functions (with examples of proteins) are listed below.

1. **Function – Structural**

   Ex 1. structural proteins in **cell membranes**, some of which form channels allowing movement of molecules into or out of cells (see back to lesson 2a).

   Ex 2. **elastin** in artery walls giving flexible support.

2. **Function – Enzymes**

   Enzymes are biological catalysts which speed up the rate of biochemical reactions.
   (See lesson 5c, later).

   Ex 1. **amylase** breaks down starch to maltose.

   Ex 2. **pepsin** breaks down protein to peptides.

3. **Function – Hormones**

   Hormones are chemical messengers which regulate growth and metabolism. They are carried in the blood.

   Ex1. **insulin** promotes conversion of glucose to glycogen

   Ex 2. **somatotrophin** promotes growth of long bones.

4. **Function – Antibodies**

   Antibodies are Y-shaped proteins produced by white blood cells. They defend the body against antigens. [Antigens are complex molecules, produced by e.g. viruses, and are recognised as alien by the body].
   Examples – many exist, just as there are many disease-producing organisms producing different antigens (e.g. chicken pox virus, polio virus).

Activity

- Copy the heading: **Shapes and Functions of proteins.**
- Answer the following question in a sentence

What gives rise to the variety of protein shapes and functions?

- Copy and complete the following table using the information given on the previous page.

Protein function	Named example	Description of function
	structural protein in cell membranes	
		breaks down protein to peptides
hormones		
	antibodies for polio virus antigens	defend the body against polio virus antigens

5c

Enzymes

Learning Outcomes

Enzymes:

- are biological catalysts
- are made by all living cells
- speed up cellular reaction
- are unchanged in a reaction

- The shape of the active site of the enzyme is complimentary to a specific substrate

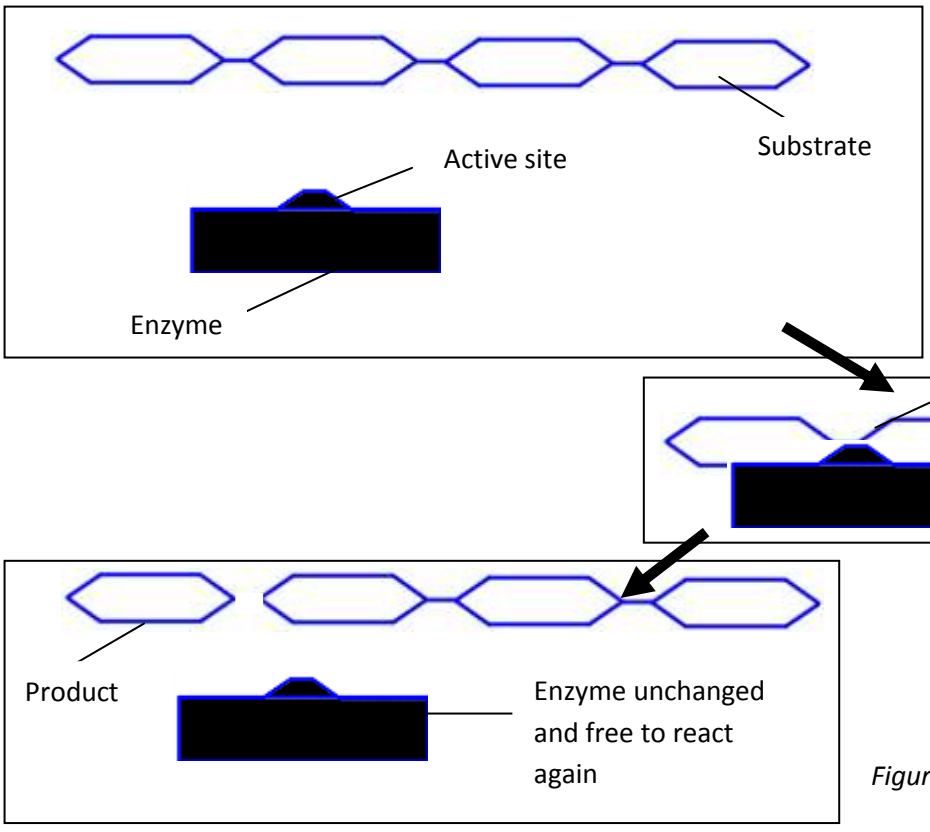


Figure 3

Now watch the short video *'Catalase'*

From your level 4 work you should already know that enzymes are biological catalysts and are made by all living cells.
Enzymes speed up cellular reactions and are unchanged by reactions.
The shape of the active site is complementary to a specific substrate (figure 3 below). During the reaction the substrate fits the active site (this is called the enzyme – substrate complex).
Enzymes can be involved in:

1. Degradation reactions (breaking down);
2. Synthesis reactions (building up) Enzyme reactions can be summarised as in the following table.

Type of Reaction	Substrate	Enzyme	Product
Degradation	Starch	Amylase	Maltose
Degradation	Protein	Pepsin	Peptides
Degradation	Fat	Lipase	Fatty acids and glycerol
Degradation	Hydrogen peroxide	Catalase	Oxygen and water
Synthesis	Glucose-1-phosphate	Phosphorylase	Starch

Activity 1

Use the previous information and video to write a short note on enzymes. You may wish to include a diagram.

5d

Optimum conditions

Learning Outcomes:

- The conditions in which an enzyme will work best is called its optimum
- Two conditions which must be at an optimum for an enzyme to work are temperature and pH.
- If an enzyme is not at its optimum it can result in a change of shape until the enzyme is damaged
- An enzyme which is damaged and unable to work is said to be denatured

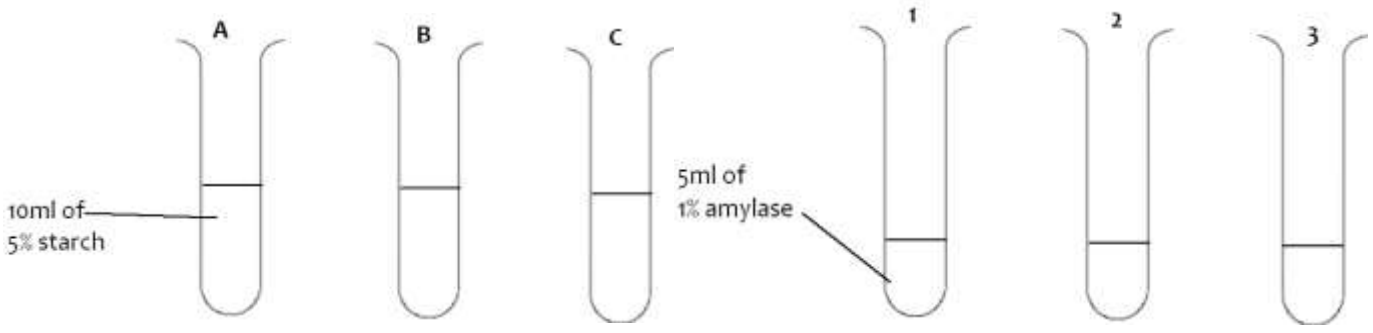
Each enzyme has a specific condition in which it will work best. This is called the optimum. Enzymes can have an optimum temperature and an optimum pH, out with this optimum, enzymes will work very slowly or not at all. If an enzyme becomes so damaged that it cannot function, it is said to be denatured.

Activity 1

In this experiment you will discover the effect of temperature on the activity of an enzyme. The enzyme you will use is amylase and this enzyme digests starch into maltose. If the starch has been digested into maltose it can be detected by Benedict's Solution which changes from blue to brick red.

Apparatus

Six boiling tubes; 5% starch solution; 1% Amylase solution; Water bath at 37°C Water bath at 90°C; Ice & Plastic trough.



Method

1. Set the boiling tubes up as shown on the previous page.
2. Place Tubes A, 1 into the trough filled with ice for 10 minutes
3. Place tubes B, 2 into the 37°C water bath for 10 minutes
4. Place tubes C, 3 into the 90°C water bath for 10 minutes
5. Combine the contents of tubes A&1, B&2, C&3
6. Leave in the correct conditions for 20 minutes
7. Test each solution for reducing sugars

Results
Record your results in a suitable table

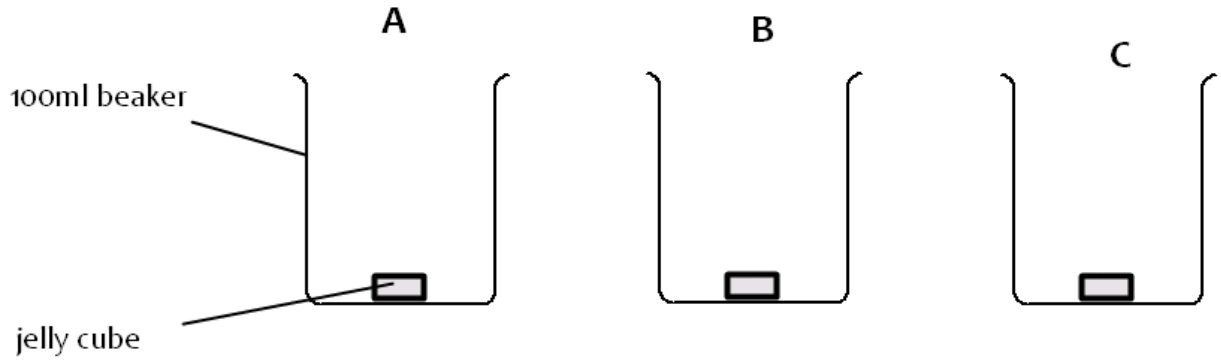
Conclusion
Write a short note on the effect that temperature has on the activity of enzymes.

Evaluation
How could you improve the reliability of this experiment?
Name a variable which should be controlled to make this experiment more valid.

Activity 2
In this experiment you will discover the effect of pH on the activity of an enzyme. The enzyme you will use is called pepsin and this enzyme digests protein into peptides. The protein used in this experiment is in the form of a jelly cube which will become liquid if digested.

Apparatus
Three 100ml beakers
Three small cubes of jelly
Pepsin at pH 2
Pepsin at pH7
Pepsin at pH14
Distilled water
Three droppers

Method



1. Set up the apparatus as shown above
2. Using a dropper add 2ml of pH2 pepsin to beaker A
3. Using a dropper add 2ml of pH7 pepsin to beaker B
4. Using a dropper add 2ml of pH14 pepsin to beaker C
5. Leave overnight and observe any changes in appearance.

Results

What happened in beaker A? Why?
What happened in beaker B? Why?
What happened in beaker C? Why?

Conclusion

Write a short note on the effect that pH had on the enzyme pepsin.

Evaluation

How could you improve the reliability of this experiment?
Name a variable which should be controlled to make this experiment more valid.

Section 6 Genetic Engineering

Learning Outcomes

- Genetic information can be transferred from one cell to another naturally or artificially
- The stages of genetic information as follows;
  - Identifying required gene on DNA
  - Extracting the required gene
  - Extraction of bacterial plasmid
  - Insertion of the required gene into a plasmid
  - Insertion of plasmid into host cell
  - Growth of genetically modified organism producing required product

Genetic engineering can be described as the transfer of pieces of DNA from one organism to another organism e.g. the insulin gene from a human to a bacterium.

Genetic information can be transferred from one cell to another in a variety of ways. Some genetic information can be transferred naturally for example when a virus invades a cell in 'injects' its own DNA and therefore changes the function of that cell.

DNA can be inserted into a cell artificially and this is called genetic engineering.

During genetic engineering the gene which is required (for example one which codes for the production of insulin) must be located and extracted from the source DNA. Once extracted, several steps are then followed resulting in a genetically modified organism (e.g. bacteria). The diagram below shows these steps.

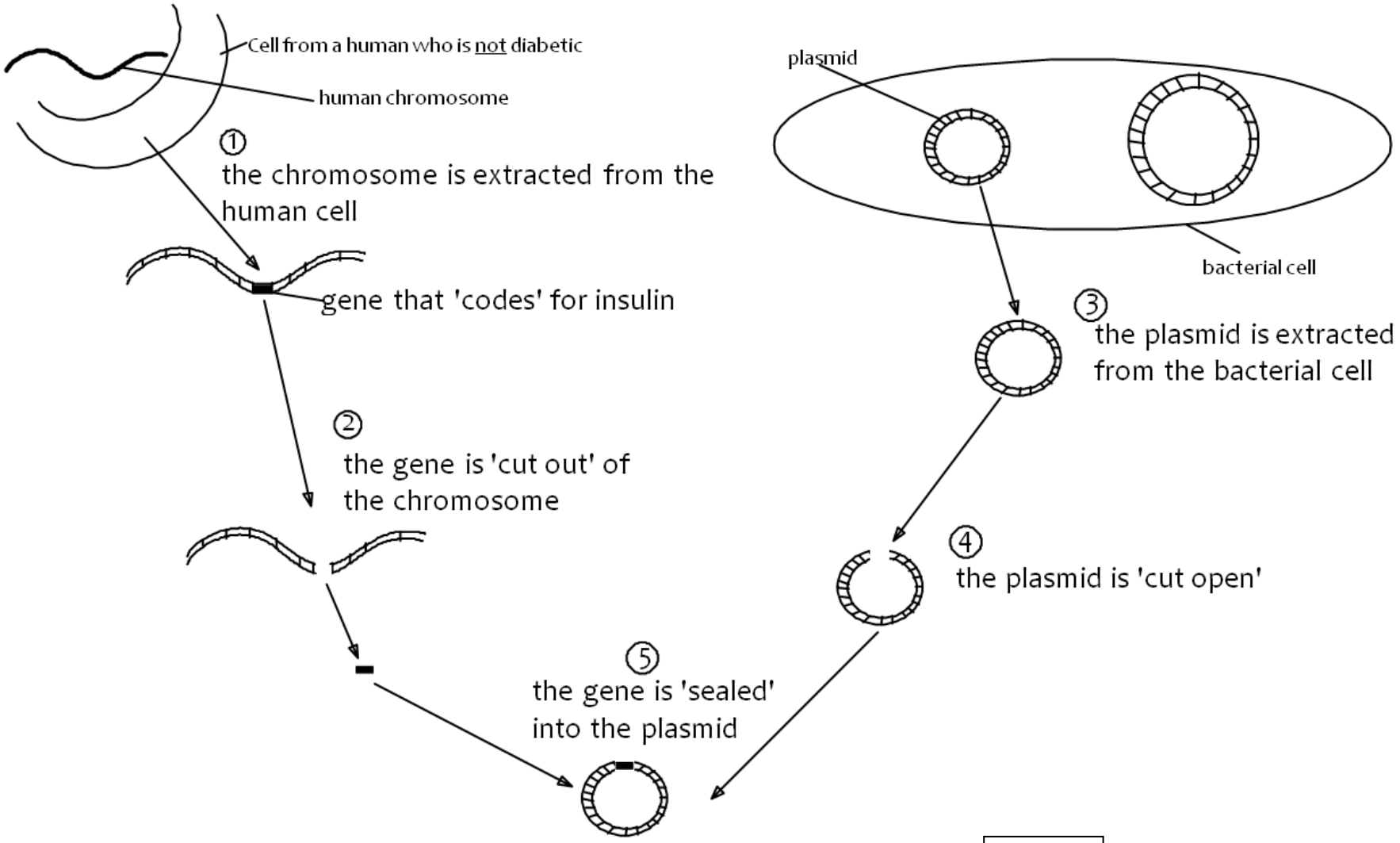

Cell from a human who is not diabetic
human chromosome
1
the chromosome is extracted from the human cell
gene that 'codes' for insulin
2
the gene is 'cut out' of the chromosome
5
the gene is 'sealed' into the plasmid
plasmid
bacterial cell
3
the plasmid is extracted from the bacterial cell
4
the plasmid is 'cut open'

Figure 1

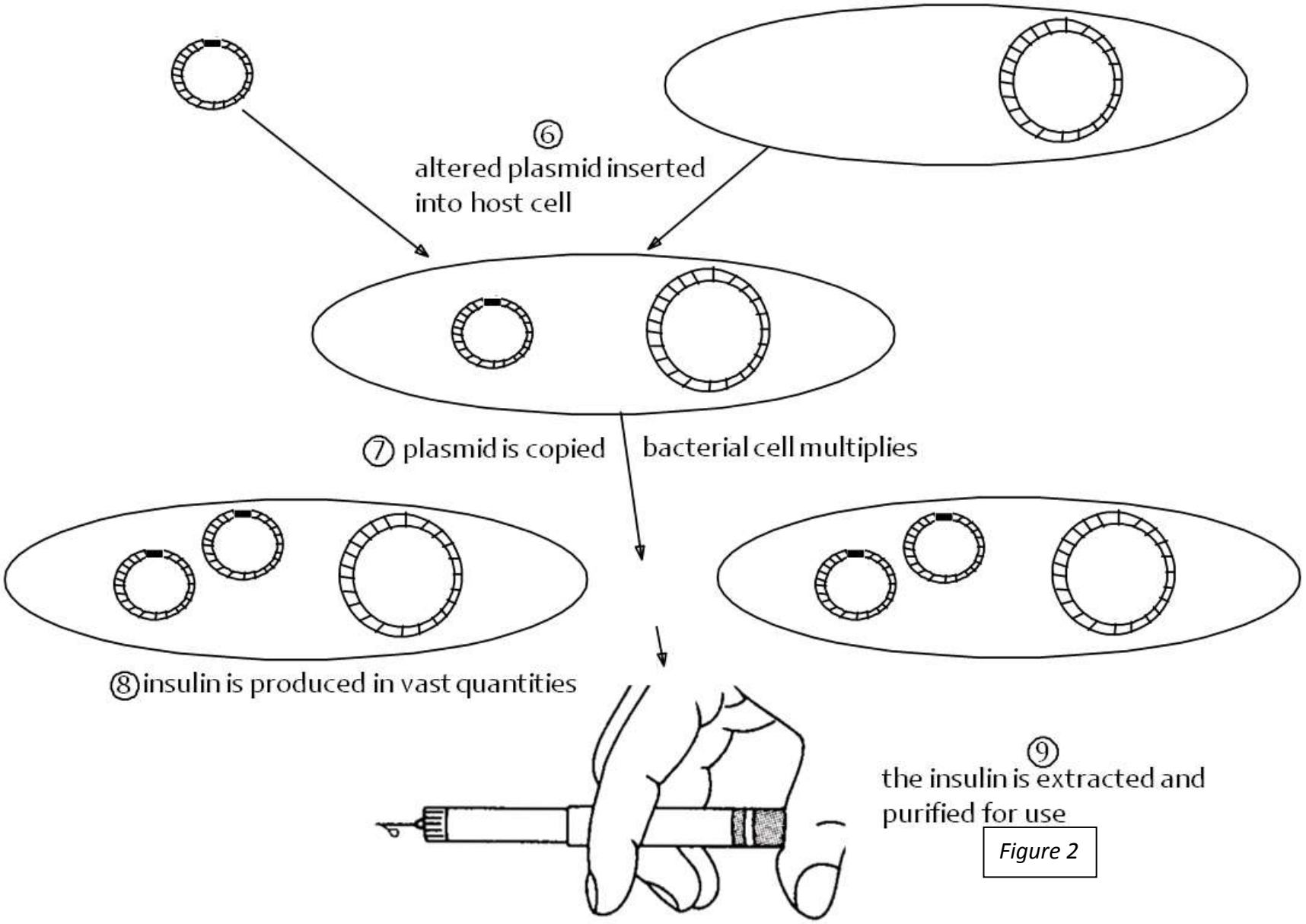

⑥
altered plasmid inserted into host cell
⑦ plasmid is copied
bacterial cell multiplies
⑧ insulin is produced in vast quantities
⑨
the insulin is extracted and purified for use

Figure 2

Activity 1

Use the information on the previous pages to complete the sheets 'genetic engineering' and stick them into your jotter. Once you have done this, answer the following questions in a paragraph.

1) What is genetic engineering?
2) Where did the gene for insulin production come from and how was it found?
3) What acts as a carrier between the two species (human and bacteria)?
4) Draw and complete a table with the headings 'advantages of genetic engineering' and 'disadvantages of genetic engineering'.
5) If you have time, research other products made through genetic engineering.

Section 7 Photosynthesis

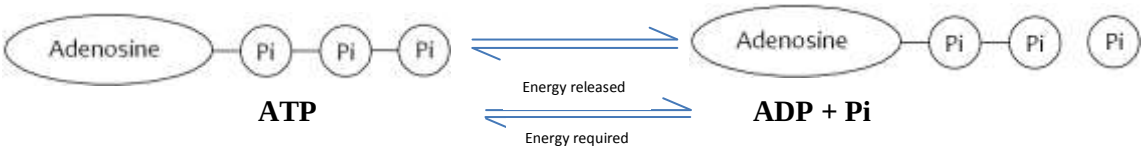
7a The Chemistry of Photosynthesis

Learning Outcomes

- Photosynthesis is an enzyme-controlled series of reactions in green plants.
- The raw materials are water and carbon dioxide
- Light energy and chlorophyll are also required
- The product of photosynthesis is glucose
- Adenosine tri-phosphate (ATP) provides instant energy
- ATP is involved in energy transfer
- In the light reaction, light energy from the sun is trapped by chlorophyll and is used to form ATP from ADP + Pi and also used to spilt water into oxygen and hydrogen.
- In carbon fixation, carbon dioxide and hydrogen are built into sugar (glucose) using energy in the form of ATP

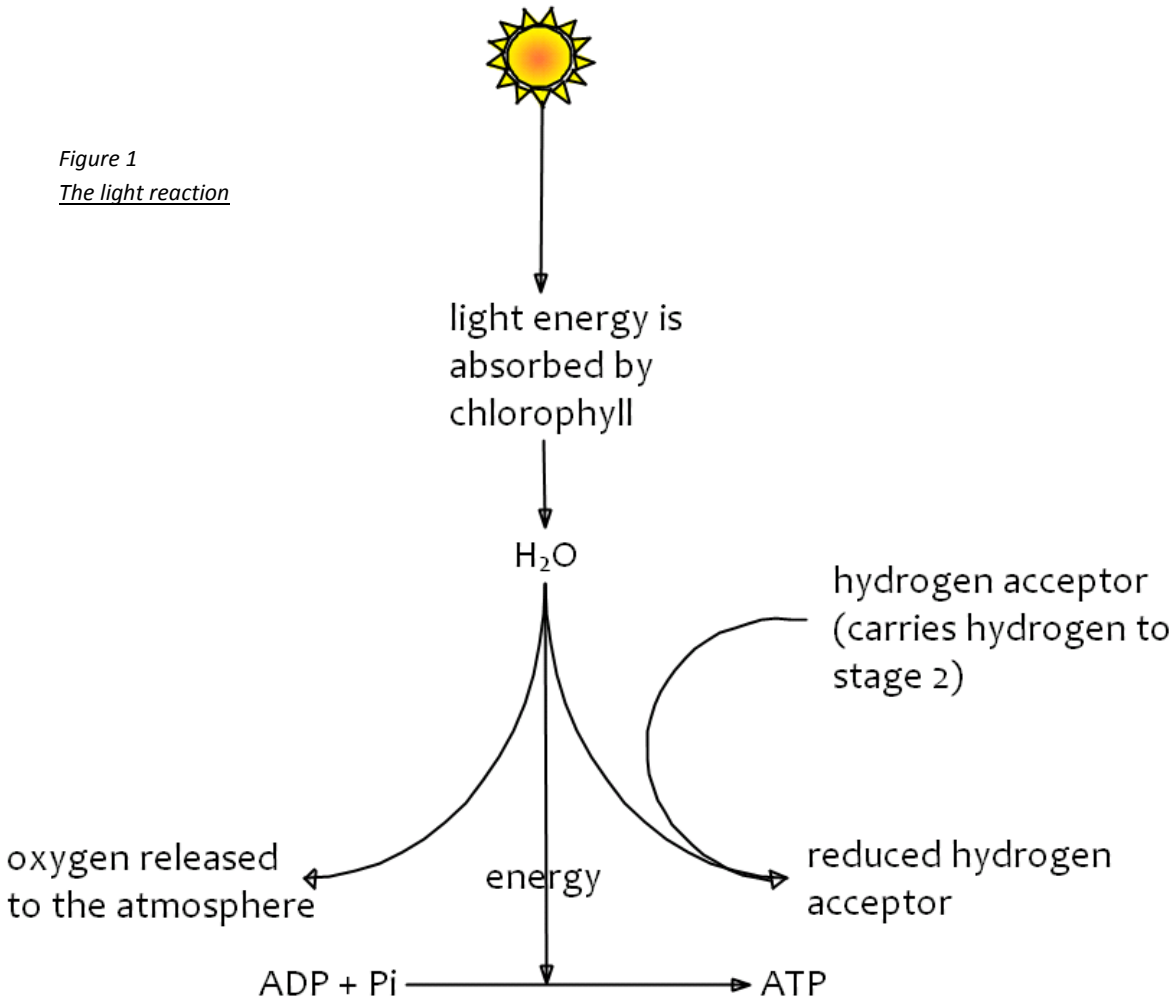
Photosynthesis is an enzyme-controlled series of reactions in green plants. It produces glucose from the raw materials water and carbon dioxide. Light energy and chlorophyll are also involved in the reaction.

Adenosine tri-phosphate (ATP) is a molecule which transfers energy. It breaks down to form adenosine di-phosphate and inorganic phosphate (ADP + Pi) which releases energy. ATP can be made by combining adenosine di-phosphate and inorganic phosphate using energy. It can be described as an 'instant energy' molecule. The break down and regeneration is shown below.



The first reaction in the chemistry of photosynthesis can be described as the 'Light Reaction'. This is because the energy from sunlight is trapped by chlorophyll (in the chloroplasts) and used to split water into hydrogen and oxygen. Hydrogen is required by the second stage, it binds to a hydrogen acceptor making it reduced. Oxygen diffuses out of the cells and is released into the atmosphere. Some light energy is also converted into chemical energy by making ATP from ADP + Pi. This is summarised below.

Figure 1
The light reaction



In the second reaction carbon dioxide and hydrogen (from stage one) is built into sugar (glucose) using energy in the form of ATP (also from stage one). The hydrogen acceptor delivers the hydrogen from stage one and is then free to combine with more hydrogen. ATP is broken down into ADP + Pi and this can be reformed into ATP using energy. In this way ATP transfers energy between the two stages. This is summarised below.

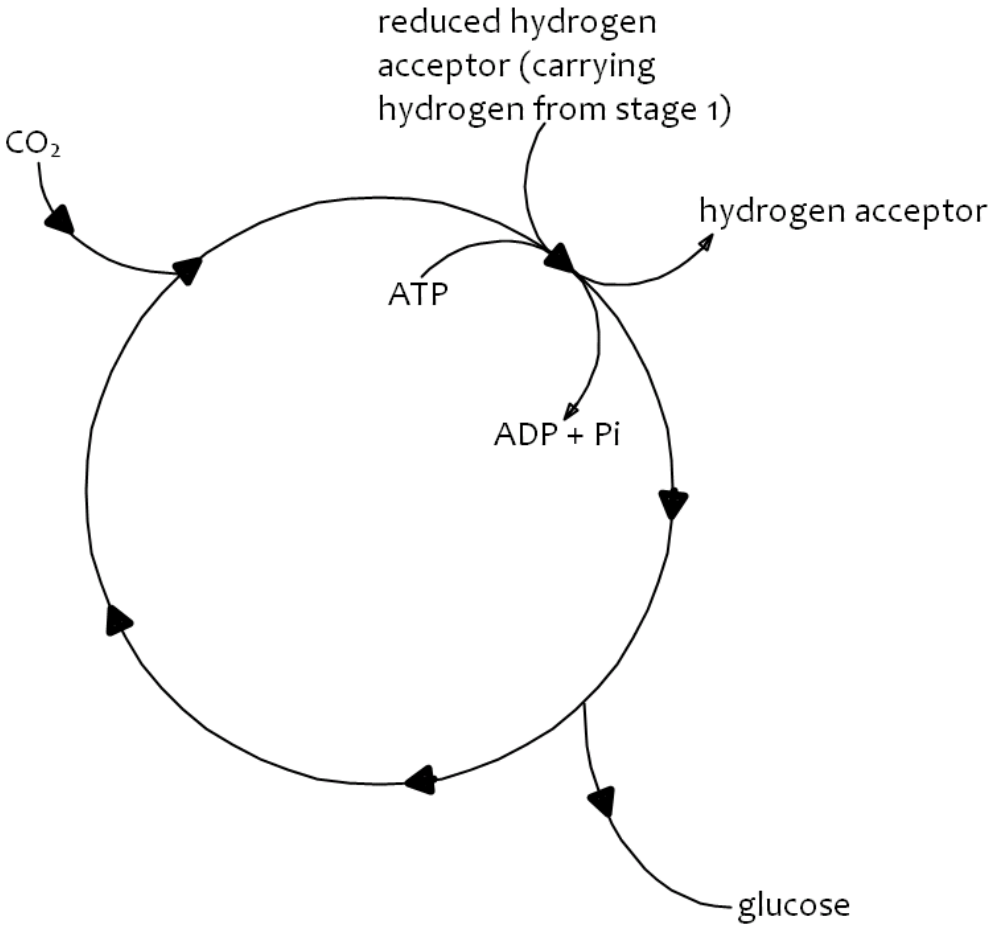


Figure 2
Carbon fixation

7b

The Fate of Sugar.

Learning outcomes

- The chemical energy in sugar (glucose) can be used for respiration or can be converted into starch or cellulose

Once sugar (glucose) has been formed by photosynthesis is can be used in several ways. The chemical energy can be used straight away for respiration therefore providing energy for the cellular processes or it can be converted to starch or cellulose. Starch is a storage molecule and cellulose is a structural carbohydrate found in cell walls.

Activity 1

1. Copy the two previous diagrams into your jotter.
2. How can ATP be described?
3. What is the reversible reaction for the synthesis of ATP?
4. What is the name of the green pigment which traps light energy and where is it found?
5. What two products from photolysis are required for carbon fixation?
6. What is the by-product from photolysis?
7. What is the product of photosynthesis?
8. What controls all the stages of photosynthesis?

7c

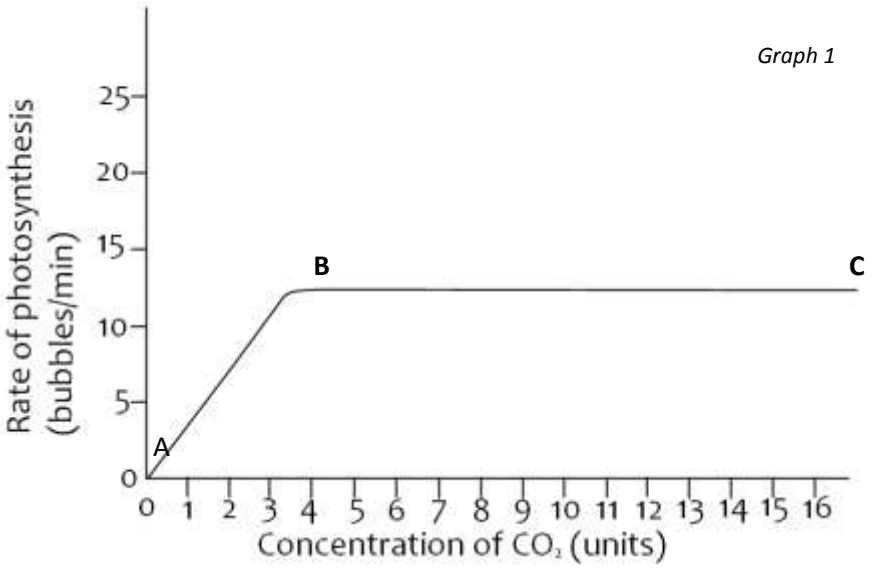
Limiting factors

Learning Outcomes

- Limiting factors can be;
  - Carbon dioxide concentration
  - Light intensity
  - Temperature

Anything that is in short supply can be said to limit growth. Factors that can be in short supply for photosynthesis are: carbon dioxide concentration, light intensity and temperature. All these factors can be referred to as limiting factors. Limiting factors can be monitored by measuring the rate of photosynthesis. There are several ways to measure the rate of photosynthesis. Dry mass change over time can be measured as can bubbles of oxygen produced over a set time. Graph 1 below shows the effect of changing the concentration on the rate of photosynthesis.

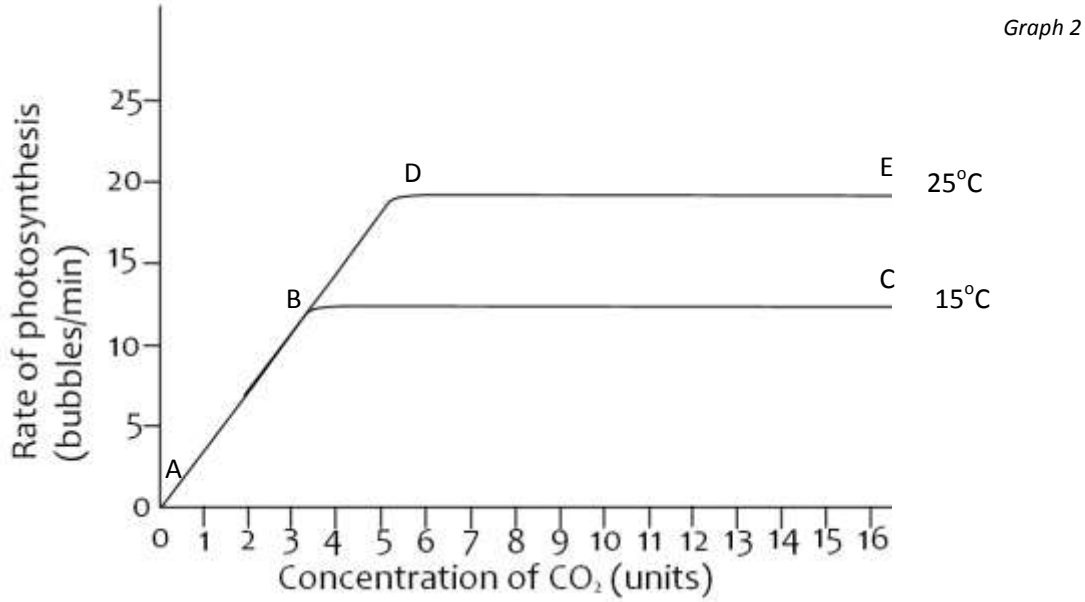
Graph 1



Between A and B, the rate of photosynthesis increases. This shows that between these values carbon dioxide concentration is the limiting factor.
It could be concluded that, as the carbon dioxide concentration increases the rate of photosynthesis increases between A and B.
Increasing the concentration of CO_2 between B and C has no effect on the rate of photosynthesis. It can therefore also be concluded that between B and C the rate of photosynthesis is limited by another factor. That other factor may be light intensity or temperature.

Graph 2 shows the effect of changing two limiting factors on the rate of photosynthesis.

Graph 2



This graph shows that between A and B (and A and D) the concentration of carbon dioxide is a limiting factor.
We know this because as the concentration of CO_2 increases the rate of photosynthesis increases.

Between points B and C carbon dioxide concentration cannot be the limiting factor anymore. Either temperature or light could be limiting.

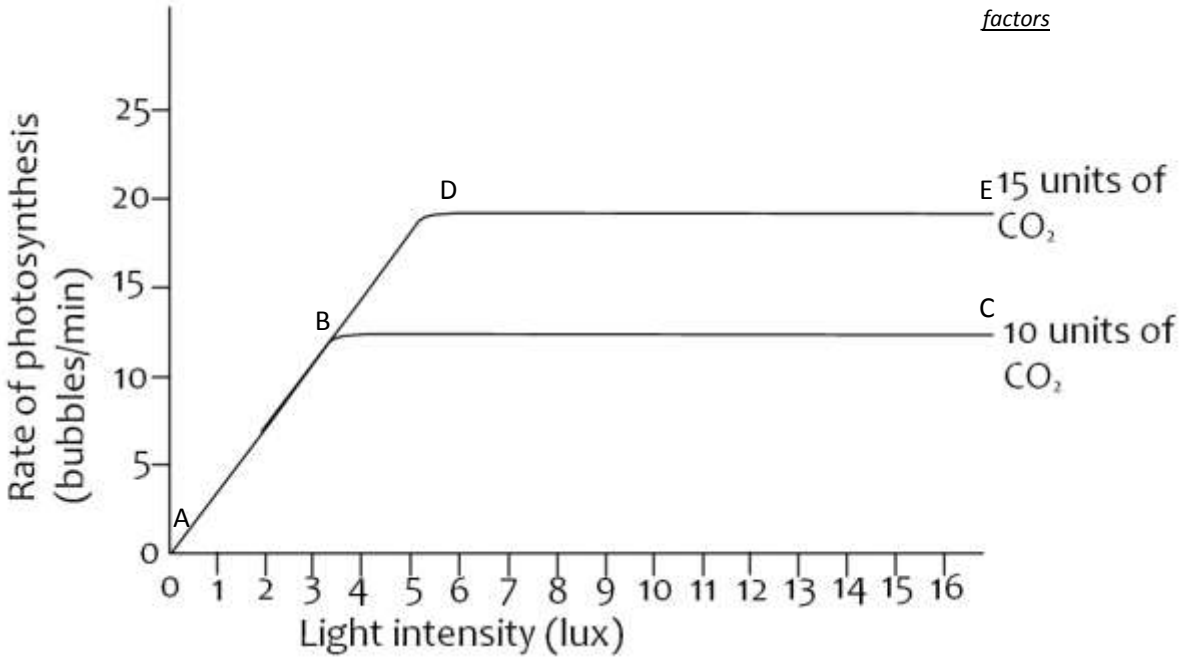
In this case, temperature is the limiting factor between B and C. This is shown when line B-C is compared with line D-E.

D and E have been exposed to a higher temperature which has increased the rate of photosynthesis.

Activity 1

Stick the limiting factors graph (graph 3) into your notes, complete the labels and answer the following questions.

Graph 3
Limiting factors



1) What is the limiting factor between A and B?
2) What is the limiting factor between A and D?
3) What is the limiting factor between B and C?
4) What is the limiting factor between D and E?
5) How could you provide optimum conditions for plants so that there were no limiting factors?

Section 8 Respiration

The Chemistry of Respiration

Learning Outcomes

- The chemical energy in glucose is released in all cells through a series of enzyme-controlled reactions called respiration.
- The energy released from respiration is used to generate ATP from ADP and Pi
- Energy produced can be used for cellular activities including; Muscle cell contraction, cell division, protein synthesis and transmission of nerve impulses
- The breakdown of each glucose molecule in the presence of oxygen produces 38 molecules of ATP
- Aerobic respiration starts in the cytoplasm and is completed in the mitochondria
- The by-products of respiration are carbon dioxide and water
- Anaerobic respiration produces 2 molecules of ATP
- In animals anaerobic respiration is reversible and produced lactic acid
- In plants and yeast cells anaerobic respiration(fermentation) is irreversible and produces ethanol and carbon dioxide
- Aerobic respiration can be summarised as;

glucose + oxygen + 38ADP + 38Pi ⟶ carbon dioxide + water + 38ATP

8a Copy into your notes

Respiration is an <u>enzyme</u>-controlled series of reactions in all living cells. It releases chemical energy from glucose.

8b+c

The energy rich molecule adenosine tri-phosphate (ATP) is synthesised (made) during respiration and this energy can be used for cellular activities. These cell activities can include:

1. Muscle cell contraction,
2. Cell division,
3. Protein synthesis,
4. Transmission of nerve impulses.

Once energy has been transferred from ATP, adenosine di-phosphate (ADP) and inorganic phosphate (Pi) is formed. ATP can be regenerated from ADP + Pi during respiration. This is summarised in figure 1 below:

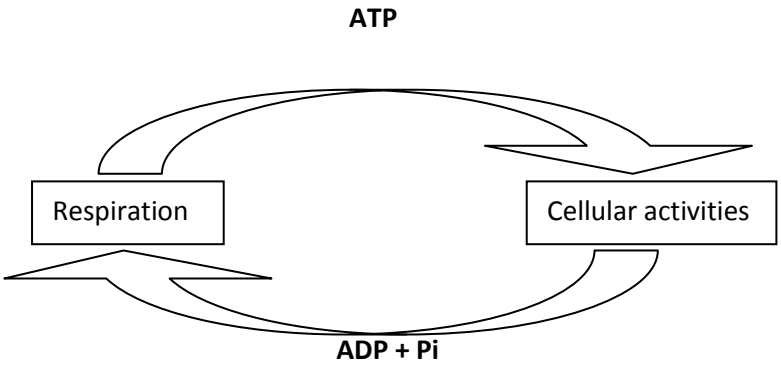
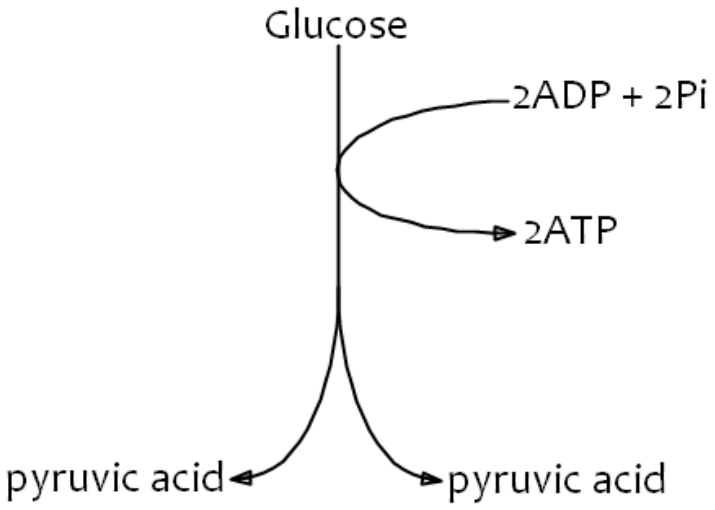


Figure 1
The transfer of energy

The first stage of respiration, called glycolysis, involves the breakdown of glucose into two molecules of pyruvic acid. This stage occurs in the cytoplasm and occurs in both aerobic respiration (oxygen is present) and anaerobic respiration (oxygen is absent). Anaerobic respiration is also known as fermentation. The first stage is summarised below:

Figure 2
Glycolysis



If oxygen is present then the breakdown of pyruvic acid can continue in mitochondria. Pyruvic acid breaks down releasing carbon dioxide and transferring energy rich hydrogen along the process. This energy is used to generate ATP from ADP + Pi. Enough energy is available to generate eighteen molecules of ATP from eighteen molecules of ADP and eighteen molecules of Pi. This is summarised in the diagram below.

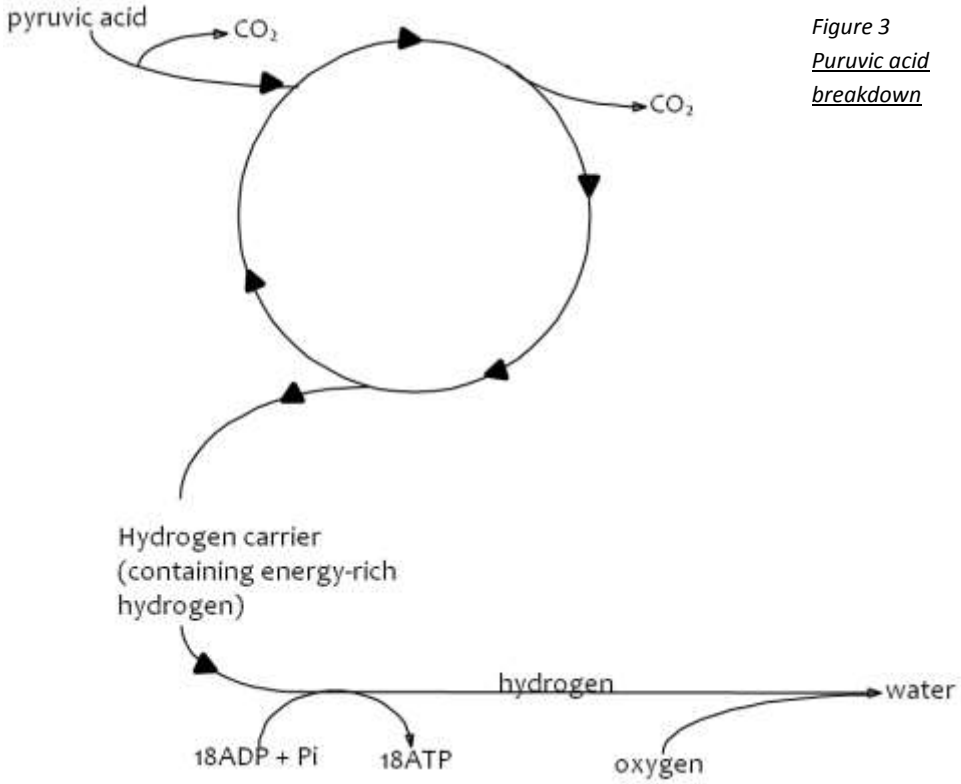


Figure 3
Puruvic acid breakdown

As two molecules of pyruvic acid are produced from every molecule of glucose then this process happens twice. This means that, if oxygen is present, each molecule of glucose produces 38 molecules of ATP. Two molecules are produced from glycolysis and thirty six from the breakdown of two molecules of pyruvic acid. Hydrogen is left over after the energy has been transferred to ATP and this combines with oxygen to produce water. Oxygen can be described as the final hydrogen acceptor.

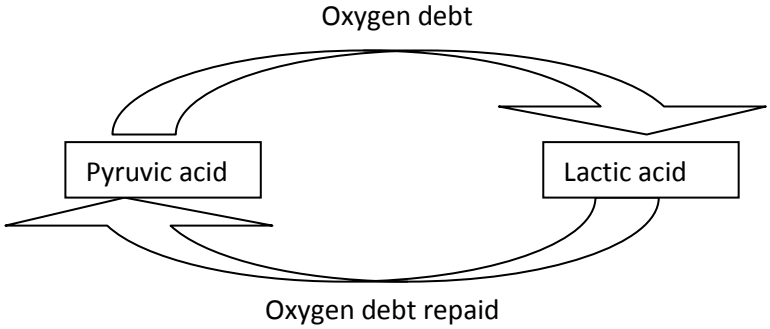
Aerobic respiration can be summarised in the following word equation:

glucose + oxygen + 38ADP + 38Pi ⟶ carbon dioxide + water + 38ATP

Anaerobic Respiration

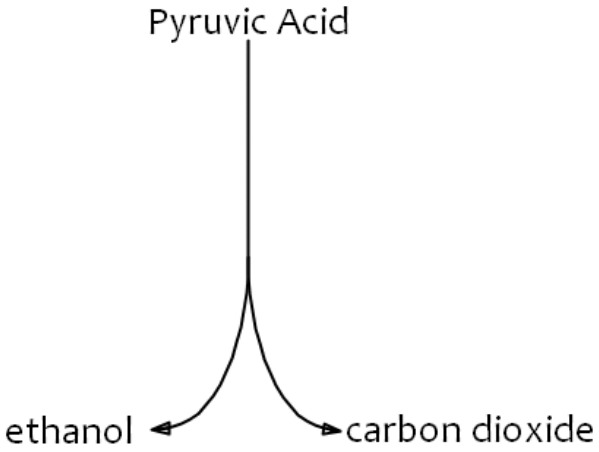
If oxygen is not present, glycolysis can still occur yielding two molecules of ATP but pyruvic acid cannot be broken down through the previous process. In humans, pyruvic acid is broken down into lactic acid when oxygen is not present. This is called an oxygen debt. This process is reversible once enough oxygen is present and the debt has been repaid. Once the debt has been repaid the breakdown of pyruvic acid can recommence. This is shown below:

Figure 4 Anaerobic respiration in animals



If oxygen is not available for plants to fully respire, pyruvic acid is produced and is converted into ethanol and carbon dioxide. This process is not reversible. This occurs in water logged plants and yeast cells and is more commonly known as fermentation and takes place in the cytoplasm. It is summarised below.

Figure 4 Anaerobic respiration in plants and yeast



Activity 1

Answer the following questions in a paragraph in your jotter.

1. Copy out the summary for glycolysis and state where it takes place.
2. What are the two different products of glycolysis?
3. Name the second stage of aerobic respiration and draw the summary. Where does this take place?
4. How many molecules of ATP are produced from one molecule of glucose?
5. What is the word equation for aerobic respiration?
6. If oxygen is not available for aerobic respiration what process occurs?
7. Write a word equation for anaerobic respiration in animals.
8. Write a word equation for anaerobic respiration in plants.
9. How many molecules of ATP are produced during anaerobic respiration?