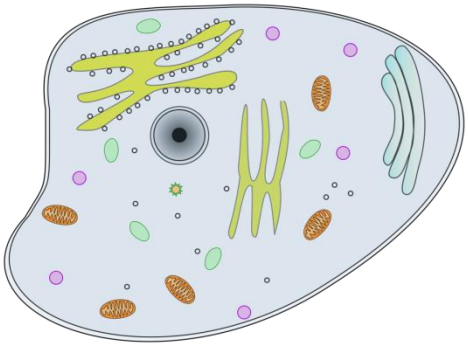
St Ninian's High School

Biology Department

National 5 Biology

Cell Biology

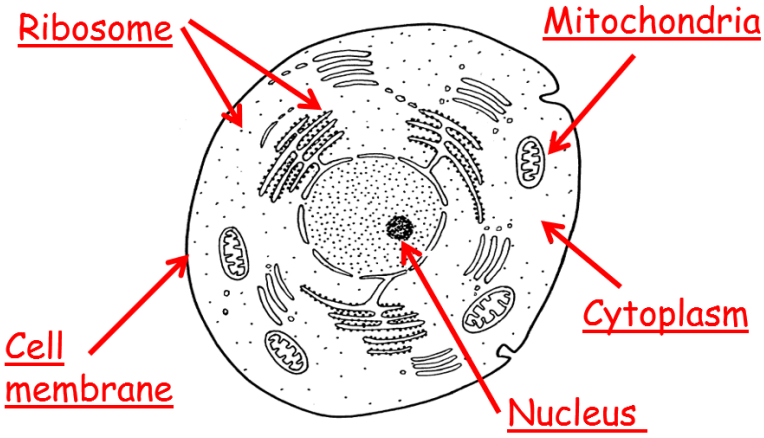


Revision Notes

Cell structure & function

A **cell** is the basic unit of life and there are **4 main types of cells** that you need to learn about to prepare for your N5 exam.

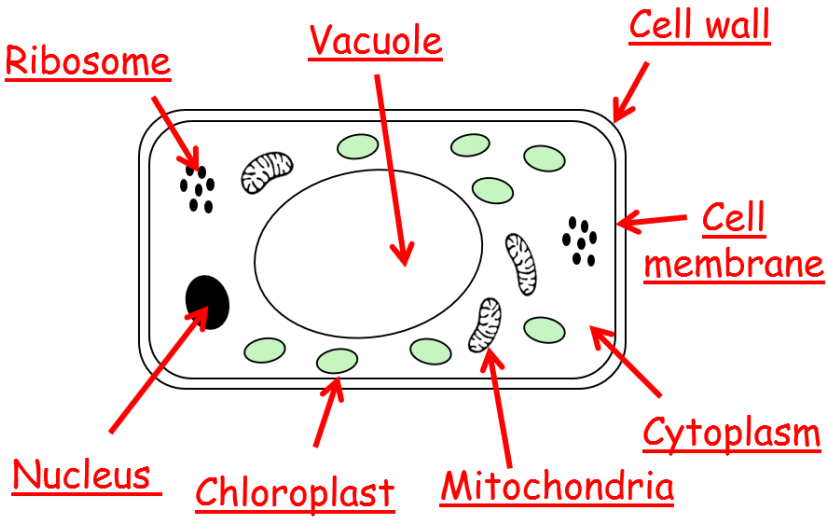
<u>Animal</u> cell – 5 key structures



<u>Plant</u> cell – 8 key structures

Remember only green plant cells e.g. pallisade mesophyll leaf cells have **chloroplasts.** Plant cells taken from the roots lack chloroplasts.

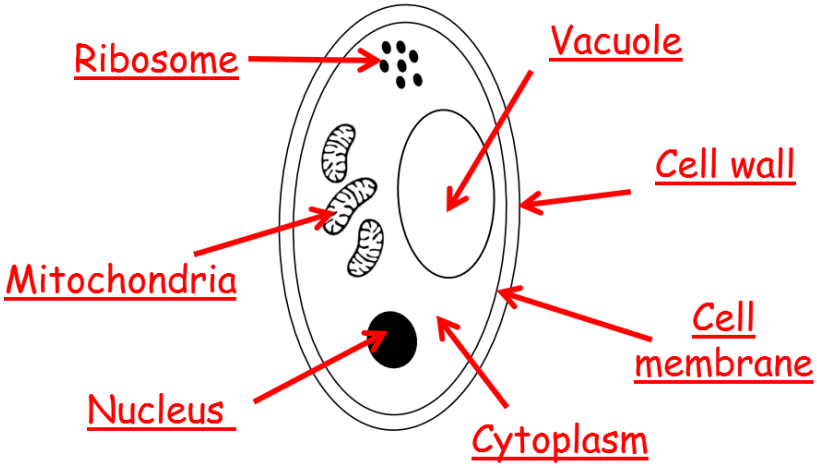
The plant cell wall is different from the bacterial and fungal cell wall as only the plant cell wall is made of **cellulose.**



<u>Fungal</u> (yeast) cell – 7 key features

Fungal cells are identical to green plant cells except they do not have any **chloroplasts**.

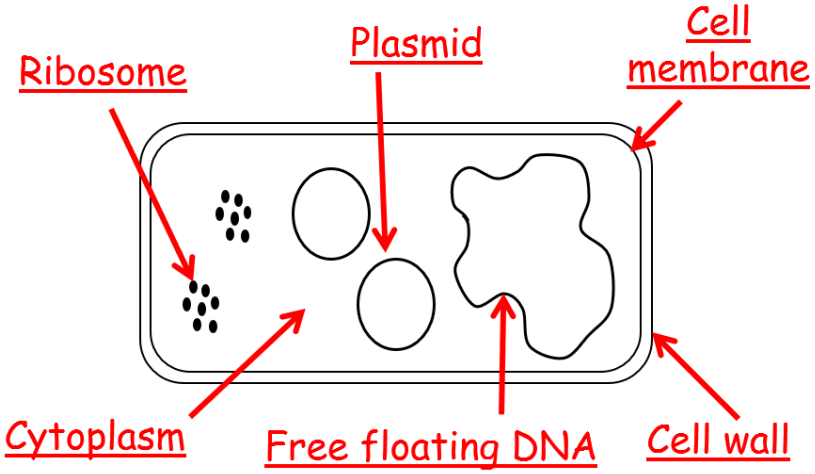
Yeast cells have a different type of cell wall from plant cells as only plant cells have a cell wall made of **cellulose**.



<u>Bacteria</u> cell – 6 key features

Bacterial cells have an **absence of organelles** e.g. no nucleus/ mitochondria/vacuole/chloroplasts etc.

Bacterial cells have a different type of cell wall from plant cells as only plant cells have a cell wall made of **cellulose**.



Cell Organelle Function * New parts learned this topic *****

Organelle	Function	Found in
Cell membrane	Controls movement of substances in and out of cell.	All cells
Cytoplasm	Where all chemical reactions occur	All cells
Ribosome***	Site of protein synthesis.	All cells
Mitochondria***	Where **aerobic** respiration occurs.	Plant, animal and yeast
Nucleus	Controls all cell activities.	Plant, animal and yeast
Cell wall	Supports cells.	Bacteria, yeast and plant
Vacuole	Stores cell sap.	Plant and yeast
Chloroplast	Site of photosynthesis.	Plant only
Plasmid***	Bacteria exchange DNA between cells	Bacteria only
Free floating DNA ***	Genetic code for protein	Bacteria only

Summary of cell organelles

Structure	Animal	Plant	Fungal	Bacterial
Cell membrane	✓	✓	✓	✓
Cytoplasm	✓	✓	✓	✓
Ribosome	✓	✓	✓	✓
Mitochondria	✓	✓	✓	
Nucleus	✓	✓	✓	
Vacuole		✓	✓	
Chloroplasts		✓	✓	
Plasmid				✓
Free floating DNA				✓

Common exam question

Q. Describe a similarity and difference between two different cell types.

A. Model Answer

Similarity:

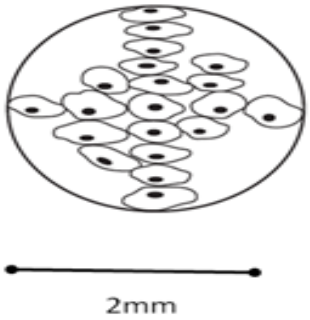
Both _____ and_____ cells have a _____.

Difference:

A _____ cell has a _____ but a _____ cell does not.

Likely Problem Solving Question in Cell Biology

Calculating cell size

Average cell length		Average cell breadth
2mm distance has 5 cells		2mm distance has 10 cells
2/5 cells = 0.4mm		2/10 cells = 0.2mm

Calculating total magnification

Formula given: **Total magnification = eyepiece lens x objective lens**

Worked Example 1:

If the eyepiece lens has a magnification of 4x and the objective lens has a magnification of 200x, what is the total magnification?

Total magnification = eyepiece lens x objective lens

Total magnification = 4 x 200

Total magnification = 800

Worked Example 2:

If the total magnification is 400x and the eye piece lens has a magnification of 4x, what is the magnification of the objective lens?

Total magnification = eyepiece lens x objective lens

400 = 4 x objective lens

Objective lens= 400/4 = 100

Genetic Engineering

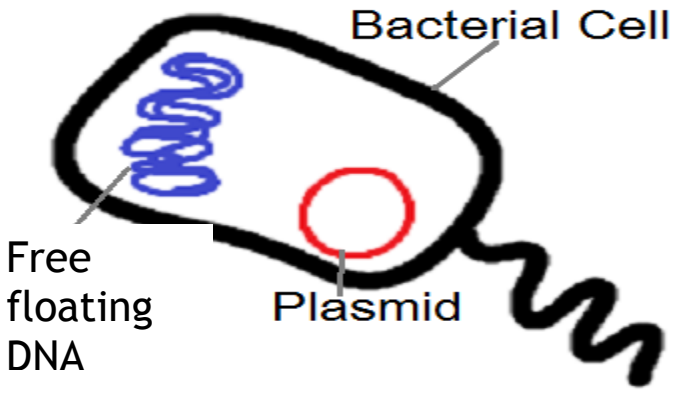
Genetic Engineering

Genetic information can be transferred from one cell to another.

A foreign gene from an animal/plant cell can be inserted into a bacterial plasmid causing the bacteria to produce the **foreign protein**.

Why use bacteria as the host cell?

- Bacterial cells reproduce quickly.



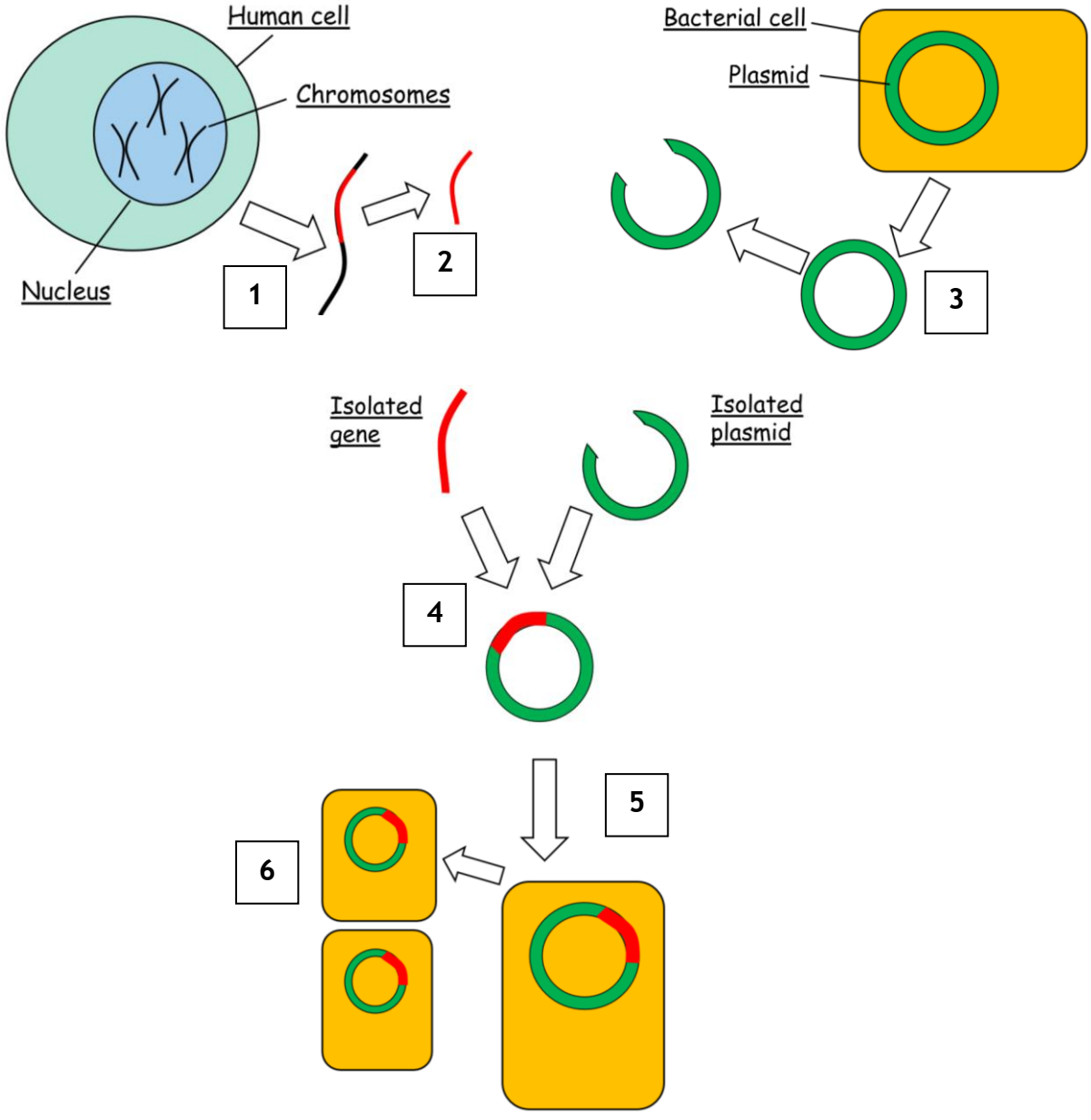
Uses of Genetic Engineering

Human Hormones
1. Insulin
2. Human Growth Hormone

Genetically Modified Organisms
1. Tomato with longer shelf life.
2. Potato with disease resistance.
3. Golden Rice with added nutrients

Stages of genetic engineering

1. Identify section of DNA that contains required gene from source chromosome
2. Extract required gene using **enzymes**
3. Extract plasmid from bacterial cell and cut the plasmid open using **enzymes**
4. Insert required gene plasmid using **enzymes**
5. Insert plasmid into new bacterial cell creating a **GM organism**
6. Allow genetically modified (GM) cells to reproduce and then extract the required product



DNA

DNA & Chromosomes

DNA is a molecule of **genetic information** found in the **nucleus** of our cells and arranged in structures called **chromosomes**.

Chromosomes and Genes

Small sections of DNA on a chromosome are called a **gene**.

A gene is a DNA molecule that codes for **one specific protein**.

Haploid/Diploid Chromosome Complement

All our body cells e.g. lung, heart, brain cells are **diploid** and contain **2 sets of chromosomes.**

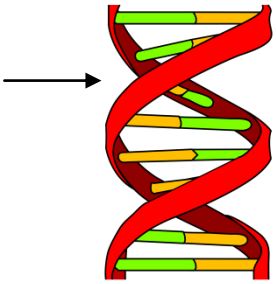
Exception

Gametes (sex cells) are **haploid** and contain **1 set of chromosomes** (egg/sperm/pollen/ovule).

DNA function

Carries the genetic information for making **specific proteins**

DNA structure



DNA is a **double** stranded molecule which forms a 3D **double helix.**

The two stands are held together by **complementary** bases.

The 4 bases that make up the **genetic code** are:

- Adenine (A)
- Thymine (T)
- Guanine (G)
- Cytosine (C)

Complementary base pairs

Adenine always pairs with Thymine

Guanine always pairs with Cytosine

Complementary base code Example

A G T C A G C T – original strand

T C A G T C G A – opposite strand

DNA Calculations

You may be asked to calculate the number/percentage of bases as shown in the following worked examples.

Worked example 1:

If there are 1200 bases in total and 300 are adenine (A) – calculate how many are cytosine (C)?

A - 300 = T – 300

G + C = 1200 – 600 = 600 bases for both

Cytosine = 600/2 = 300 bases

Worked example 2:

If 10% of 4000 bases are Thymine (T), calculate the number that are guanine (G)?

10% - A = 10% = T

G + C = 80% divide by 2 = 40% are guanine

Convert 40% into a number – 40/100 x 4000 = 1600 bases that are guanine

Producing Proteins

The genetic code

Each gene acts as a **genetic code** for making **a specific protein**.

Base Code

3 DNA bases within a gene act as a **genetic code** for a specific amino acid

Changing the base sequence will change the amino acid that is coded for.

Example

Original base sequence AAA ⇨ genetic code for amino acid **serine**

Base sequence altered A**C**A ⇨ genetic code for amino acid **lysine**

Summary Diagram

Different base sequence

⇩

Different amino acid sequence

⇩

Different shape of protein

⇩

Different function of protein

Step 1: DNA makes mRNA in the nucleus

As DNA is a **double stranded** molecule it is **too big** to pass through the selectively permeable nuclear membrane surrounding the nucleus.

DNA creates a complementary **single stranded** copy of the genetic code in the **nucleus** called **mRNA** (messenger RNA)

Function of mRNA (likely exam question)

Takes a complimentary copy the DNA from the nucleus to the ribosome.

Step 2: mRNA creates a specific protein at the ribosome

mRNA attaches onto the ribosome.

Depending on the base sequence, a specific amino acid sequence is created.

The amino acids assemble at the ribosome to form a specific protein.

Types of Proteins

Having different genetic codes (different base sequences) creates a different amino acid sequence at the ribosome.

Different sequences of amino acids cause **different types of proteins** to be made at the ribosome.

These proteins have different **shapes** and therefore different **functions.**

Type of Protein	Function
Enzyme	Speeds up chemical reactions but not used up
Antibodies	Defend the body against pathogens
Receptors	Binds to a specific hormone at the target tissue to cause a response
Hormone	Chemical messengers that travel in blood from one place to another
Structural	Provides support in membrane

Common exam question

Q. Describe how different types of proteins can be produced.

A. **Different DNA base sequence** would result in **different proteins** being made.

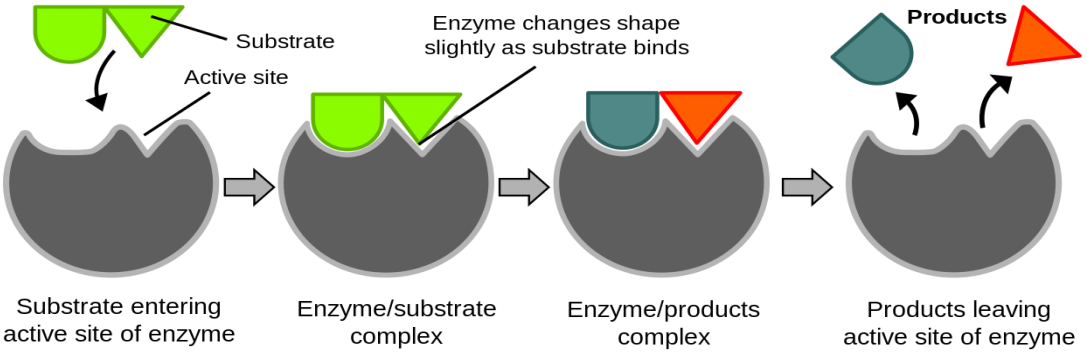
Enzymes

Enzymes are **biological catalysts** – they **speed up reactions** in living cells but are unchanged in the reaction.

Lock & Key Theory

Enzymes are said to be **specific** as they only interact with 1 type of substrate producing a **product**.

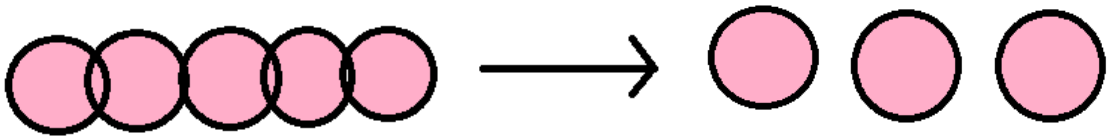
The **shape** of the **active site** is **complementary** to only one type of substrate making enzymes **specific** to their substrate.



Types of Enzyme Reactions

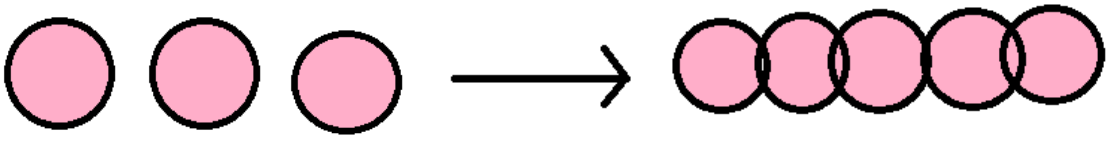
Degrading reactions:

A large substrate is **broken down** into smaller products. i.e.during digestion



Synthesising reaction:

Smaller substances are **built up** into a larger molecule i.e. during photosynthesis.



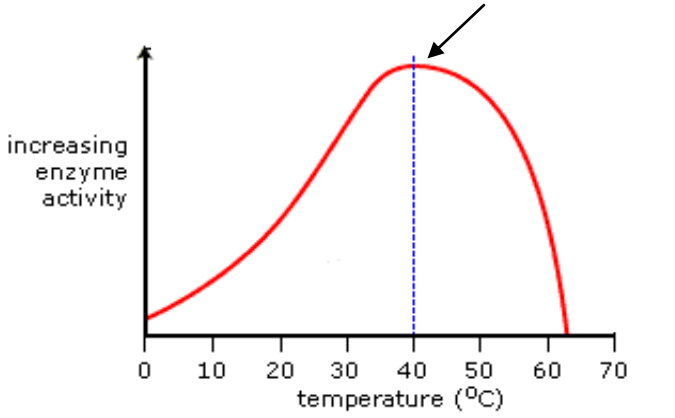
Learn the following enzyme reactions.

Substrate	Enzyme	Product	Type of reaction	Memory aid
Starch	Amylase →	Maltose	Degrading	SAM
Protein	Protease/pepsin →	Amino acids	Degrading	PPAA
Fat	Lipase →	Fatty acids & glycerol	Degrading	FLAG
Hydrogen peroxide	Catalase →	Oxygen & water	Degrading	HPCOW
Glucose-1-phosphate	Phosphorylase →	Starch	**Synthesising**	G1PPS

Enzyme Action

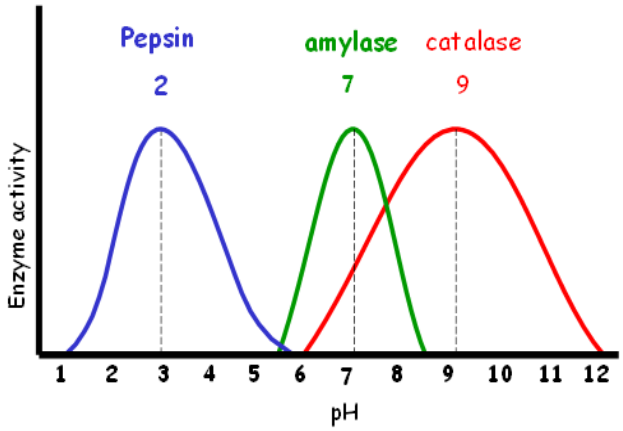
The activity of enzymes & other proteins can be affected by the **temperature** and **pH**.

Temperature



Optimum temperature - when enzymes are their **most active** which is **37°C**

pH



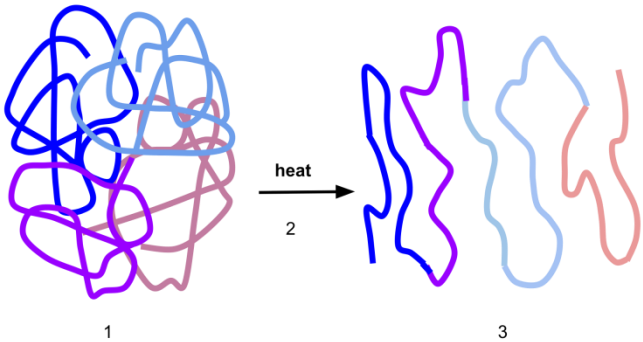
Different enzymes work best at different pH values, their optimum pH.

Many enzymes' optimum pH is neutral (pH 7) but not all!

Denatured Enzymes

At high temperature or pH's out with the enzyme's acceptable range the enzyme is **denatured**.

When an enzyme is denatured the **shape of the active site** is destroyed so the substrate can no longer react with the enzyme **lowering the reaction rate**.



Respiration

Respiration is the **breaking down** of glucose to release the **chemical energy** stored in food to generate **ATP**.

ATP is generated from the chemical energy stored in glucose is by combine ADP and inorganic phosphate (Pi).

ADP + Pi ⟶ ATP

The ATP produced during respiration is used for **cellular activities**.

Examples of cellular activities;

- Protein synthesis
- Nerve transmission
- Muscle contraction
- Cell division

Types of Respiration

Respiration is a series of **enzyme controlled reactions** which produces ATP from glucose.

There are two types of respiration;

1. Aerobic respiration – in the presence of **oxygen** – producing **38** ATP

   Location – starts in Cytoplasm and ends in Mitochondria

2. Fermentation – in the **absence of oxygen** – producing **2** ATP

   Location - Cytoplasm

1. Aerobic Respiration

Two step process requiring enzymes to **produce 38 ATP** from glucose in the presence of oxygen.

<u>Step 1: Glycolysis</u>

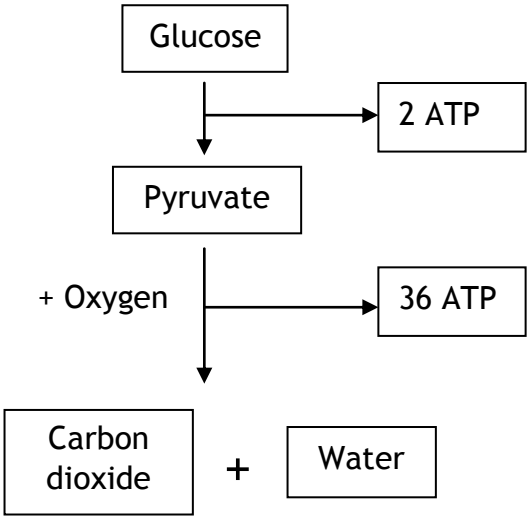
(glucose ⟶ pyruvate)

Location - **cytoplasm**

<u>Step 2: Aerobic respiration</u>

(pyruvate ⟶ CO_2 & Water)

Location - **mitochondria**

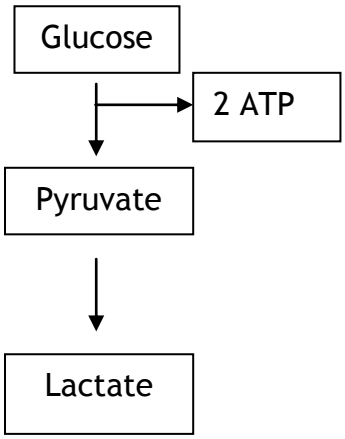


2. Fermentation

Two step process requiring enzymes to produce **only 2 ATP** from glucose when **no oxygen is present** in the **cytoplasm**.

The products of fermentation are different in different types of cells.

<u>Fermentation in animal cells</u>



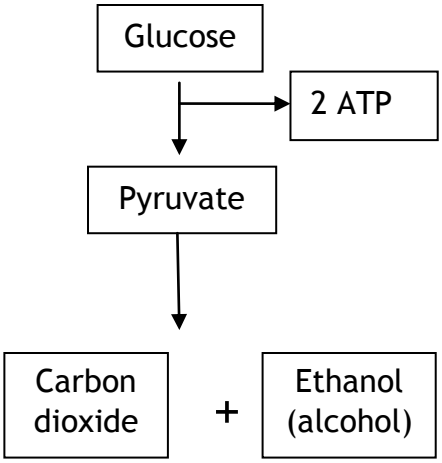
<u>Step 1: Glycolysis</u>

- Glucose is broken down to pyruvate.
- This releases 2 ATP in the cytoplasm.

<u>Step 2 Fermentation</u>

- In the absence of oxygen, pyruvate is converted into **lactate in muscle** cells.
- This occurs in the cytoplasm of cells.

Fermentation in plant/yeast cells



Step 1: Glycolysis

- Glucose is broken down to pyruvate.
- This releases 2 ATP.

Step 2: Fermentation

- In the absence of oxygen, pyruvate is converted into **carbon dioxide and ethanol** in plant/yeast cells.
- This occurs in the cytoplasm of cells.

Respiration Word Summaries

Aerobic Respiration

Glucose + Oxygen ⟶ Water + Carbon Dioxide + LOTS of energy (38 ATP)

Fermentation in Animals

Glucose ⟶ Lactate + energy (2 ATP)

Fermentation in Plants/Yeast

Glucose ⟶ Carbon Dioxide + Ethanol + energy (2 ATP)

Mitochondria energy requirement

The **higher the energy** requirement of the cell the **greater** the number of **mitochondria** present for **aerobic respiration.**

Example 1:
Muscle cells need lots of mitochondria to produce ATP for muscle contraction.

Example 2:
Sperm cells need lots of mitochondria to produce ATP for movement (SWIMMING)

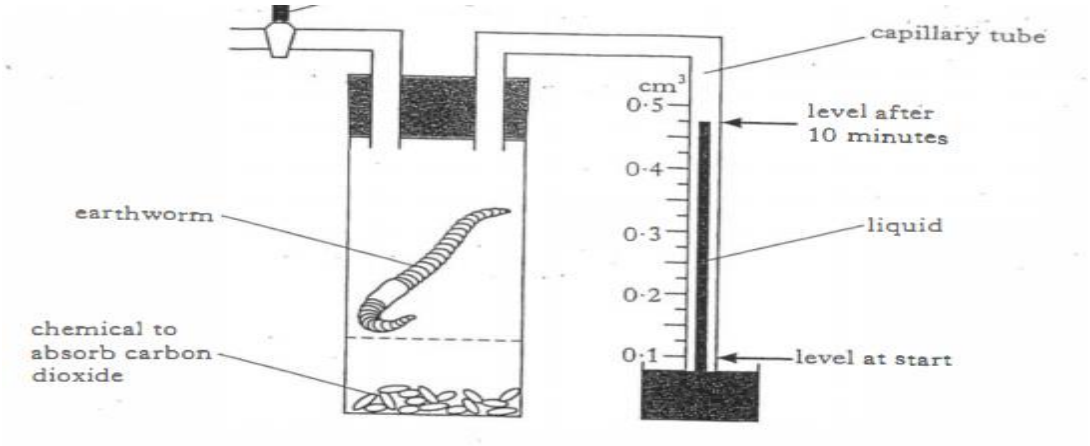
Respiration – experimental question

Respirometer

A respirometer is used to measure the rate of respiration by measuring the rate of oxygen uptake as shown by the coloured dye moving up the tube.

An example of an investigation is shown using the following aim.

Aim
To investigate the effect of the **number of earth** worms on the **rate of respiration.**



Independent variable	Dependent variable
Number of earth worms	Rate of respiration

Q. Describe how you would set up a control?

A. Exact same set up but with no worm.

Q. Explain the purpose of setting up a control?

A. To prove that the worm is doing respiration/taking in the oxygen.

Q. Describe how to control temperature in this experiment?

A. Use a water bath.

Q. Why leave the set up for 10 minutes before starting?

A. To allow animal to adjust to the temperature.

Q. State a variables that would have to be held constant for valid results?

A. pH, type of earth worm, mass or concentration of chemical to absorb CO_2

Q. The results are said to be unreliable. Describe how the reliability can be improved?

A. Repeat the experiment again with each number of worms.

Q. Using the tables below draw a conclusion about the results.

Hint 1 – remember to refer to the dependent variable in the conclusion and NOT the measurement in the table i.e. time.

Hint 2 – remember that the smaller the time period, the higher the rate of the reaction.

Easier conclusion

Number of earth worms	Time taken to move dye up tube
2	150
4	100
6	45
8	30

A- As the number of earth worms increase, the **rate of respiration** increases

Harder conclusion

Number of earth worms	Time taken to move dye up tube
2	150
4	100
6	45
8	45

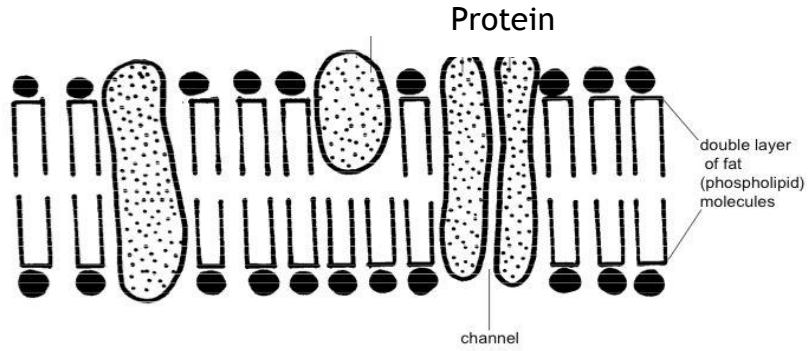
A- As the number of earth worms increase, the **rate of respiration** increases until 6 earth worms then the rate levels off.

Transport Across Cell Membranes

Cell Membrane: Two key parts to the membrane

1. Phospholipids
2. Protein (structural proteins for support)

<u>Diagram of cell membrane</u>



Phospholipid bilayer (two layers)

Function of the membrane

Controls the substances that enter and exit the cell as it is **selectively permeable.**

Selectively Permeable Membrane

Allows **small molecules to enter** the cell but not large molecules as they are too big to fit through.

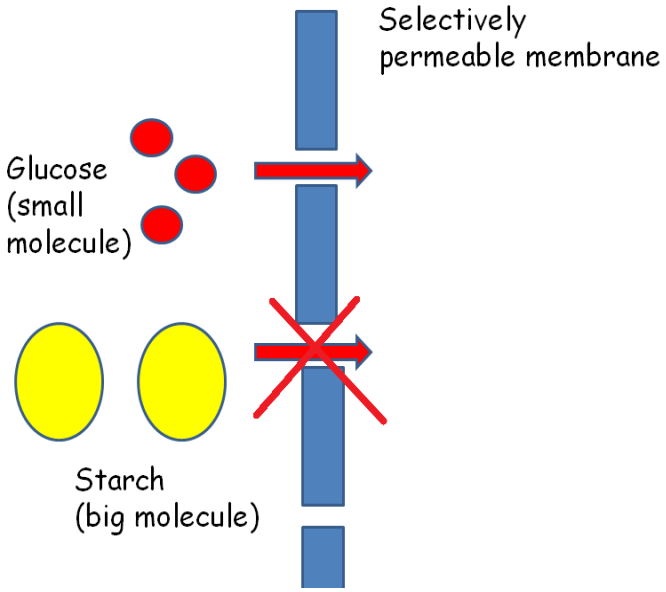
Small molecules:

1. Oxygen
2. Carbon dioxide
3. Water
4. Glucose/fatty acids/glycerol/amino acids

Large molecules:

1. Starch (carbohydrate)
2. Protein
3. Fat

Large molecules require to be digested by enzymes before they are absorbed into the body in the small intestine.



Transport across the membrane

There are two main ways molecules can move across the cell membrane as different concentrations of substances exist inside and outside cells:

1. Passive transport (diffusion and osmosis)

   Does not require energy to move molecules across membrane.

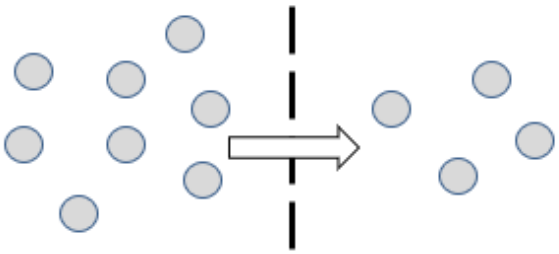
2. Active transport

   Requires energy to move molecules across membrane.

Passive Transport

Diffusion

Movement of molecules from an area of **high** concentration to an area of **low** concentration **down a concentration gradient**.



High concentration Low concentration

Energy requirement

Diffusion does **not** require energy.

Remember in diffusion:

Eventually the concentration inside the cell will be the **same** as the concentration outside the cell.

Why is diffusion important to life?

1. Gas Exchange Alveoli

Oxygen diffuses from the **alveoli to the blood capillaries** during gas exchange.

Carbon dioxide diffuses from the **blood capillaries to the alveoli** during gas exchange.

2. Absorption of food in villi (small intestine)

Glucose and amino acids diffuse into the **blood capillary.**

Fatty acids & glycerol diffuse into the **lacteal.**

3. Stomata Gas exchange

During photosynthesis carbon dioxide moves into plants through holes called stomata.

Oxygen moves out of plants through the stomata pores.

Passive Transport

Osmosis

Movement of **WATER** molecules from an area of **higher water** concentration to an area of **lower water** through a **selectively permeable** membrane.

Energy requirement

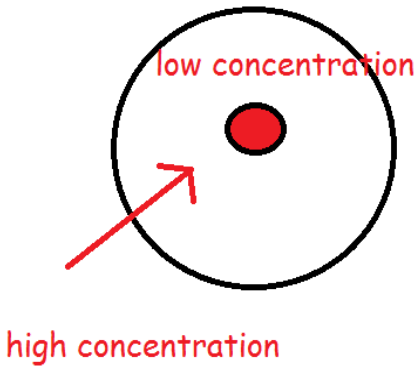
Osmosis does **not** require energy.

Osmosis in cells

Cell placed in **pure water**;

High water outside ⇨ Low water inside

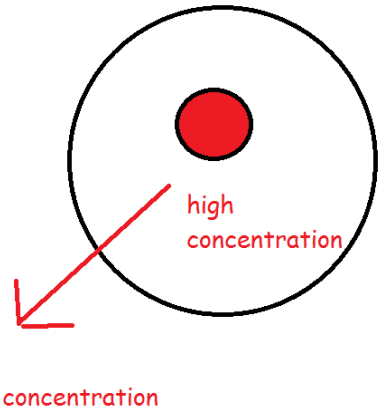
Water moves INTO the cell, cell **gains mass**.



Cell placed in **sugar/salt** water;

High water inside ⇨ Low water outside

Water moves OUT of the cell, cell **loses mass**.



<u>Osmosis in animal cells</u>

Animal cells are only surrounded by the cell membrane so they either **burst or shrink** when placed in a solution.

Pure water

In a high water concentration animal cells will swell and **BURST**.

Strong salt/sugar solution

In a low water concentration animal cells will **SHRINK.**

Osmosis in plant cells

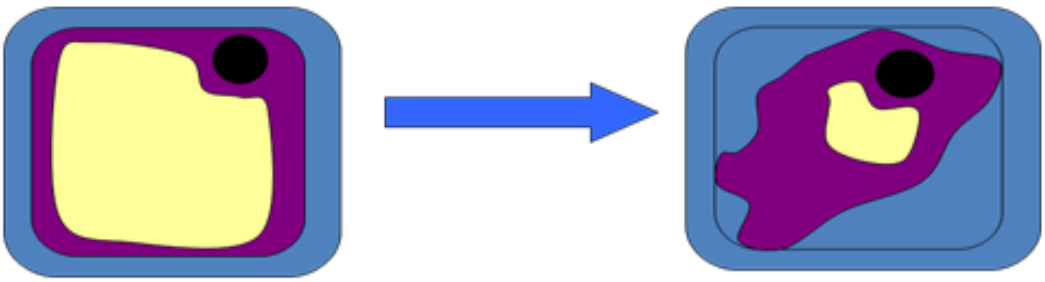
Pure water

Normal plant cell | Turgid plant cell

Turgid cells

1. Vacuole has swollen (taken in extra water)
2. Cytoplasm and cell membrane push against the cell wall.
3. The cell wall supports the cell preventing it from bursting.

Salt/sugar solution



Normal plant cell | Plasmolysed plant cell

Plasmolysed cells

1. Vacuole has shrunk
2. Cytoplasm and cell membrane pull away from the cell wall.
3. The cell wall supports the cell preventing it from shrinking.

Osmosis - Problem Solving Questions

Worked Example 1:

A plant cell is placed in pure water. The plant cell weighed 12g before, and now weighs 15g after osmosis has occurred. Calculate the percentage decrease in mass.

Change = 15-12g = 3g

Original number = 12g

Change/original number x 100
3/12 x 100 = **25%**

Worked Example 2:

The cells weighed 16g before being placed into salt solution. The cells now weigh 4g. Calculate the percentage decrease in mass of these cells.

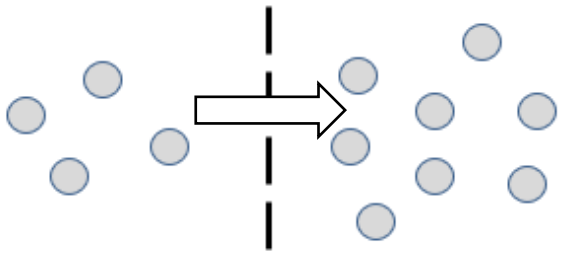
Change = 16-4 = 12g

Original Number = 16g

Change/original number x 100
12/16 x 100 = **75%**

Active Transport

Movement of molecules from an area of **low** concentration to an area of **high** concentration **against** the concentration gradient.



Low concentration High concentration

Energy requirement

Active transport **requires** energy.

How does active transport take place?

Proteins in the membrane require ATP to pump molecules/ions across the membrane from low to high concentration.

Summary of transport across cell membranes