Inorganic Ions

Inorganic ion	Biological compound	Role
Potassium	k^+ ions	Maintaining electrical potentials across neurones
Calcium	Calcium pectate	Component of the middle lamella between plant cells walls
Calcium	Ca^{2+}	Used in muscle contraction and blood clotting Constituent of bone, enamel and shells (Calcium Phosphate)
Magnesium	Chlorophyll Mg^{2+}	Gives chlorophyll its light absorbing abilities
Iron	Haemoglobin	Constituent of haemoglobin and the electron carries in respiration
Nitrate	NO_3^-	Component of nucleic acids , amino acids and chlorophyll
Phosphate	Phospholipid PO_4^{3-}	Phospholipids are a component of cell membranes, ATP and nucleic acids
Hydrogen Carbonate	HCO_3	Acts as a natural buffer

Polysaccharides

They are complex carbohydrates which often form very long chains of monomers joined through condensation reactions

- The general formula of a polysaccharide is $(C_6 H_{10} O_5)_N$ where N is a large number that can vary.
- Polysaccharides are not 'sugar'; they are not sweet
- Polysaccharides are also insoluble in water.

Starch

Starch is a polymer of alpha glucose that consists of a mixture of two types of chains:

Amylose: in amylose alpha glucose molecules are linked by alpha 1, 4 glycosidic bonds. These chains are coiled to form a spiral, with the spirals held in place by hydrogen bonds only 1, 4 bonds are involved, and amylose forms long unbranched chains

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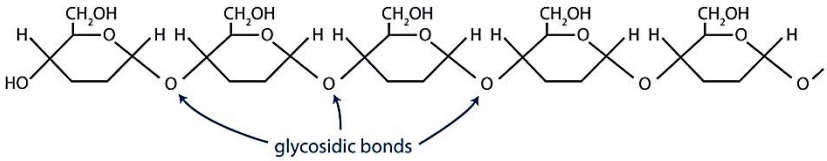
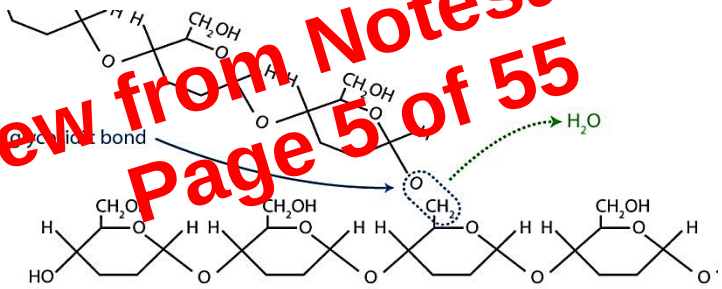


Amylopectin: amylopectin also links its constituent alpha glucose monomers together by alpha 1, 4 glycosidic bonds. In addition alpha 1, 6 glycosidic bonds form side branches to produce a branched molecule.



Starch as a Storage Molecule

Starch is an excellent storage carbohydrate and is the storage compound of many plants. It is commonly stored as solid grains and can be found in plant chloroplasts. Its benefits include:

- Amylose and amylopectin are very compact aided by the coiled configuration, and therefore they contain a rich store of glucose in a small space.
- As it is insoluble it will not affect the water relations of the cell.
- Being a large molecule it will not easily pass through the cell membrane
- The branching nature of amylopectin creates many terminal ends that are easily hydrolysed. This aids in the rapid enzymatic breakdown of starch into its constituent glucose molecules at times of high respiratory demand.

Fibrous proteins

Fibrous proteins are parallel polypeptide chains form thread-like fibres or sheets with a mainly structural function. The chains are linked by cross-bridges form very strong and stable molecule

- They are insoluble in water
- They are not easily denatured

One example of a fibrous protein is collagen:

Collagen is a fibrous protein consisting of three polypeptide chains around each other. Each of the three chains coils itself. Hydrogen bonds form between these coils, which are around 1000 amino acids in length, which gives the structure strength. This is important given collagen's role, as a structural protein. This strength is increased by the fact that collagen molecules form further chains with other collagen molecule and form covalent cross links with each other, which are staggered along the molecules to further increase stability. Collagen molecules wrapped around each other form collagen fibrils which themselves form collagen fibres.

Globular proteins

Globular proteins tend to form ball-like structure where hydrophilic parts are towards the centre and hydrophobic parts are towards the centre and hydrophilic parts are towards the edges.

- They are soluble in water
- They are easily denatured by temperature/pH
- They have a metabolic role

One example of a globular protein is haemoglobin:

Haemoglobin is a water soluble globular protein which is composed of four polypeptide chains and an inorganic prosthetic haem group. Its function is to carry oxygen around of the haem group which contains a Fe^{2+} ion, onto which the oxygen molecules can bind

The Meselson and Stahl (1958) experiment

There are two methods of replication:

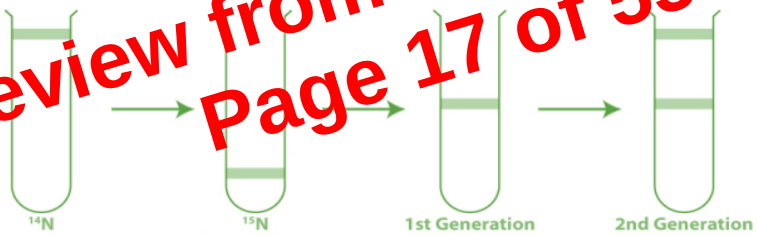
- The conservative model- this model proposed that the parental DNA remained intact but copied the new DNA molecule.
- The semi-conservative model this model proposed that the replication would produce two copies that each contained one of the original strands and one new strand.

Meselson and Stahl cultured the bacterium *Escherichia coli* using the 'heavy' isotope of nitrogen ^{15}N. The heavy nitrogen was incorporated into the bases of the DNA in all the bacteria over time, as older bacteria containing a lighter nitrogen isotope ^{14}N died and were replaced.

The bacteria were then transferred to a medium containing the lighter nitrogen-14. Following the transfer the bacterial DNA was extracted and analysed at intervals.

- Bacteria growing in nitrogen-14 (before transfer to nitrogen-15)
- Bacteria growing in nitrogen-15(many generations after transfer from nitrogen -14)
- One generation after transfer to nitrogen-14
- Two generations after transfer to nitrogen-14

Density-gradient centrifugation was used to separate the bacterial DNA following sampling at the stages. DNA containing the 'lighter' nitrogen-14 accumulated in a zone near the top of the centrifuge tube, whereas DNA consisting of the 'heavy' nitrogen-15 formed a zone near the bottom of the centrifuge tube.



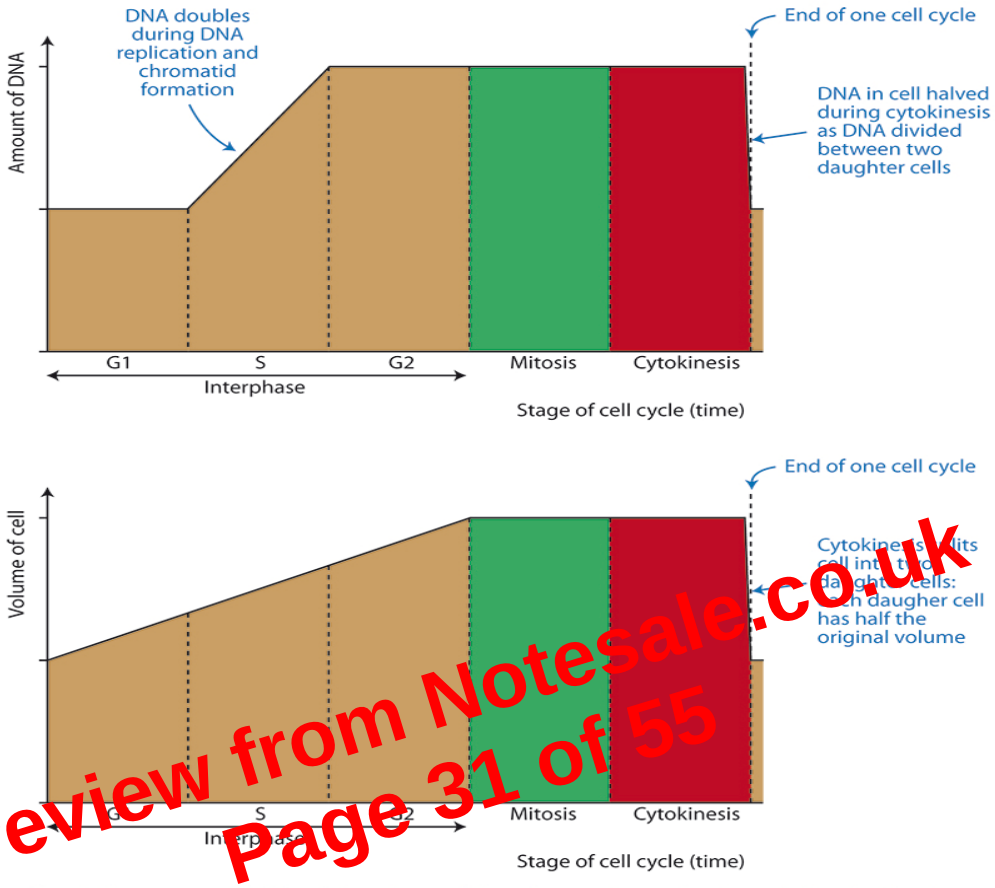
Explanation of Meselson and Stahl's results

- After one generation – the intermediate position of the DNA can be explained but all the DNA consisting of one strand that has bases containing ^{15}N and one strand have bases containing ^{14}N
- After two generations – About half the DNA consisted of mixed DNA containing both ^{15}N and ^{14}N but the other half contained only ^{14}N

Note: In the third generation the pattern would be the same as with the second generation. However, there would be proportionally less mixed DNA and much more DNA containing lighter DNA

DNA and The Cell Cycle

In preparation for mitosis, the DNA content of a cell doubles. This is to provide enough DNA for the new chromosomes that need to be synthesised. The DNA doubles during the S phase and only returns to its normal cellular level during cytokinesis



Note 1: The amount of DNA and the volume of the cell are unchanged at the end of each cell cycle
Note 2: The amount of DNA and the volume of the cell do not change during mitosis

Chromosomes

Chromosomes consist of an extended DNA molecule supported by special proteins called histones. The histones are particularly important in providing support for the DNA when the chromatin condenses to form visible chromosomes during nuclear division. The histone proteins are folded into compact stacks and the DNA coils tightly around the stack to form a structure called a nucleosome. This arrangement both protects and supports the DNA

Humans and most other complex organisms are described as being diploid. Diploid organisms have their chromosomes arranged in homologous pairs within their cells which are very similar to each other; they carry the same genes in the same sequence along their length. However, they are not identical, as the alleles for a small number of the genes may differ in the two chromosomes.

Cell Physiology

Simple Diffusion

Non–polar molecules such as soluble oxygen and carbon dioxide can pass through the membrane unaided. Very small molecules, such as water, can also pass through due to their very small size. Water soluble substances generally are unable to pass through by simple diffusion due to the hydrophobic nature of the centre of the phospholipid bilayer.

Diffusion can be defined as the net movement of a substance from where it is in a higher concentration to where it is in a lower concentration. Diffusion is not restricted to occurring across membrane surfaces.

Diffusion across membranes if affected by a number of factors including:

- ***The concentration gradient:*** the greater the concentration gradient the faster the diffusion.
- ***The size of the molecule:*** small molecules diffuse faster than larger molecules
- ***The temperature:*** Diffusing is faster at higher temperature due to molecules having more kinetic energy.
- ***The thickness of the exchange surface:*** membranes are generally very thin so ideal for rapid diffusion.
- ***The surface area of the membrane:*** the greater the surface area, the faster the diffusion. In many cells where diffusion in important, the cell surface membrane is extended to increase the area across which diffusion can take place.

Cytosis

Some substances can be transported into or out of the cell without having to pass through the membrane itself. The process of Cytosis is important in transporting:

- Large molecules that are too big for the carriers
- The bulk transport of smaller molecules

Endocytosis

Endocytosis is the movement of substances into the cell and

In endocytosis, the cell surface membrane invaginates (infolds) around substances entering the cell from outside to form a membrane-bound sac or vesicle, which then pinches off on the inside of the cell surface membrane. When the vesicles are taken into the cell, the fluid nature of the cell surface membrane allows it to reform and close the gap created by Cytosis.

There are two types of endocytosis:

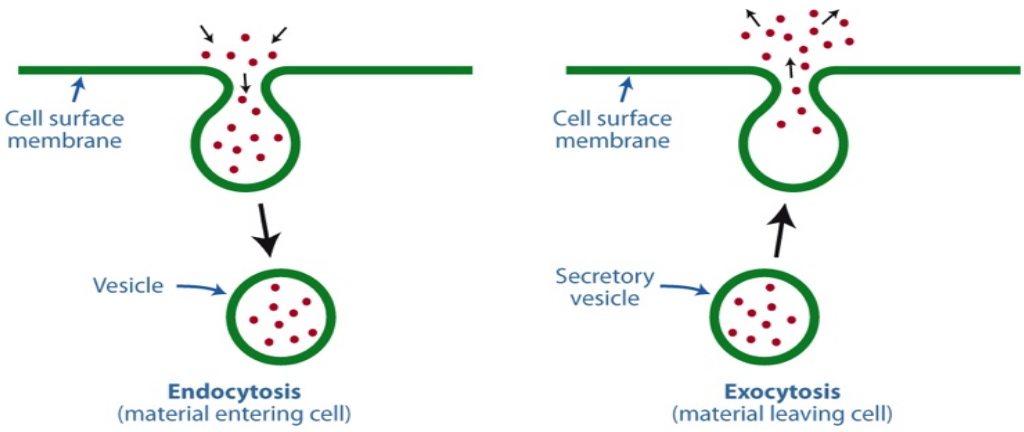
- Phagocytosis: involves the transport of solid material into the cell
- Pinocytosis: involves the transport of fluid into the cell

Exocytosis:

Exocytosis is the movement of substances out of the cell

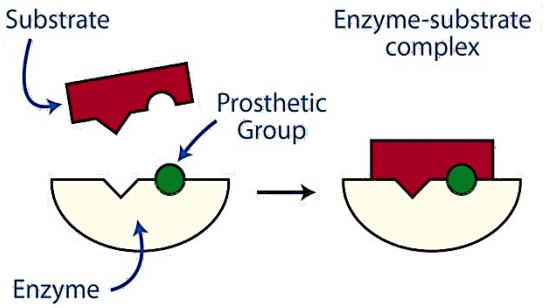
Secretory vesicles move to and fuse with the cell surface membrane. The contents of the vesicle are then released outside the cell. As with endocytosis, the creation of the gap in the cell surface membrane is followed by the reforming of the membrane

Exocytosis is important in the secretion of many proteins from cells, including digestive enzymes and many hormones



Cofactors

Cofactors are non–protein substances that enzymes require in order to function. Like metal ions mg $^{2+,}$ Ca$^{2+,}$ FE$^{3+.}$ These non-protein substances form attachments to enzymes to change the site of the active site to allow reactions to change shape



Prosthetic groups:

Prosthetic groups are cofactors that bind tightly to proteins or enzymes. They are not easily removed. They can be organic or metal ions and are often attached to proteins by a covalent bond.

Coenzymes:

Coenzymes are a particular type of cofactor. They are non–protein, organic molecules necessary for enzyme action. Unlike some other cofactors they are not permanently attached.

Factors that Affect Enzyme Activity

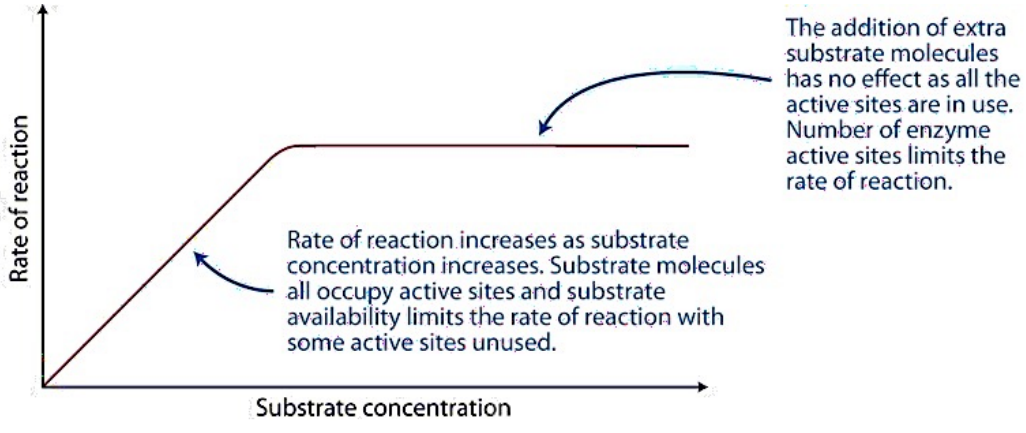
Substrate/Enzyme Concentration:

The more substrate molecules there are in a solution, the more likely they will collide with an enzyme and so there will be more enzyme-substrate complexes formed.

Thus an increase in in substrate concentration will increase an enzyme's rate of reaction as at low levels the substrate concentration is the limiting factor.

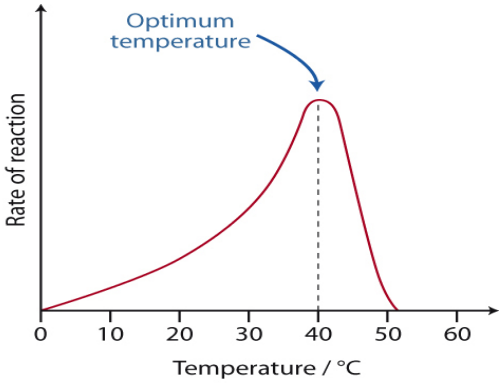
At high substrate concentration the enzymes are fully saturated and so the rate of reaction cannot increase any further as the substrate concentration is no longer the limiting factor, the enzyme concentration is now the limiting factor.

The same will occur for increasing enzyme concentration



Temperature:

As the temperature increases from 0°C to the optimum, the reaction increases steadily. At the optimum the enzyme reaches its maximum rate of reaction. As the temperature increases past the optimum, the rate of reaction dramatically decreases until the rate of reaction is 0



Temperatures Effect on Enzymes

Increasing the temperature provides more kinetic energy, and so both the enzyme and the substrate move faster, which results in more collisions, which results in more enzyme-substrate complexes being formed, which therefore increases the rate of reaction.

High temperature results in more kinetic energy being given to the enzyme and the substrate. The enzyme molecules vibrate more as the kinetic energy increases. The hydrogen bonds holding the tertiary structure of the protein break, this changes the 3-D globular shape of the enzyme which changes the active site, and the substrate can no longer fit as the enzyme has been de-natured, and there is no reaction occurring.

pH

Changes in pH cause the ionic bonds in the tertiary structure of the enzymes to break which in turn changes the shape of enzyme's actives site This causes the active site to no longer be complementary to the substrate and so no reactions occur.