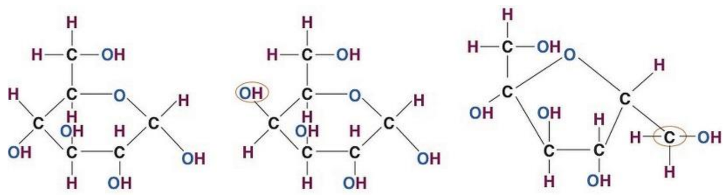
3.1 Biological Molecules

Monomers and Polymers

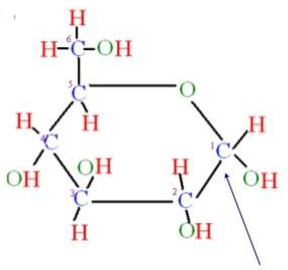
- Monomers
  - Smaller units from larger polymers are made from
- Polymers
  - Molecules made from a large number of monomers joined together
- Condensation reactions
  - Join monomers together into larger molecules, releasing water
  - Monosaccharides → Disaccharides → Polysaccharides: glycosidic bonds formed
  - Amino acids → Polypeptides: peptide bonds
  - Glycerol + fatty acids → Triglycerides: ester bonds
- Condensation reactions
  - Break down molecules, by using water

Carbohydrates

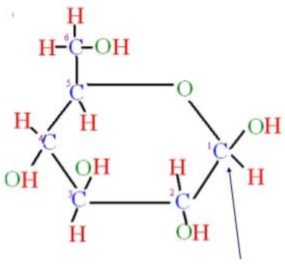
- Made up of monosaccharides (monomers of carbohydrates)
- Common monosaccharides - glucose, galactose, fructose
- Disaccharides
  - Formed by condensation reaction of 2 monosaccharides
  - Maltose → Glucose + Glucose
  - Sucrose → Glucose + Fructose
  - Lactose → Glucose + Galactose
- Glucose
  - Two isomers:



Glucose Galactose Fructose



ALPHA GLUCOSE



BETA GLUCOSE

α-glucose: Carbon atom 1 has hydrogen pointing up, and hydroxyl group pointing down

β-glucose: Carbon atom 1 has hydrogen and hydroxyl groups flipped

- Polysaccharides
  - Formed by condensation of many monosaccharides
  - Glycogen → condensation of α-glucose
  - Starch → condensation of α-glucose
  - Cellulose → condensation of β-glucose
- Structure of Glycogen
  - Energy store in animals
  - Highly branched structure, coiled – so compact
  - Unable to diffuse out of cells, so stays where it is needed until energy is required
- Structure of Cellulose
  - Unbranched, linear chains
  - Used in plant cell wall – provides rigidity to plants
  - Fibres group together to form microfibrils – hydrogen bonds (strength in large numbers)
- Structure of Starch
  - Forms granules – unable to move out of cells it is formed in – doesn't have to diffuse far, so reasonably quick access to energy
  - Branched chains, coiled – compact

3.1 Biological Molecules

Lipids

- Triglycerides
  - Glycerol + 3 fatty acid tails
  - Form oils, waxes, fats
  - Hydrophobic – do not mix with water
- Phospholipids
  - Form the cell wall – phospholipid bilayer
  - Phosphate + glycerol + 2 fatty acid tails
  - Polar molecules – phosphate head is hydrophilic (water loving) // fatty acid tails are hydrophobic (water hating)
- Fatty acids
  - Saturated – all carbon atoms have single bonds – with the maximum number of hydrogens possible
  - Unsaturated
    - Monounsaturated – 1 pair of carbon atoms have a double bond; removes 2 hydrogens, causes a kink in the chain
    - Polyunsaturated – More than 1 pair of carbon atoms have a double bond; removes more than 2 hydrogens, causes many kinks in the chain
    - Have less energy content than unsaturated fatty acids

Proteins

- Made up of amino acids
- Amine group: NH2 Carboxyl group: COOH
- R group – the side chain causing the amino acid to be unique
- Dipeptides – condensation of two amino acids
- Polypeptides – condensation of many amino acids
- Proteins can be made up of multiple polypeptide chains
- Primary structure: order of amino acids – polypeptide chain
- Secondary structure: α-helix or β-pleated sheet – formed by hydrogen bonds between R-groups
- Tertiary structure: further coiling of α-helix / β-pleated sheet – more compact
- Quaternary structure: linking together of multiple tertiary structure polypeptide chains
- Hydrogen bonds – hold together the polypeptide chains in quaternary structure
- Ionic bonds – join together amino acids into polypeptide chain
- Disulphide bridges – strong bonds between R-groups holding α-helix / β-pleated sheet together

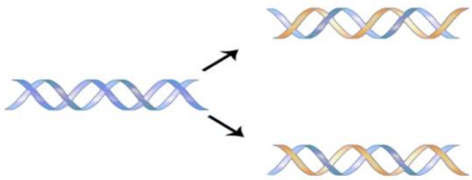
Enzymes

- Lower the activation energy of the reaction it catalyses
- Lock and Key model of enzyme action
  - Substrate fits perfectly in the enzyme
  - No explanation as to how the enzyme catalyses the reaction
- Induced Fit model of enzyme action
  - Enzyme active site changes shape slightly to allow the substrate to bind to it
  - Active site puts stresses on the substrate, causing bonds to brake
  - Reaction is catalysed, causing the product(s) to be released
- Enzymes are only able to have 1 substrate fit it – amylase only catalyses starch hydrolysis
- Enzyme concentration – a higher concentration will cause the substrate to be broken down faster. The rate of reaction will plateau as the substrate concentration decreases, as collisions are less likely to occur

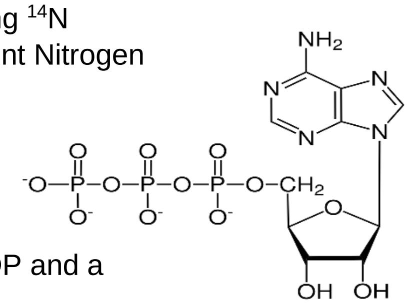
3.1 Biological Molecules

- Substrate concentration – higher concentration of substrate means that the enzymes are more likely to collide with substrate. Increase rate of reaction, to a point. Once all of the enzyme has substrate in active site, reaction cannot continue further
- Inhibitor concentration – higher concentration of competitive inhibitors will cause reaction to slow, as more competitive inhibitor blocks active sites
  Non-competitive inhibitors will have an impact, however it is not based on concentration as they do not block the active site
- pH – outside of the enzymes optimum pH, the active site denatures quickly. This prevents the reaction from being catalysed
- Temperature – below the optimum temperature, the reaction slows, as less energy to cause collisions
  Above optimum temp – reaction stops – enzymes denature

Nucleic Acids



- DNA – deoxyribonucleic acid
- RNA – ribonucleic acid
- Genetic material for living organisms
- Adenine (purine), Thymine / Uracil (pyramidal), Guanine (purine), Cytosine (pyramidal)
- Semi-Conservative Replication
  - DNA unzips: DNA Helicase
  - Base pairs move in between the unzipped strands
  - DNA Polymerase used to bind the new bases to the old strands
  - Forms 2 DNA strands, each with 1 old strand and 1 new strand
- Proof for semi-conservative replication
  - DNA replicated until all Nitrogen is ^{15}N – this is heavier, causing the strand to be lower in solution
  - DNA then replicated 1 generation with ^{14}N – this creates a hybrid DNA, with 50% ^{15}N and 50% ^{14}N
  - DNA replicated 1 further generation in ^{14}N solution – creating DNA with 25% ^{15}N and 75% ^{14}N
  - This is repeated, eventually forming DNA only containing ^{14}N
  - The solution can be centrifuged, DNA containing different Nitrogen isotopes to be identified



ATP – Adenosine Triphosphate

- Used to transfer energy within cells
- Made of: Adenine, 3× Phosphate groups, Ribose sugar
- $ATP + H_2O \rightarrow ADP + P_i$ – condensation on ATP, forming ADP and a phosphate group; breaking the bond releases energy
- Low activation energy, so it is easy to release energy
- ATPase – enzyme catalysing hydrolysis of ATP (break down of ATP into ADP)
- Photophosphorylation
  - Photosynthesis: Plants only, Using light to synthesise ADP → ATP
- Oxidative Phosphorylation
  - Using respiration to synthesise ADP → ATP; Plants and Animals
- Substrate-level Phosphorylation
  - When phosphate groups are transferred from donors; plants and animals
- Uses of ATP
  - Metabolic Processes – provides energy to build up molecules from subunits
  - Movement – energy is required for muscular contraction
  - Active Transport – movement of molecules against a concentration gradient
  - Secretion – ATP is needed to form lysosomes to encase cell products
  - Activation of Molecules – inorganic phosphate released in hydrolysis of ATP can phosphorylate other molecules

3.1 Biological Molecules

Water

- Essential for all living organisms
- Polar Molecule
  - Hydrogen bonds between water molecules require lots of energy to break
  - Causes water to have a high surface tension
- Solvent
  - As water is polar, other polar molecules are able to dissolve in it
  - Ionic compounds are surrounded by water molecules when dissolved
  - Allows gases to be dissolved – CO_2, O_2, NH_3…
- High Specific Heat Capacity
  - A lot of energy is required to increase the temperature by 1° - this is due to the strength of the hydrogen bonds
  - This means that water acts as a buffer, reducing temperature fluctuations
- High Latent Heat of Vaporisation
  - A lot of energy is required to evaporate water (into steam)
  - Ideal for cooling an organism – sweating (animals) or transpiring (plants)
- Cohesion between Molecules
  - High surface tension means that column of water is able to be pulled up a vessel (such as a xylem)
- Metabolite
  - Used in condensation / hydrolysis reactions to break / form bonds

Inorganic Ions

- Occur in solution in the cytoplasm / bodily fluids
- Some are in high concentrations, others in low concentrations
- Each ion has a specific role
- Iron ions — Haemoglobin
- Sodium ions — Co-transport of Glucose and Amino Acids
- Phosphate ions — Part of DNA and ATP

Benedict's Test for Reducing Sugars

- Add $2cm^3$ of Benedict's reagent to $5cm^3$ of homogenised food sample
- Heat in gently boiling water bath for 5 mins
- Observe colour change:
  - Negative – blue
  - Positive – Green (lowest concentration) → Brick red (highest concentration)

Benedict's Test for Non-Reducing Sugars

- Carry out Benedict's test as above
- If result is negative:
  - Boil homogenised food sample in acid for 5 mins
  - Neutralise with sodium hydrogen carbonate powder
  - Carry out Benedict's test again, as above

Iodine Test for Starch

- Add a few drops of iodine in potassium iodide solution to the food sample
- Observe colour change
  - Yellow / orange (no change) – no starch is present
  - Blue / black – starch is present

Emulsion Test for Lipids

- Add 2cm3 of homogenised food sample to $2cm^3$ of ethanol
- Shake, then add some water
- Observe whether an emulsion forms (emulsion present = lipids present)