Unit - BY1

Biology Revision

WJEC GCE AS

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Basic Biochemistry

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About this Book

Water

Key Terms For This Section

Covalent, Ionic, Atom, Molecule, Cell, Tissue, Organ, Organ System, Organism.

Water

Water is a very important molecule because of it's properties - first of all water is a polar molecule. This means that water has a slightly positive end and a slightly negative end, this property is caused by the uneven distribution of electrons throughout the molecule. In water the Oxygen atoms have more electrons (-ve charge) than Hydrogen atoms causing the Hydrogen end to have a slight positive charge and the Oxygen end to have a slight negative charge.

This is normally written as δ - and δ + (δ is the Greek letter delta).

Water specifically is Dipolar since it has both a positive and negative side.

Water forms Hydrogen Bonds because the different poles attract their opposites, +ve is attracted to - ve much like North and South in Magnets. Hydrogen bonds are weak however - especially in comparison to Ionic and Covalent Bonds.

Water has several other useful properties, firstly it is a solvent i.e a substance capable of dissolving one or more other substances. This is particularly useful as it allows reactions to take place in solution (in cells for example) and for substances to be transported around an organism dissolved in water (this happens in your own blood). Along with this water has a low viscosity (its not thick like bitumen - the stuff that makes up the road surface. And yes it is a liquid just in case you didn't know) and since it makes up over 60% of us it's the perfect medium for transportation.

Water molecules stick together, this is known as cohesion and occurs in water molecules due to (surprise, surprise) its polarity. This is what allows water to be 'pulled' up plant stems in plants.

You will have seen in any body of water that the surface molecules are pulled back in. This is Surface tension, another exciting property of water. Water has a very high surface tension which allows it to support small insects such as the pond skater. This allows it to serve as a habitat for animals both above and below the surface. Because water is translucent light can pass through allowing photosynthesis to take place below the surface. Its thermal properties also allow water to form a habitat. Since water has a maximum density at approximately 4 degrees Centigrade, Ice can float on the surface of it, this again provides a surface on which animals can live (such as the polar bear). The ice layer also insulates the water below so that life can also exist below the ice.

Water also has a few other nifty thermal properties, its Large Latent heat of vaporization for example. This means that a large amount of energy is required in order to change it into a vapor, this is important in regulating body temperature. In order for sweat to evaporate it must be given a large amount of thermal energy which stays with it when it evaporates off your skin - cooling you down. Because large amounts of energy are needed to change waters state it helps provide a stable environment for organisms.

Carbohydrates

Carbohydrates

Carbohydrates are Organic compounds because they contain carbon and are made up of smaller molecules in a chain - each element of the chain is a monomer.

In carbohydrates the monomer is called a monosaccharide - these are basic molecules which form the basis of carbohydrates. Monosaccharides have the basic formula C(H2O)n and the names of each individual monosacharide is given by the number of Carbon atoms in the molecule. For example: Triose has 3 Carbon atoms, Pentose has 5 and Hexose has 6. Glucose is a Hexose Sugar.

The next largest unit in the chain is a disaccharide which is made up of two monosaccharides, you need to know these ones: Maltose (2 Glucose Molecules), Sucrose (Glucose and Fructose) and Lactose (Glucose and Galactose).

After disaccharides are trisacharides polysaccharides which are two or more monomers in a chain.

Glucose (Alpha and Beta)

Alpha and Beta Glucose are Isomers which mean they have the same molecular formula but different structures. The exact difference is that in beta glucose molecules the OH on carbon one is at the top and the H is at the bottom. Glucose molecules are joined together through Glycosidic bonds, or more specifically alpha/beta 1,4 glycosidic bonds. These bonds are formed from condensation reactions where H2O is removed from the molecules. The opposite of this process is a hydrolysis reaction which involves the adding of water to break bonds.

Starch (an important part of your diet)

Starch is a polysaccharide (a mixture of two or more monosaccharide molecules) and is made up of Amylose and Amylopectin. Starch is a large, insoluble molecule which is found in seeds, potato tubers and in chloroplast as granules.

Amylose is made from 200 to 5000 alpha glucose units which are bonded by alpha 1,4 glycosidic bonds and coiled tightly together.

Amylopectin is made from 5000 to 100 000 alpha glucose molecules joined by both 1,4 and 1,6 glycosidic bonds.

Starch is made up of 80% amylopectin and 20% amylose (approx.)

So what makes Starch so good? Firstly starch is insoluble so it has no osmotic influence and does not diffuse out of the cell. Its also compact which means a large amount of starch can be stored in a small area. But most importantly when starch is hydrolysed it forms glucose which provides energy quickly and is used in respiration.

Glycogen (‘Animal Starch’)

Glycogen has the same storage properties as starch and it is the store of carbohydrates in animals and fungi. It has a similar structure to that of amylopectin (see picture above) but is more ‘branched’ with shorter chains. As a result of this glycogen is more readily hydrolysed than starch.

Cellulose (perhaps the most abundant organic molecule on earth)

Cellulose is a polysaccharide that is made from beta glucose molecules however every other beta glucose molecule must be ‘flipped’ upside down in order for the OH to be in the correct place for it to react. When the two beta glucose molecules bond it is through a condensation reaction which forms a beta 1,4 glycosidic bond. Unlike glycogen cellulose is a straight and unbranched chain.

Cellulose molecules form hydrogen bonds between their hydroxyl groups, much like water. This forms micro-fibrils which in turn form cellulose fibres. Cellulose has an important structural function and makes up to 50% of plant cell walls, its purpose is to prevent the cell bursting from osmosis. To do this cellulose has a very high tensile strength which is almost equal to that of steel - this is due to the hydrogen bonding between the cellulose molecules. The cellulose fibrils are produced in layers and these are held together by a glue like matrix. The matrix provides resistance to compression and shearing forces.

Cellulose is difficult to digest because it is made from beta 1,4 glycosidic bonds which are highly resistant to bacterial attack since few bacteria contain the enzyme cellulase.

Cellulose isn’t just used in plant cell walls however, it makes (good old fashioned) camera film, sellotape , cellophane and much much more.

Chitin (a little like cellulose)

Chitin makes up the cell wall of fungi and the exoskeleton of arthropods, (crabs, beetles).

Chitin is a long chain polymer of N-acetylglucosamine (a monomer). Like in cellulose every other molecule is flipped and the bond between the monomers is a beta 1,4 glycosidic bond.

Proteins

Proteins

Proteins are made up of a sequence of amino acids, it is this sequence of amino acids that makes every protein. Proteins are used for growth and repair and lots of other things. In fact all enzymes are proteins too. Not to mention every single one of our characteristics is controlled by proteins. And they make up 50% of the dried mass of cells since they are an essential part of cell membranes. The amino acids form the primary structure of a given protein and are joined together by peptide bonds. There are 20 different amino acids that can join together, 12 of these are non-essential amino acids and 8 are essential amino acids. The difference between these two types of amino acids are that essential amino acids can not be synthesised by ourselves (or an organism) and therefore must be provided in our diet. The naming convention for sets of amino acids are similar to the saccharides from earlier. Where 2 amino acids form a dipeptide and more than two form a polypeptide.

The secondary structure of a protein is the folding of the amino acid chain in different ways by hydrogen bonds, this bends proteins into alpha helices and beta pleated sheets. A protein can have many alpha helices and many beta pleated sheets. The hydrogen bonds in this structure form from the carboxyl group of one amino acid to the Hydrogen on groups which are not part of an R group on the other.

Tertiary structure - this is the part that makes proteins unique and is formed by the folding of secondary structures. The tertiary structure is caused by the formation of bonds between R groups. The bonds found at this level of protein structure are: Disulphide Bonds, Ionic bonds (if R group is charged), Hydrogen Bonds and Hydrophobic Interactions (If R group is uncharged).

Enzymes can be damaged or permanently denatured by a number of factors. High Temperatures can cause Hydrogen bonds in the protein to vibrate (since they gain energy) and eventually break, Too low or Too High a ph can also break hydrogen bonds as well as ionic bonds in a protein. Solvents can also denature enzymes, especially powerful solvents such as ethanol which can break Disulphide bonds.

The final level of protein structure is the Quaternary structure, this is when you have a protein that has more than one polypeptide chain like haemoglobin which has four. There are two distinct types of protein - Fibrous and Globular. Globular Proteins are curled into a ball and are soluble since their hydrophobic R groups are pointed inwards. Globular proteins are important in metabolism (all the reactions that take place in cells). Fibrous proteins on the other hand are made from long chains and are insoluble, their function is a structural one.

Collagen and Hemoglobin (Protein examples)

Describe Collagen:

“Collagen is a fibrous protein with a Quaternary structure. Collagen is made form three chains, each of these three chains wrap around each other and hydrogen bonds form between them. These molecules then bond together to form fibres. The molecules are lined up with staggered end so as to prevent any weak points from forming in the fibre, this gives collagen a high tensile strength.”

Describe hemoglobin:

“hemoglobin is a globular protein which consists of four individual poly-peptide chains makeing two matching pairs of sub units. Each sub group has a prosthetic group (i.e one that is not made from an amino acid) at its centre, this holds the Fe Ions which are responsible for the binding of oxygen.”

Lipids and Triglycerides

Trigycerides have several roles including: Energy Reserves, Providing Buoyancy, Insulation, Protection of vital organs and even metabolic sources of water (see the Kangeroo Rat).

A large number of lipids are triglycerides. Triglycerides are made from a glycerol (an alcohol) group and 3 fatty acids. Fatty acids consist of a Carboxyl (COOH) group and long (14-16) hydrocarbon tails. The bonds between glycerol and fatty acids are called ester bonds.

Unsaturated fatty acids have at least one double bond in their structure - Vegetable Fats are mainly unsaturated whilst aminal fats are mainly saturated. Unsaturated fats are more fluid and have a lower melting point, making them liquid at room temperature. These are often referred to as oils whilst saturated fats are called fats and these are solid at room temperature (and do not have double bonds).

Phospholipids have a Hydrophilic head which is polar and therefore attracted to water. They are made up of glycerol and a phosphate group which makes it charged. Attached to the Hydrophilic head is two hydrophobic tails - these are non polar.

Quick Note: Phospholipids in water form micelles.

Phospholipids play an Important role in cell membranes (the lipid bi-layer) (they can also form monolayers). But more on that later.

Chemical Tests

Test for Starch:

One: Measure out approximately 1cm3 of test solution into the test tube.

Two: Add 5 Drops of Iodine Solution to this.

Three: Record the colour change (this is blue/black for positive results)

Test for Reducing Sugars:

One: Measure out 2cm3 of test solution into a boiling tube.

Two: Add 1cm3 of Benedict's solution and mix.

Three: Heat the boiling tube gently over a Bunsen burner flame until the mixture boils.

Four: Record the colour change. (Red, Green or Yellow Precipitate is Positive)

Test for Non-Reducing Sugars:

One: Measure out 2cm3 of test solution into a boiling tube.

Two: Add three drops of dilute hydrochloric acid.

Three: Boil in a water bath for 2 minutes.

Four: Leave to cool.

Five: Slowly add sodium carbonate solution to the test tube until it stops fizzing - this is done in order to neutralize the solution.

Six: Add 1cm3 of Benedict's solution and mix.

Seven: Heat the boiling tube gently over a Bunsen burner flame until the mixture boils.

Eight: Record the colour change. (If positive a red/brown precipitate will form out of the solution)

Test for Protein (the Biuret test):

One: Measure out approximately 1cm3 of test solution into a test tube.

Two: Add 2cm3 of dilute sodium hydroxide (Biuret Sol. 1).

Three: Add several drops of copper sulphate solution (Biuret Sol. 2) down the side of the test tube.

Four: Record the colour change. (Purple for Positive, Blue for Negative)

Test for Lipids A (Emulsion Test):

One: Measure out 2cm of ethanol into a test tube.

Two: Add 3 - 4 drops of test solution and shake to dissolve.

Three: Filter if Necessary.

Four: Add to 2cm of distilled water.

Five: Record changes. (If positive a white emulsion is produced).

Cell Structure & Organisation

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Structure

There are two different types of cell - these are Prokaryotic and Eukaryotic cells. Prokaryotic cells have no nucleus and therefore the DNA contained within these cells is in direct contact with the cytoplasm. Eukaryotic cells have a nucleus and the DNA is contained by a nuclear membrane, unlike prokaryotic cells Eukaryotes have membrane bound organelles. Examples of which include: Mitochondria, Golgi Apparatus, Nucleus, etc

Prokaryotes such as blue and green algae have a cell wall which contains the polysaccharide murein - eukaryotic cells mostly do not have a rigid cell wall - though plant cells are the exception however the cell wall in this case is made up of cellulose not murein.

Unicellular organisms carry out all Life functions with a single cell. Multi cellular organisms are therefore more efficient since they have specialised cells of a variety of different types which allow the to suit the role they they will perform at the point when they differentiate - for example in the nervous system nerve cells become long and thin in order to carry electrical impulses.

Viruses

Viruses cause infections in animals plants and us and are extremely small. So small that a electron microscope must be used in order to see them. Viruses have no cytoplasm or organelles and chromosomes. When they are not present in living cells they are inert and are known as virion. If a virus can enter a cell it can take over the cells metabolism and multiply. Each virus is made out of a nucleic acid core surrounded by a protein coat called the capsid. Viruses which are found to attack bacteria (bacteriaophages) and animal cells have the nucleic acid DNA. Other viruses contain RNA.

Cells are usually grouped together into tissues, tissues are groups of cells with a particular function. Tissues are grouped into organs which are in turn grouped into organ systems and then the organism.

Cell Membranes

Surrounding cells is the cell membrane - this serves to separate the cell from its environment. The cell membrane is made up of the phospholipid bilayer as proposed by the fluid mosaic model. The fluid mosaic model describes the bilayer as constantly moving (fluid) and with proteins dotted throughout the surface much like a mosaic. The membrane can contain intrinsic (proteins which extend across both layers) and extrinsic proteins (which occur on the surface of the protein or partly embedded in it. As well as these proteins the membrane can also contain cholesterol. Cholesterol fits between the phospholipid molecules increasing their rigidity and therefore making the membrane more stable. Glycolipids (lipids that have combined with polysaccharides) can also me found in the outer layer and these are thought to play a role in cell to cell recognition.

The cell membrane also acts as a barrier. Lipid soluble substances may pass across the membrane along with small uncharged molecules such as oxygen and carbon dioxide. Water soluble substances must pass through special proteins which form channels across the membrane.

There are several methods of transport across the cell membrane: Diffusion, the movement of molecules from a region of high concentration to an area of low concentration until there is a point when they are evenly distributed. The second: Facilitated Diffusion, Use of protein molecules to help substances pass across the membrane. There are two types or protein that perform this function - Channel proteins which are made up of pores lined with polar groups allow ions to pass down them. Each channel protein is unique for one type of ion and can close or open depending on the needs of the cell.

Carrier proteins: These allow large polar molecules like amino acids to diffuse across the phospholipid bilayer. A particular molecule binds with the carrier protein at it's binding site which in turn causes it to modify its shape which releases the molecule through the membrane.

Both types of protein increase the speed at which diffusion occurs across the membrane along the concentration gradient without the need for energy (which usually comes in the form of ATP).

The process which uses energy to move substances across the cell membrane is called Active Transport and uses energy produced through respiration in the form of ATP. ATP moves substances against the concentration gradient unlike the two types of diffusion above. Because Active transport uses ATP anything that effects respiration such as Cyanide will affect active transport. The process of Active transport occurs through the proteins that span the membrane - these proteins take the molecule and then change shape allowing the molecule to enter or leave the cell. An example of an active transport process is muscle contraction and protein synthesis.