EDEXCEL: AS BIOLOGY

REVISION NOTES: UNIT 1

Metabolism

Metabolism is a term to describe all reaction which is taking place within a cell and is separated into two types which are

- anabolic = compounds being built up
- catabolic = compounds being broken down

Water

The water molecule is a molecule which is made up from 2 hydrogen atoms and 1 oxygen atoms. It is bounded by 2 covalent bonds and has is polar.

The reason why water molecules are important for living organisms are because :

1. They are important solvents since they are polar
2. Important coolants for excessive metabolic reactions
3. Important for insulation since they have high specific heat capacities
4. It is a very good mechanism for transport since they are highly cohesive
5. Important reagents for chemical reactions (such as hydrolysis and photosynthesis

Carbohydrates

Separated into 3 types which are monosaccharides, disaccharides and polysaccharides

Monosaccharides

- they are three main types of monosaccharides which you have to know in this level which are

Pentoses - Such as ribose (with formula $C_5H_{10}O_5$) and fructose

Hexose - Such as alpha and beta glucoses

- All members of monosaccharides are reducing since they have the aldehyde groups, therefore they will cause a brick red persipitate to form when tested with benedict`s solution.

Disaccharides

- You would need to know 3 types of dissacharides in this level which is
    1. Lactose - Formed between glucose and galactose and is bounded by 1,4 glycosidic bonds (found in milk)
    2. Maltose - Formed by 2 molecules of glucose and is bounded by 1,4 glycosidic bonds (found in starch after being hydrolysed)
    3. Sucrose – Formed by a molecule of glucose and a molecule of fructose bounded by 1,2 glycosidic bonds (Found in most plant since it is used to transport sugary compounds)
- The formation of bonds between 2 monosaccharides is called condensation and the breakage of these bonds are called hydrolysis. Hydrolysis of these bonds can be brought about by adding dilute HCl.
- Both lactose and maltose are reducing but sucrose is not a reducing sugar. Therefore disaccharides can or cannot be reducing. It is not always a reducing agent.

Polyssacharides

- There are three types of polyssacharides that we need to know at this level which are

Starch

- A polymer of alpha glucose and is bounded by 30% amylose (1,4 glycosidic bonds) and 70% amylopectin (both 1,4 and 1,6 glycosidic bonds)
- It is used as a food storage for plants and is built from the amyloplasts in the cytoplasm of plant cells.
- Starch is an important storage molecule since it is compact, insoluble in water, inert to chemical reactions and is easily hydrolysed when required.

Glycogen

- A polymer of alpha glucose with 1,4 glycosidic bonds but even more 1,6 glycosidic bonds compared to starch since it is even more branched..
- It is used as an energy store in animals and is also found in bacterias
- Glycogen is an important storage molecule since it is compact, insoluble in water, inert to chemical reactions and is easily hydrolysed when required.

Cellulose

- A polymer of beta glucose and is by only 1,4-glycosidic bonds. Therefore it is not branched but arranged in a matrix which is bounded by hydrogen bonds

- It is the constituent of cell walls and can be hydrolysed by ruminant animals by the action of cellulase enzymes..
  All polysaccharides are non reducing sugars.

Lipids

- Lipids are basically fats and oild that contain elements of carbon, hydrogen and oxygen
- An example of a lipid would be the triglyceride which is formed by glycerol and fatty acids .The bond formed is catalysed by the the process of condensation between the –OH groups of the glycerol and the fatty acids. The bonds formed between them are the ester bonds. Since triglyceride itself is an ester.
- There are two types of fatty acids which are unsaturated and saturated fatty acids. An example of a saturated fatty acid would be stearic acid and unsaturated would be the oleic acid. The difference between saturated and unsaturated fatty acids are the double bonds and the amount of hydrogen present at where saturated acids have more hydrogen and no double bond present.
- The usages of triglycerides are important energy stores, compact, insoluble in water, releases energy twice the amount of carbohydrates, and provides buoyancy for aquatic animals.
- The usages of fatty acids include the formation of triglycerides and is also required for the formation of phospholipids.

Phospholipids

- Formed between fatty acids, glycerol and a phosphate group.
- The head is hydrophilic (soluble in water) but the tail is hydrophobic (insoluble in water).
- Therefore phospholipids are used as the main constituents of cell membranes

Protein

Primary structure

- It is the number , type and sequence of amino acids which makes up a polypeptide chain

8Each amino acid is binded to another acid by peptide bonds by the process of condensation. Amino acids are amphoteric since it has a zwitterion shapes.

Secondary structure

- It is the shape of molecule formed when polypeptide chains are either coiled by hydrogen bonds into a spiral springs ,the alpha helix or linked to form beta pleated sheets
- The alpha helix coils the polypeptide chains and are help in place by hydrogen bonds. An example of this would be keratin.
- The beta pleated sheets are formed by hydrogen bonds taking place between the CO and NH groups .It is very strong but supple. An example would be collagen since it is fibrous.
- Insoluble in water.

Tertiary structure

- It is the folding of a polypeptide to form a globular shape.
- R groups of these proteins are bounded by ionic bonds, disulphide bridges and hydrogen bonds.
- An example would be enzymes.

Quaternary structure

- A complex protein molecule which has more than one polypeptide chains bounded to it.
- An example would be haemoglobin.

Experimental tests

- Bear in mind that most of the unit 1 tests has at least 1 biological test question which can yield up to 5 points and these tests should not be neglected.

Benedict test

- Test to confirm reducing properties of sugars.
- Add a few drops of benedict solution into the sugar and boil. If it shows a brickred precipitate, a reducing sugar is present. Since copper 2+ is reduced in copper +1 which shows are brick red precipitate

Biuret test

- Test to confirm the contents of protein or the presence of protein.
- Add an equal amount of protein and biuret reagent. A purple-violet color would confirm the presence of proteins. This can be used as a qualitative test since the color is gets more intense as the protein content increases.

Sudan III test

- To test the for the presence of fat
- Add equal amount of Sudan III and fat contents together. A suspension of red liquid and white precipitate on the top would confirm that there is fat present.

Nucleic acids

- A nucleotide is made up of a pentose sugar ,and organic nitrogenous base and a phosphoric acid
- It is formed between the condensation of of a necleoside and a phosphate molecule
- Bonds which link a phosphate group to another phosphate group in a nucleotide is called the phosphodiester bond and the bond which links the phosphate and the nucleoside is the phosphoester bonds.
- There are 2 types of ribonucleotides which are RNA(the one containing ribonucleotides) and DNA(the one containing the deoxyribonucletides)
- There are two types of purines (Adenine, Guanine) and three types of pyrimidines (Uracil ,thymine and cystosine)

DNA replication

- Replication of DNA is semi conservative, which means that the original DNA strand is reused to form new double stranded DNA.
- The process is as follows:
    1. Helicase unwinds the double stranded DNA by breaking the hydrogen bonds.

2. DNA attracts complementary bases onto the single stranded DNA which was used as a template .(A is attracted to T) and (G is attracted to C) and vice versa in the 5` direction to the 3` direction.

- The phophodiester linkages from other parts are joined by DNA Ligase from the 3` direction to the 5` direction
- In the end, there will be two identical strains of DNA formed as a result.
- This is important in cell divisions of mitosis and meiosis

Protein synthesis

- This process involves the synthesis of protein molecules by using genes found in the DNA
- The process of transcription and translation is assisted by RNA(tRNA ,mRNA and rRNA).They differ in three ways, which are
    1. It is single stranded
    2. It contains a pentose instead of a deoxyribose
    3. The base thymine is replaced by uracil
- The process starts off with transcription which involves the unwinding of the double stranded DNA molecule. This is then followed by the enzyme RNA polymerase catalyzing the binding of mRNA bases to the DNA bases which are complementary.
- After this is done, the mRNA is modified by adding a guanine cap at the 5` end and a poly A being added to the 3` end of the mRNA. Thus it moves out of the nuclear envelope and into a ribosome in the cytoplasm or the rough endoplasmic reticulum.
- After the mRNA reaches the ribosomes, a process known as translation occus. mRNA then binds to a subunit of a ribosomes in such a way that the codons (3 units bases) are exposed.
- A unit of ribose consists of rRNA which has an entering point for 2 codons of mRNA whereelse a tRNA is a clover shaped molecules which has 3 anticodons facing outwards.
- As the mRNA reaches the the ribosomes,2 tRNA molecules can be help at one time. The enzyme peptidyl transferase catalyses the formation of a peptide bond between 2 amino acids. After it is formed, tRNA is moves out of the RNA and the product of the amino acids are moved into the golgi apparatus with the help of a transport vesicle for further modification of the amino acids.

Enzymes

- Enzymes are basically tertiary proteins which have an active sites which binds on to a substrate. The reaction causes bonds to be formed and broken much easier. This is because enzymes act as organic catalysts which reduces the activation energy needed for a reaction to go forward.
- The process is summarized as below :
- Enzyme + Substrate ---àenzyme-substrate complex---àenzyme + products
- There are a few factors which affect the rate at which the enzymes react, they are
    1. Temperature
        - The increase in temperature would increase the total kinetic energy of the substrate and enzyme, thus the rate of collision increases and the rate of reaction increases. The opposite is shown if the temperature is reduced
    2. pH
        - The decrease in pH would lead to excess H+ ions which will ionize the side groups in the enzyme`s amino acids residue. This would lead to a change in its molecular structure and cause the enzyme`s active site to be not complementary to the substrate anymore. Thus the lower the pH, the more ionization and a less rate of reaction.
    3. Enzyme and Substrate concentration
        - The increase of any of the substate or concentration would lead to a higher rate of collision and thus increases the rate or reaction
    4. Inhibitors
        - There are two types of inhibitors which are reversible inhibitors and non-reversible inhibitors
        - An irreversible inhibitor are inhibitors which has a shape which is complementary to the active site of an enzyme and therefore competes with the substrate for a reaction to proceed..this decreases the rate of reaction
        - A non competitive inhibitors are inhibitors, this is usually heavy metals which binds on to the enzyme and causes the enzyme to change its shape and loses its catalytic abilities. Therefore the rate of reaction is reduced

Classification of enzymes

- There are 5 types of enzymes which are
    1. Oxidoreductase – catalyses the process of oxidation and reduction
    2. Transferase – catalyses the transfer of one molecule to another
    3. Hydrolases – catalyses the hydrolysis of a molecule
    4. Lyase – catalyses the lysis (breakage) of a molecule
    5. Ligase – catalyses a formation of a bond between molecules

Industrial usages of enzymes

Cellulase

- Catalyses the breakage of cellulose into beta glucose
- Uses include the production of single cell protein and saccharification (sweetening)

Pectinases

- Catalyses the breakage of pectins into galacturonic acid
- Uses includes the clarification of fruit juices and the increase in total fruit juice yield.

Amylases

- Catalyses the hydrolysis of glycosidic bonds in starch into alpha glucose
- Uses includes the clarification of fruit juices and sweetening of fruit juices.

Protease

- Catalyses the breakage of protein into amino acids
- Used for the clarification of beer, biological detergents and the tenderisation of meat.

Lactase

- Catalyses the breakage of lactose into glucose and galactose
- Uses includes sweetening, production of lactose free milk and the production of immobilized enzymes.

Lipase

- Catalyses the breakage of lipids into glycerol and fatty acids.
- Uses includes the enhancement of cheese ripening and biological detergents.

Practical : The production of immobilized enzymes

- Mix sodium alginate solution with desired enzymes in a beaker and place it into a plastic syringe.
- Add this mixture dropwise into a calcium chloride solution for dehydration.
- Strain beads and rinse. Place into a syringe barrel and pour in the substrate.
- Collect the yield which is produced drop by drop

Advantages of immobilized enzymes

- Highly resistant to extreme conditions such as heat and pH
- Immobilized enzymes can be filtered and reused

Disadvantages of immobilized enzymes

- A slower rate of reaction since the beads are now restraint of movement by the alginate solution

Aggregations of cells

An overview of a multicellular organism. Where cells make up the entire body. This is as follows

Cells-->Tissues->Organs-->individuals

There are distinct differences between an animal cell and a plant cell. Among the many, they are:

1. Vacuoles which are found to be much larger in plant cells
2. Chloroplasts which are found more abundantly in plant cells
3. Cell walls are usually present in plant cells

Cell membrane

- The membrane functions as a passage of control for the substances into and out of the cells. The membrane is not only present on the surface of the membrane but also at the membrane of organelles (mitochondrion, golgi apparatus, chloroplsts etc.)
- It follows the fluid mosaic model at where fluid represents the phospholipid molecules having a fluid arrangement and mosaic represents the random arrangement of proteins, which moves above the phospholipid bilayer.
- The model shows phospholipids pointing head up. This is because the head section of the phospholipds is hydrophilic (soluble in water) where else the tail is hydrophobic (insoluble in water)
- Thus, having to know that, the bilayer only allows non-polar molecules to diffuse through a concentration gradient. Molecules which are sufficiently small (such as water, oxygen and carbon dioxide diffuses through the membrane freely regardless of being polar or not. Polar molecules are only allowed to enter if they are incorporated into a carrier protein at where it is actively transported into the cell or undergo facilitated diffusion (diffusion using a protein molecule).
- Glycolipids are also present on the cell surface membrane since it allows cell recognition and also to promote an immune response
- Carbohydrates and cholesterol functions to reduce the fluidity of the membrane and maintain its stability to ensure that no leaking occurs.
- Proteins which are present can ether be intrinsic or extrinsic and is important in maintaining the stability of the membrane.

Endoplasmic Reticulum (ER)

Smooth ER

- Important with the synthesis of lipids and the production of steroids.

Rough ER

- Important at protein synthesis since it has ribosomes at the top of its surface.

Golgi apparatus

- It is a stack of flattened cistern and associated vesicles.

- It functions to modify proteins which are produced from the process of protein synthesis
- After the synthesis of the proteins, the product is brought out of the cells with the cell through a secretary vesicle. As the secretory vesicles fuses with the membrane, it releases its contents into the surroundings through the process of exocytosis.
- The Golgi apparatus is also important in the process producing lysosomes, which contains hydrolytic enzymes. These hydrolytic enzymes cause the breakdown of unwanted organelles. It is also important to digest phagocytic vesicles.

Nucleus

- Contains a double layers membrane which separates the genetic material from the cytoplasm.The nuclear membrane sometimes contains ribosomes for protein synthesis.
- Among the contents of the Nucleus are chromosomes, chromatin, histones, rRNA.

Mitochondrion

- It is rod shaped with a double layered membrane consisting of cristae for increasing the surface area.The membrane of the mitochondria is called the matrix.
- It is involved in the production of ATP from cellular respiration.

Chloroplasts

- Contains a double layered membrane with molecules of chlorophyll anchored on it. It also has stacks of granum (formed by stacks of thylakoids) and its cytoplasm Is called the stroma.
- It also contains starch, lipid droplets and circular DNA.
- Involved in the process of photosynthesis.

Microtubules

- Fine tubular organelles which contribute to the network of fibrous protein.
- It is necessary for microtubules to be present since it provides the maintenance and shape of certain organelles such as centrioles and is also present in the flagellum of some bacterias.

Cell walls

- The composition of cell wall varies from one organism to another

- In fungi, its cell wall composition is made out of chitin.
- In bacteria, its cell wall composition is made out of murein
- In plant cell walls, its composition is made out of cellulose.
- The main function of plant cell walls are to provide mechanical strength and the resist expansion of plant cells when subjected to high hydrostatic pressure.

The difference between prokaryotic cells and eukaryotic cells

- Prokaryotes are basically cells with a smaller size wherelse eukaryotic are larger
- Prokaryotes have smaller (70s) ribosomes whereas eukaryotes have larger (80s) ribosomes
- Prokaryotes lack a true nucleus whereelse a eukaryotes has a real nucleus present
- Prokaryotes have no membrane bounded organelles whereas eukaryotes do.
- Flagellum present in prokaryotes lacks a 9+2 arrangement of microtubules whereelse eukaryotes does not.

Transfer across cell membranes

Diffusion

- There are 2 types of diffusion which are facilitated diffusion and simple diffusion.
- Simple diffusion involves the transfer of molecules across a membrane or barrier following a concentration gradient.
- Facilitated diffusion involves the transfer of molecules across a barrier or membrane following a concentration gradient with the help of a protein carrier. This is because as the molecules bind on the the protein, it changes its shape in a way that it allows the molecule to be detached form the protein and get released into the cytoplasm of the cell or vice versa.

Osmosis

- It is the process whereby water is moved according a concentration gradient across a semi-permeable membrane.

Active transport

- It is a process whereby molecules are moved across a membrane or barrier against the concentration gradient with the help of a protein carrier and a molecule of ATP.
- The molecules bind on to the protein and ATP releases a phosphate group to the protein which alters the protein shape for it to release its contents against the concentration gradient.

The Cell cycle (mitosis)

Interphase

- Separated into 3 phases which are the G1,S and G2 phase.
- In the G1 stage, the cell is undergoing a period of rapid growth.
- In the S stage, DNA molecules are replicating and therefore the number of chromosomes are now doubled here. Histones are built up and the chromosomes are divided into two chromatids.
- In the G2 stage, more cell growth is taking place at where some organelles divide and there is an accumulation of energy stores

Prophase

- This phase can be seen clearly through a light microscope since it is positively charged and it takes up the orcein staind much easier.
- Chromosomes become shorter and thicker on this stage, nucleoli starts to disappear.

Metaphase

- Chromosomes get attached to the spindle fibres and the chromosomes align at the equator of the cell

Anaphase

- Centromers divide and the spindle fibres shorten and pulls the centromers to opposite poles. (attracted by centrioles)

Telophase

- Chromosomes begin to uncoil from histones and the nuclear envelopes begins to form.

Cytokinesis

- A process whereby furrows are formed after the process of anaphase .It only occurs in animal cells .A plant cell forms cell walls between the two nucleus formed to separate the cells.