AS Biology – Revision Notes
Unit 1 – Core Principles

Biochemistry

1. Carbohydrates have the general formula $(CH_2O)_x$.
2. The simplest carbohydrates are monosaccharides, e.g. glucose ($C_6H_{12}O_6$), and are monomers.
3. Monosaccharides can join together to form disaccharides in a condensation reaction, forming a glycosidic bond. This can be broken by hydrolysis:
4. Polysaccharides are formed from multiple glycosidic bonds, and include starch, glycogen and cellulose.
5. 1-4 glycosidic bonds create straight chains, whereas side chains are produced from 1-6 bonds.
6. Cellulose is fibrous, with β 1-4 linkages, and is used in cell walls. Glycogen and starch are both coiled, with α 1-4 linkages, and 1-6 side chains, and are used for storage.
7. Amino acids are the monomers of proteins – they have an amino group at one end, and a carboxylic acid group at the other.
8. The 'R' group distinguishes one amino acid from another – there are about 20 in total; those that are needed in the diet are called essential amino acids.
9. Some amino acids can be synthesised by transamination.
10. Amino acids bond like monosaccharides, creating peptide bonds.
11. Fibrous proteins, e.g. collagen and keratin, have long, straight, polypeptide chains.
12. Globular proteins, e.g. gels and enzymes, have a roughly rounded shape.
13. Proteins have four different structures:
    a. The primary structure is the basic sequence of amino acids.
    b. The secondary structure is how the chain becomes coiled and folded due to the bonding.
    c. The tertiary structure is the 3D structure of the protein, due to disulphide bridges and hydrogen bonding.
    d. The quaternary structure is when more than one protein is joined together (e.g. in haemoglobin).
14. The tertiary structure of an enzyme gives rise to the active site – when an enzyme is denatured the hydrogen bonds are broken and so the active site changes shape.
15. Lipids are made of glycerol (propan-1,2,3-triol) and fatty acids. The fatty acids join via their carboxylic acid group to the hydroxyl groups on glycerol, forming three ester bonds and a triglyceride.
16. Saturated fatty acids are all single bonds, and are mainly fats and waxes, where as unsaturated fatty acids contain double bonds and form oils. Polyunsaturated fatty acids contain many double bonds.
17. If a phosphate group replaces one fatty acid then a phospholipid is formed. The phosphate is hydrophilic, but the fatty acids are hydrophobic, so they will form either a monolayered vesicle or a phospholipid bilayer (as in plasma membranes).
18. Benedict's solution (containing copper sulphate) will test for a reducing sugar – it will turn orange/red in its presence upon heating.
19. Non-reducing sugars (e.g. sucrose) are tested for by first hydrolysing with dilute HCl then using Benedict's solution.
20. Iodine will produce a blue/black colour in the presence of starch.
21. Biuret solution (copper sulphate and sodium hydroxide) will test for proteins, by turning lilac in its presence.
22. The emulsion test is for lipids – dissolve the lipid in ethanol, then pour into water. A fine emulsion is formed if it is a lipid.
23. Chromatography is used to separate out soluble components of a mixture (e.g. amino acids). This is done by calculating the Rf value for a specific solvent – $\text{Rf} = \frac{\text{Distance moved by spot}}{\text{Distance moved by solvent}}$.
24. Two-way chromatography can be more accurate, as two different solvents are used, and so the mixture can be more easily separated.
25. Water is essential to life due to the following properties:
    a. It is polar, so will dissolve other polar substances.
    b. Due to hydrogen bonding it has a much higher melting/boiling point than expected, allowing it to be liquid within cells.
    c. It can be a breathing medium – typically there is about 1% dissolved oxygen in water.
    d. It has a high latent heat of vaporisation, and so evaporation removes a lot of energy and is used as a cooling mechanism.

e. It has a high specific heat capacity – it absorbs a lot of energy with little change in temperature. So it is thermally very stable.

Cells And Transport

1. Prokaryotic cells have no nuclear membrane – the nucleic acids are free in the cytoplasm.
2. In a bacterium, there is a cell membrane, a cell wall (containing polysaccharide but not cellulose) and a protective capsule. They may have one or more flagella that enable it to move. The cell membrane contains a folded intrusion called the mesosome, which is responsible for respiration (there are no mitochondria).
3. Eukaryotic cells have a nuclear membrane.
4. The resolving power of a microscope is the highest magnification possible. With light microscopes this is limited by the wavelength of light. Electron and X-Ray microscopes have better resolving powers, but are still limited, and the sample must also be dead.
5. The plasma membrane consists of phospholipids and proteins. The Danieli-Dauson hypothesis said that this was a phospholipid bilayer coated with a protein cap on each side.
6. The fluid mosaic model refined this to say that it is a phospholipid bilayer with proteins embedded into it, like a mosaic.
7. Intrinsic proteins pass through both layers and are used as active transport or facilitated diffusion carrier molecules, or as pores for simple diffusion.
8. Extrinsic proteins are on either the upper or the lower lipid layer, and are used in cell recognition (using glycoproteins), or as membrane bound enzymes.
9. The mitochondria are found in all plant and animal cells, and are the site of aerobic respiration.
10. They have a double membrane – the inner membrane is folded into cristae, containing membrane-bound enzymes. The matrix, filling the mitochondrion, contains enzymes needed in the early stages of respiration.
11. Mitochondria have their own DNA and ribosomes, and replicate independently. They are thought to have developed from an early bacterial symbiotic relationship.
12. In respiration, $ADP + P_i \rightarrow ATP$. ATP (adenosine triphosphate) is used as the energy source in cells, and so many mitochondria are found in cells involved with active transport, secretions and movement (i.e. muscle cells).
13. The golgi body is found in cells involved with secretions. It is a stack of smooth ER.
14. The rough ER packages proteins (produced from the ribosomes) into vesicles, which are passed to the golgi body, forming a layer at the bottom of the stack. As this layer moves up the stack, the proteins combine with sugars to form glycoproteins. At the top layer, the glycoproteins are packaged into small vesicles that can be released as a secretion.
15. Lysosomes are also produced by the golgi body – these are the 'suicide bags' containing a cocktail of enzymes to digest the cell contents.
16. The secretion of materials outside the cell is called exocytosis, whereas the ingesting of materials for inside the cell is called endocytosis.
17. A pinocytic vesicle is a 'pinching' of the plasma membrane to form a vesicle containing contents from outside the cell (i.e. endocytosis).
18. Autoradiography can be used to label substances (e.g. amino acids) and follow their movement through cells or organisms.
19. Chloroplasts are only found in plant cells, and are the site of photosynthesis. Like mitochondria they have a double membrane, their own DNA and ribosomes, and were originally independent of the plant cells.
20. The chlorophyll is membrane bound, and contained on thylakoid membranes. These are arranged into stacks called grana (singular granum), which are joined together by lamellae. The 'filling' of the chloroplasts is called the stroma.
21. Centrioles are small T-shaped organelles and are involved in cell division.
22. Differential centrifugation is used to isolate organelles. The tissue is homogenised in an ice-cold, isotonic buffer, and then is centrifuged at increasing speeds. The lower speeds remove the larger organelles, which sink to the bottom, and the supernatant contains the rest of the cell fragments.
23. Cells become differentiated as an organism grows, so as to suit a specific function. In a plant, new cells are produced at the meristem, and pass through a region of elongation before differentiating into xylem tissue, phloem tissue etc.
24. Diffusion is the movement of molecules from a region of high concentration to a region of low concentration passively. It is affected by:
    a. The concentration gradient.
    b. The temperature.

   c. The distance over which diffusion takes place.
   d. The surface area.

25. Fick's Law says that: $\text{rate of diffusion} = \frac{\text{surface area} \times \text{concentration difference}}{\text{distance between the two areas}}$
26. Facilitated diffusion is still a passive process, but uses either:
   a. Ion channels (i.e. pores with charges along them) that can open and close to allow or prevent the movement of ions.
   b. Carrier proteins allow a specific substance to attach to a receptor site, causing the molecule to change shape and move the substance across the membrane. No energy is required to 'reset' the carrier protein.
27. Active transport is the movement of substances across a cell membrane, against a concentration gradient, requiring energy as ATP from respiration. Carrier proteins are used, but energy is needed to 'reset' them. There are three types:
   a. Uniport carriers – carry a single substance in a single direction.
   b. Symport carriers – carry two substances in the same direction.
   c. Antiport carriers – carry two substances in opposite directions.
28. Osmosis is the movement of water from a region of high water potential to a region of low water potential across a differentially permeable membrane. Solutions can be compared to tissues using the following terms:
   a. Hypertonic – lower water potential (more concentrated).
   b. Isotonic – same water potential (same concentration).
   c. Hypotonic – higher water potential (less concentrated).

Enzymes And Digestion

1. Enzymes are biological catalysts that control all the reactions carried out in the cell. They reduce the activation energy needed for reactions to take place, so that they can occur more easily.
2. The induced fit hypothesis states that the enzyme locks onto the substrate at its active site by slightly changing shape. The substrate then reacts and the products are released.
3. All the reactions within the cell are classified as metabolism:
   a. Anabolic reactions – build up substances.
   b. Catabolic reactions – break down substances.
4. The turnover rate of an enzyme is the number of times it catalyses a reaction in a minute. Carbonic anhydrase is the fastest enzyme known.
5. Enzymes are classified by their function. In digestion there are three main types:
   a. Carbohydrases – break down carbohydrates.
   b. Proteases – break down proteins.
   c. Lipases – break down lipids.
6. Carbohydrases are mostly named after the substrate, e.g. maltase breaks down maltose etc.
7. There are two types of proteases:
   a. Endopeptidases – break down protein chains inside the protein (e.g. pepsin).
   b. Exopeptidases – break amino acids off the ends of the protein (e.g. trypsin).
8. Increasing the temperature by 10°C will double the rate of enzyme activity – i.e. $Q_{10} = 2$. This takes place until the enzyme starts to denature, and the optimum temperature is reached (normally about 37°C in mammals), and then the rate quickly drops off for further temperature increases.
9. Thermostable enzymes don't denature at lower temperatures, but have a higher optimum temperature.
10. All enzymes have an optimum pH, and the rate drops off dramatically for increases or decreases in pH from this point. The optimum pH depends on where they are located. (pepsin = pH 2/3, trypsin = pH 8).
11. For an increase in the concentration of substrate, the rate is proportional to the concentration, until when all the active sites become occupied this levels off to a constant rate.
12. There are two types of inhibitor:
   a. Competitive – compete with the substrate for the active site. They are similar in shape to the substrate. Increasing the substrate concentration will increase the rate of reaction.
   b. Non-competitive – lock onto the active site permanently, or attach to another part of the enzyme (e.g. cyanide) to change the shape of the active site. Increasing the substrate concentration will have no effect.
13. Enzymes also have industrial applications, e.g. in washing powders, making sugars, and in the oil industry (clearing oil spills).

14. Extracellular digestion takes place in saprophytic fungi. In the mycelium, enzymes are secreted from the hyphae. Digestion takes place on the food surface, and the products of digestion are absorbed. Note that fungi are multinuclear (i.e. there are no cell membranes or walls).
15. In the alimentary canal, digestion takes place by both mechanical and chemical breakdown. There are five processes involved in feeding:
    a. Ingestion – taking food in.
    b. Digestion – breaking food down.
    c. Absorption – taking useful substances into the body.
    d. Assimilation – making use of absorbed substances.
    e. Egestion – getting rid of waste (this is not excretion).
16. In the mouth, food is broken down by mechanical breakdown (i.e. with the teeth), and saliva is introduced. This contains amylase to start to break down the starch into maltose, and also mucus to act as a lubricant as it passes down the oesophagus.
17. No digestion takes place in the oesophagus – food is simply transported by peristalsis (contractions of smooth muscle) into the stomach. It enters the stomach through the cardiac sphincter.
18. In the stomach, mechanical breakdown (churning), and protein digestion (with pepsin) take place. Some lipase enzymes are also released. HCl is released to kill bacteria, provide the right conditions for enzymes, and to begin some hydrolysis. Alcohol is absorbed.
19. The contents of the stomach enter the duodenum through the pyloric sphincter:
    a. Bile is released from the gall bladder (produced in the liver as waste from the breakdown of red blood cells). It neutralises the HCl (it contains $NaHCO_3$) and emulsifies fats (with bile salts). There are no enzymes in bile.
    b. Pancreatic juice contains proteases, lipases and Carbohydrases, including trypsin and amylase. It also helps to neutralise the HCl.
    c. Brunner's glands in the submucosa release an alkaline mucus to help neutralise the HCl.
20. In the ileum digestion is completed:
    a. Glands at the base of the villi produce enzyme secretions – lipases, carbohydrases (e.g. maltase) and Exopeptidases (e.g. trypsin) are secreted.
    b. Paneth cells in the walls of the villi produce a secretion to protect against bacterial infection.
    c. Monosaccharides and amino acids are absorbed into the capillary network and taken through the hepatic portal vein to the liver. Excess glucose is stored as glycogen. Some amino acids are used to make plasma proteins. Excess amino acids are deaminated, so that the amino group is converted into urea, and the rest is stored as glycogen.
    d. Fatty acids and glycerol are absorbed into the central lacteal and reform into fat droplets. These re-enter the blood at the junction between the subclavian and jugular veins.
21. In the colon, water is absorbed along with some vitamins and minerals.
22. The wall of the oesophagus has:
    a. Well-developed longitudinal and circular muscles for peristalsis.
    b. Very elastic submucosa, which contains mucus-secreting glands.
23. The wall of the stomach has:
    a. Thick muscles, in three layers, to churn up the contents.
    b. A thick mucosa, with large folds to grind up the contents.
    c. The stomach is a temporary food store.
24. The walls of the duodenum and ileum have:
    a. Two layers of muscle used in peristalsis.
    b. Finger-like projections in the mucosa (villi) to increase the surface area for absorption.
    c. Submucosa contains many blood and lymph vessels (more in the ileum than duodenum).
25. The epithelium in the gut will be several cells thick as they will be continually work away and replaced.

Gaseous Exchange

1. Small organisms have a high surface area to volume ratio, and so can obtain O_2 by simple diffusion across the cell surface.
2. In larger animals, the surface area to volume ratio is too low for this, and so four main organ systems are introduced to replace this – a respiratory surface, a digestive system, a transport system and an excretory system.
3. There are three main respiratory surfaces used:
    a. External gills – folds in the body surface, e.g. tadpole.
    b. Internal gills – folds within the body, e.g. fish.

   c. Lungs – bronchial/alveolar network within the pleural cavity, e.g. most mammals.
4. All respiratory surfaces have the following properties:
   a. Large surface area.
   b. Short diffusion pathway (thin walls).
   c. Well supplied with blood.
   d. They are moist (as a consequence of thin walls).
5. In a dicotyledonous leaf, air enters through the stomata by simple diffusion into the air spaces within the spongy mesophyll. Gaseous exchange takes place into the palisade and spongy mesophyll cells.
6. In bony fish, the mouth is opened and the floor of the buccal cavity drops. Water rushes in due to the drop in pressure. As the mouth is closed, the floor of the buccal cavity is raised, forcing water over the gills and out through the operculum.
7. The gills consist of filaments protruding from the gill arches in a stack. The gill filaments have a series of lamellae on the top side of them, through which blood flows. This uses a countercurrent system whereby water and blood flow in opposite directions so that all the available oxygen is removed from the water.
8. In humans, ventilation takes place as follows:
   a. External intercostal muscles and diaphragm contract.
   b. Larger volume and lower pressure is created, forcing air into the lungs (inspiration).
   c. Internal intercostal muscles contract and diaphragm relaxes.
   d. Smaller volume and higher pressure is created, forcing air out of the lungs (expiration).
9. A large network of capillaries lie close to the alveoli, and the alveoli create a large surface area for gaseous exchange. A lipoprotein surrounds the alveolus wall, in the fluid, which acts as a surfactant to reduce surface tension and stop the alveolus from collapsing.
10. The partial pressure of O_2 is the pressure acting on the alveoli due to O_2 (i.e. about 20% of atmospheric pressure). O_2 goes from a high PP to a low PP into the blood, and CO_2 goes from a high PP to a low PP out of the blood.
11. Lung capacities:
    a. The tidal volume is the normal inspiratory/expiratory volume at rest.
    b. The inspiratory reserve is the extra volume you can breathe in.
    c. The expiratory reserve is the extra volume you can breathe out.
    d. The residual volume is the minimum volume in the lungs (that you can't breathe out).
    e. The vital capacity is the maximum inspiratory/expiratory volume.
    f. Ventilation rate = tidal volume $\times$ number of breaths per minute.