OCR (A) Biology GCSE

Topic 1: Cell Level Systems

Notes

(Content in bold is for higher tier only)

Cell structures

Microscopes (1.1a and c)

Light (optical) microscopes

The specimen is placed onto a slide, which is a thin piece of glass. Sometimes if the specimen is colourless then a stain is needed to identify the organelles. Another small piece of glass called a cover slip is placed on top to protect the lens. It is mounted onto the stage of the microscope and the lamp at the bottom of the microscope shines constant light on the slide so that the specimen can be viewed. The objective lens is found closest to the specimen and magnifies the image, which is then further magnified by the eyepiece lens.

Definitions:

- Magnification = the degree to which the size of an image is larger than the real object
    - Magnification of an object = image size/object size
    - Magnification of microscope = magnification of the eyepiece lens x magnification of the objective lens
- Resolution = the ability to distinguish between to 2 points that are close to each other

When working with calculations in microscopy, it is common to come across very large or small numbers. Standard form can be useful when working with these numbers. To be able to compare the size of numbers while using standard form, the 'number' which being multiplied by a power of 10 needs to be between 1 and 10.

Examples:

- **$1.5 \times 10^{-5} = 0.000015$**
- **$3.4 \times 10^{3} = 3400$**

Advantages of light microscopes:

- Relatively cheap
- Can be used in the field
- Does not require specialist training
- Can look at living specimens

Disadvantages of light microscopes:

- Low resolution (200nm) as limited by the wavelength of visible light
- Low magnification strength (x1500)
- Staining is required for some organelles to present

Electron microscope

The electron microscope uses electrons, instead of light, to form images. Electrons have a much smaller wavelength than that of light waves and so allows scientists to view smaller subcellular structures, such as mitochondria and ribosomes. There are 2 types:

- SEM = Scanning Electron Microscope
    - Creates 3D images at a lower resolution
    - 10nm resolution and x100,000 magnification

- TEM = Transmission Electron Microscope
    - Creates 2D images detailing organelles at a much higher resolution
    - 0.2nm resolution and x500,000 magnification

Advantages:
- Can see very small organelles
- Can produce 3D images (SEM)

Disadvantages:
- Samples need to be placed in a special vacuum so cannot look at living specimens
- Extremely expensive
- Very large so cannot be moved easily
- Requires specialist training and skill

Subcellular structures (1.1b)

In animal and plant cells...

Structure	Function
Nucleus	• Contains the genetic material, which codes for a particular protein • Enclosed in a nuclear membrane.
Cytoplasm	• Liquid substance in which chemical reactions occur. • Contains enzymes (biological catalysts, i.e. proteins that speed up the rate of reaction). • Organelles are found in it
Cell membrane	• Contain receptor molecules to identify and selectively control what enters and leaves the cell
Mitochondria	• Where aerobic respiration reactions occur, providing energy for the cell
Ribosomes	• Where protein synthesis occurs. • Found on a structure called the rough endoplasmic reticulum.

Only in plant cells…

Structure	Function
Chloroplasts	• Where photosynthesis takes place, providing food for the plant • Contains chlorophyll pigment (which makes it green) which harvests the light needed for photosynthesis.
Permanent vacuole	• Contains cell sap • Found within the cytoplasm • Improves cell's rigidity

Cell wall (also present in algal cells)	• Made from cellulose • Provides strength to the cell

In prokaryotic cells (e.g. bacteria)...

Structure	Function
Cytoplasm	Above
Cell membrane	Above
Cell wall	Made of a different compound (peptidogylcan)
Single circular strand of DNA	As they have no nucleus, this floats in the cytoplasm
Plasmids	Small rings of DNA

What happens in cells and (what do cells need)?

DNA (1.2a-c)

- DNA stands for deoxyribonucleic acid
- It is a double helix made from 2 strands that have twisted around each other.
- It is a polymer, meaning that it is made of many different molecules that join up to make a long strand: in the case of DNA these molecules are called nucleotides.
- Each nucleotide is made from one sugar molecule, one phosphate group (which forms the backbone) and one of the four different organic bases
  - The 4 bases are A, C, G, T.
  - These nucleotides pair by complementary base pairing, meaning that only certain bases can join together: C joins to G and A joins to T
- Each group of three bases codes for an amino acid and these then join together to make a protein
- Chromosomes are structures made up of long molecules of DNA.

Protein synthesis (1.2d and e)

Biology only

DNA is too large to leave the nucleus in order to make the proteins and therefore a series of steps must be taken to copy and transport the genetic information.

Steps of protein synthesis:

1) **DNA helix is untwisted and unzipped**
2) **mRNA nucleotides (messenger RNA: a different type of nucleotide) match to their complementary base on the strand.**
3) **The mRNA nucleotides themselves are then joined together, creating a new strand called a template strand of the original DNA. This process is called transcription.**
4) **The template strand of mRNA then moves out of the nucleus to the cytoplasm and onto structures called ribosomes.**
5) **At the ribosomes, the bases on the mRNA are read in threes to code for an amino acid (the first three bases code for one amino acid, the second three bases code for another etc). This is called translation.**
6) **The corresponding amino acids are brought to the ribosomes by carrier molecules.**
7) **These amino acids connect together to form a protein. It is therefore the triplet code of bases that determines which protein is produced and therefore expressed.**
8) **When the chain is complete the protein folds to form a unique 3D structure.**

Enzymes (1.2f and g)

What are enzymes?

Enzymes are biological catalysts (a substance that increases the rate of reaction without being used up). They are protein molecules and the shape of the enzyme is vital to its function. This is because each enzyme has its own uniquely shaped active site where the substrate binds.

A simplified way to look at how they work is the Lock and Key Hypothesis:

- The shape of the substrate is complementary to the shape of the active site (enzyme specificity), so when they bond it forms an enzyme-substrate complex.
- Once bound, the reaction takes place and the products are released from the surface of the enzyme

Factors affecting the rate of enzyme controlled reactions:

Rate = change in concentration/time

Temperature

- The optimum is around 37 degrees celsius (body temperature)
- The rate of reaction increases with an increase in temperature up to this optimum, but above this temperature it rapidly decreases and eventually the reaction stops.
- When the temperature becomes too hot, the bonds in the structure will break
- This changes the shape of the active site, so the substrate can no longer fit in
- The enzyme is said to be denatured and can no longer work

pH

- The optimum pH for most enzymes is 7, but some that are produced in acidic conditions, such as the stomach, have a lower optimum pH
- If the pH is too high or too low, the forces that hold the amino acid chains that make up the protein will be affected

- This will change the shape of the active site, so the substrate can no longer fit in
- The enzyme is said to be denatured and can no longer work

Substrate concentration:
- A higher concentration generally means an increased rate of reaction as the enzymes are more likely to bump into and therefore react with the substrate
- However, after a while increasing the substrate concentration has no effect as the active sites of all of the enzymes present are full

Enzyme concentration:
- This is the same as substrate concentration - initially it increases the rate of reaction but after a while the reaction stops.
- This is because there are not enough substrate molecules to react with all of the enzymes.

Respiration (1.3a-c)

Respiration occurs in every cell in the body of all living things to supply ATP to cells. Cellular respiration is an exothermic reaction.
There are 2 types of respiration: aerobic and anaerobic.

Aerobic respiration	Anaerobic respiration
This uses oxygen. It yields the most energy. Most of the reactions that make up aerobic respiration occur in the mitochondria. $C_6 H_{12}O_6 + O_2$ ---> $CO_2 + H_2O$ $C_6 H_{12}O_6$ = glucose O_2 = oxygen CO_2 = carbon dioide H_2O = water	Occurs when there is not enough oxygen. It does not yield as much energy as aerobic respiration. It is only used as a last resort, for example during a sprint where it is difficult to breathe in enough oxygen. The oxidation of glucose is complete. In animals: Glucose ($C_6 H_{12}O_6$) ---> Lactic acid In plant and yeast cells it is called fermentation): Glucose ($C_6 H_{12}O_6$) ---> Ethanol + Carbon dioxide (CO_2) This reaction is used to make bread and alcoholic drinks.

Breakdown and synthesis of substances (1.3d-f)

<u>Carbohydrates</u>

Carbohydrates, such as as starch, are polymers made from simple sugars (monomers)
Example of breakdown
- Broken down by carbohydrase enzymes, such as amylase

- Starch → maltose by amylase enzyme
- Maltose is an example of a simple sugar that can go into the blood to provide energy

Example of synthesis

- Glucose → glycogen by glycogen synthase enzyme
- Glycogen is an energy store

Proteins

Proteins are polymers made of amino acids (monomers)
Proteins are broken down by protease enzymes in the stomach and small intestine.
Amino acids can be built up into proteins by protein synthesis.

Lipids

Lipids are broken down by lipase enzymes
Lipids → glycerol and 3 fatty acids
Bile made in the liver emulsifies fat (makes large fat molecules into small droplets) that make it easier for lipase enzymes to work on lipids.

Photosynthesis

Photosynthetic Reaction (1.4a-c)

Photosynthesis is the process of making glucose from sunlight in the leaves of the plant. It is an endothermic reaction in which energy is transferred from the environment to the chloroplasts by light.

The equation for photosynthesis is:

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{light}} \text{glucose} + \text{oxygen}$$

Carbon dioxide = CO_2, Water = H_2O, Oxygen = O_2 Glucose = $C_6H_{12}O_6$

Investigating photosynthesis (1.4d)

Calculating rate of photosynthesis

By carrying out an experiment measuring the oxygen production of a plant, you can calculate the rate of photosynthesis.

- Pondweed is placed in a test tube full with water. The top is sealed with a bung. A capillary tube also containing water leads into the test tube, and it is attached to a syringe.
- A lamp is placed at a measured distance from the test tube.
- As it photosynthesises, oxygen is produced, forming a gas tube in the capillary tube
- The distance the bubble has moved is measured using a ruler to calculate the volume of oxygen produced.
- Many variables can be changed to observe their effect on photosynthesis: the temperature (using a water bath), time the pondweed is left, the light intensity (varied by the distance the lamp is from the plant).

- It is important to control all factors that may affect photosynthesis except your independent variable (the one you want to observe), so it is a valid experiment.

Factors affecting photosynthesis (1.4e-f)

Temperature

With an increase in temperature, the rate of photosynthesis increases.
However, as the reaction is controlled by enzymes, this trend only continues up to a certain temperature until the enzymes begin to denature and the rate of reaction decreases.

Light intensity

For most plants, the higher the light intensity, the rate of photosynthesis increases.

Experiment proving photosynthesis requires light

1) Cover half of a small leaf with foil
2) Place the plant on a windowsill for 48 hours so that light can reach it
3) Put the leaf into boiling water to kill and preserve it.
4) Put the leaf in a boiling tube containing hot ethanol for 10 minutes (this removes the chlorophyll pigment).
5) Dip the leaf in boiling water to soften it.
6) Put leaf in a Petri dish and cover with iodine solution.
7) The covered half of the leaf will remain brown, whereas the exposed half will change to blue/black (as iodine solution changes colour in the presence of starch, as photosynthesis turned the glucose into starch for storage)

Inverse proportion describes a relationship between two factors which involves one increasing whilst one decreasing. As the distance between the light source and the plant increases, the light intensity decreases. The light intensity is inversely proportional to the square of the distance- called the inverse square law.

Light intensity $\propto$ 1/distance^2

This means that if a lamp is 2 metres away from a plant, then then light intensity of the lamp is a ¼ of its original value.

$1/2^2 = 1/4$

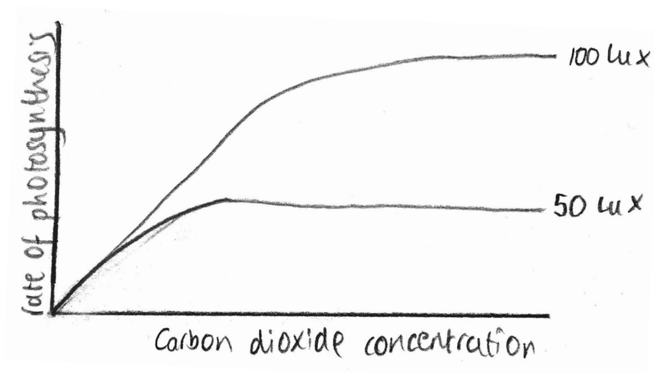
Carbon dioxide concentration

Carbon dioxide is also needed to make glucose (see equation). As the concentration of carbon dioxide increases, the rate of reaction increases.

Any of the factors above may become a limiting factor. This is an environmental condition (such as light intensity) which, in low levels, restricts any increase in the rate of photosynthesis. Despite increases in other factors (such as temperature or carbon dioxide concentration), the rate of photosynthesis will not increase any more. This can be seen on a graph as the curve levelling off.

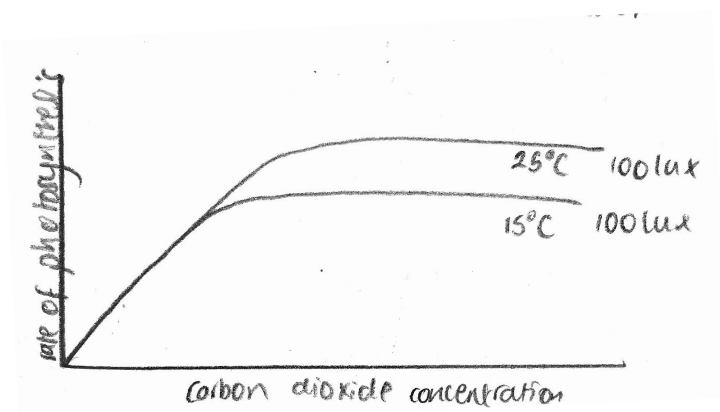
- A graph involves one limiting factor if it has one line which levels off, with the factor on the horizontal axis and rate of photosynthesis on the vertical axis.

- A graph with two lines represents two limiting factors in two experiments. The investigation involves increasing the factor on the horizontal axis, and is carried out at two different other environmental conditions, such as two different temperatures.



Light intensity is measured in lux and in this graph we can see that the limiting factor is light intensity. This is because the 50 lux levels limits the rate of photosynthesis compared to the 100 lux experiment, showing that at 50 lux light intensity was the limiting factor - it had the potential to increase the rate of photosynthesis further if it were increased.

- A graph involves three limiting factors is similar to the one above, but another factor is stated on each line, which is the same in each



The limiting factor is temperature as light intensity is the same in each and carbon dioxide is increasing.

Farmers can use the knowledge of limiting factors to enhance the conditions in the greenhouse for a greater rate of photosynthesis. This will increase growth leading to increased profits.