OCR (B) Biology GCSE

Topic B4: Using food and controlling growth

Notes

(Paragraphs in **bold** are higher tier only)

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What happens during cellular respiration?

Respiration is a process which takes place in almost all cells to **produce energy from nutrient molecules**. It involves a series of **exothermic** chemical reactions occurring in the **mitochondria and cytoplasm** of cells, which converts **glucose into ATP**. When consumers gain **biomass** from other organisms, some of this is converted into **glucose** molecules, which acts as fuel for respiration. ATP is a small molecule which can **instantly release a small, manageable amount of energy** in a **single reaction**. This energy can be used in a variety of processes including muscle contraction, nerve impulses, the breakdown and synthesis of biological molecules, homeostasis and growth. As these processes happen continuously, **respiration must also happen continuously** to provide energy.

Respiration usually occurs with the presence of oxygen (**aerobic respiration**), although it can occur in the absence of oxygen (**anaerobic respiration**). Anaerobic respiration is **less efficient** (only produces **~2 ATP** molecules compared to **~38** in aerobic respiration) and leads to **fatigue** in humans. Both types of respiration are **catalysed by enzymes**. This means that the **rate of respiration** can be influenced by factors such as **temperature and pH**.

In **eukaryotic** cells, respiration begins in the **cytoplasm**, but the majority of the reactions are carried out in the **mitochondria**. In **prokaryotes**, respiration occurs **entirely in the cytoplasm** as they **do not contain mitochondria**.

Aerobic Respiration

Aerobic respiration occurs in the presence of **oxygen**. **Glucose** is broken down and the products are **combined with oxygen** to produce **carbon dioxide** (waste) and **water**, as well as energy in the form of **ATP**. This occurs in the cell **mitochondria**. Cells which require lots of energy, such as muscle cells, therefore have high amounts of mitochondria. Mitochondria are adapted to carry out respiration efficiently by having a **large surface area**, containing **enzymes** for respiration, and having lots of **proteins** in the membrane which help molecules to move into and out of the organelle.

Equations for aerobic respiration:

- glucose + oxygen → carbon dioxide + water
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Anaerobic respiration:

Anaerobic respiration occurs when **oxygen is not present**. It is **less efficient** than aerobic respiration and **produces less energy** per glucose molecule. It occurs in the cell **cytoplasm** and thus **does not require mitochondria**.

Animal cells undergo anaerobic respiration during **vigorous exercise** as not enough oxygen is delivered to muscles. In this reaction, glucose is **partially** broken down to produce **lactic acid and ATP**. This lactic acid builds up in muscles and causes muscle fatigue. Anaerobic respiration also produces an '**oxygen debt**'. To repay this, the lactic acid must be transported to the **liver** where it is broken down into carbon dioxide and water **using oxygen.** This is the reason why the **breathing and heart rates remain high** after exercise.

Microorganisms, such as **yeast**, also undergo anaerobic respiration. Yeast breaks down anaerobically to form **alcohol and carbon dioxide** instead of lactic acid.

Equations for anaerobic respiration in yeast:

- glucose → alcohol + carbon dioxide
- $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Equation for anaerobic respiration in animal cells:

- glucose → lactic acid

How do we know about mitochondria and other cell structures?

Electron microscopy

Electron microscopy uses a **beam of electrons, focused using magnets,** to view small structures such as cell organelles. As electrons cannot be seen, the image is projected onto a screen or photographic paper. Electron microscopes have a much **higher resolution and magnification** than light microscopes, due to the wavelength of an electron being much shorter than the wavelength of photons of light.

As cell organelles, such as chloroplasts and mitochondria, can now be viewed in detail due to the development of the electron microscope, more accurate explanations about the **function** of these organelles and their **roles in cellular processes** have been developed.

Light microscopes vs electron microscopes

Light Microscope Advantages	Electron Microscope Advantages
• Cheaper and portable • Living samples can be viewed • Training less extensive • Light beams not deflected by air	• Resolution is 0.2nm (x1000 more than LM) • Detailed images of organelles can be seen • High magnification (x500 000) • 3D images
Light Microscope Disadvantages	**Electron Microscope Disadvantages**
• 2D images • Low resolution (~200nm) • Low magnification (x1500) • Detailed images of organelles cannot be seen	• Electron beams are deflected by air molecules • Samples must be placed in a vacuum • Very expensive • Preparing samples and using an EM both require skill and training • Only dead specimens can be viewed

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How do organisms grow and develop?

The cell growth cycle and mitosis

Within multicellular organisms, not all cells retain the ability to divide. Eukaryotic cells which do retain the ability to divide show a **cell cycle**. This is split into two main stages: **interphase and mitosis**. The cell spends most of the time in interphase, in which **DNA is replicated**, and the cell **grows** in preparation for the next mitosis stage, increasing the number of **organelles**. Mitosis is the part of the cell cycle in which a eukaryotic cell **divides to produce two daughter cells**, each with **identical copies of DNA**.

Cells usually only replicate when growth is required or after an injury to **repair damaged cells**. **Cancer** is a result of **uncontrolled growth and division** of cells, which happens due to a **mutation** in the cell's DNA. Uncontrolled cell division leads to many unwanted new cells, which is called a **tumour**.

Meiosis

Meiosis is another type of cell division which creates **four, genetically unique daughter cells**. Meiosis is used to produce **gametes** (reproductive cells).

During interphase, the **chromosome number doubles**. After this, meiosis occurs, involving two cell divisions so that the four gametes each contain **half** of the chromosomes found in body cells. During **fertilisation**, two gametes fuse to create a **zygote** with a full set of chromosomes. This zygote then divides via mitosis to form an **embryo**. As each gamete produced is genetically unique, each of the offspring will also be unique. This is beneficial for a species as it produces **genetic variation**.

Stem cells

Stem cells are cells which **retain the ability to differentiate** into almost any type of cell. They can be found in embryos and bone marrow in humans, and at the root and shoot tips of plants in areas called **meristems**. Embryo stem cells are able to differentiate into **any type of cell**, however adult stem cells can **only differentiate into similar cell types**, thus are more restricted in their use.

Stem cells are **unspecialised** and divide by mitosis to produce daughter cells which then specialise to have a variety of functions. Cells become specialised by **altering which genes are switched on and off** in the cell's DNA. This means that each cell will carry out particular functions and not others. Cell differentiation is important in order to produce cells that are as **efficient** as possible at carrying out their specific function. **Cells, once specialised, cannot produce unspecialised cells**. For example, a cell which makes up the heart tissue cannot divide to make a skin cell, as the cell produced will already be specialised to carry out the functions of a heart cell.

Should we use stem cells to treat damage and disease?

Stem cells can be used to treat a range of diseases and repair damaged tissues. Although stem cell therapy is relatively new, treatment using these cells could reduce risks and costs associated with other treatments. However, this treatment also comes with new risks, which must be weighed against potential benefits:

Benefits	Risks
• Can be used to treat a large variety of different diseases. • Stem cells are not rejected, unlike donor organs. • Generally, stem cell treatments have lower risks than other treatments. • Stem cells do not have to be matched to the patient, unlike organ donations which must be matched for skin type, blood type and size.	• Risk of contamination or mutation of the stem cells whilst being grown in the laboratory, which could be passed onto a patient. • Stem cell therapy is relatively new, meaning that long term risks are unknown and there is no guarantee that the treatment will work. • Stem cell treatments can have side effects, such as rashes, infections and bleeding. These side effects can be mild to severe.

There are also ethical issues with using stem cells. This is mainly because the most useful stem cells must be harvested from embryos, which are destroyed in the process. This is contentious as there is the question of at which point the embryo should be considered a person. Harvesting the cells is also difficult as they must be taken before birth, although unused embryos from IVF treatments can be used.

Different countries have different regulations about if and how stem cells can be harvested, stored and used in treatments. For example, in the UK, stem cells must be harvested before the embryo is 14 days old, which is when the nervous system begins to develop. Before this point, the embryo may not develop at all and thus is not considered an individual.

How is plant growth controlled? (biology only)

Plants are able to respond to their environment due to plant hormones, which facilitate plant growth and development and increase their chances of survival. Hormones also allow tropisms, which are growth movements of a part of a plant in a specific direction. If the plant moves towards a stimulus, it is referred to as a positive tropism, whereas if the plant moves away from it, it is a negative response. The main plant tropisms are phototropism and gravitropism:

- Phototropism is a response to light. Plant shoots are positively phototropic, meaning that they will bend towards a light source.
- Gravitropism (sometimes known as geotropism) is a response to gravity. Plant roots are positively gravitropic as they will grow downwards.

These tropisms are carried out by **auxins,** which are a type of plant hormone. Auxins are produced in the plant **shoot and root tips** and are transported through the plant via **diffusion and active transport**, or via the **phloem** for longer distances. Auxins control these responses by **stimulating cells to elongate**. For example, to make the plant shoot bend towards a light source, auxins move to the shady side of the plant and cause the cells there to elongate, which forces the shoot to bend towards the light.

Gibberellins

Gibberellins are another type of plant hormone. They react as a response to water:

- **Gibberellins are present in seeds. When water is present, they cause the seed to germinate, hence breaking seed dormancy. Dormant seeds are metabolically inactive; when water is absorbed into the cell, gibberellin causes a chain reaction to occur to begin respiration and hence produce energy for growth.**
- **In adult plants, they cause bolting. This is a response to a lack of water or cold temperatures and involves the plant flowering and producing seeds in an attempt to reproduce before death.**

Plant hormones in agriculture

Plant hormones can be used in farming to increase the yield or growth efficiency of a crop:

- **Ethene, a hormone which controls fruit ripening, can be used to slow the ripening of fruit (e.g. for transport or storage) or speed it up.**
- **Plant hormones can be used in selective weedkillers by making certain plants grow too quickly. This reduces competition for the desired plant and increases the crop yield.**
- **Gibberellins can be used to produce flowers to sell. They also impact the rate of fruit growth and can be used to increase the size of fruit.**
- **Auxins can be used in rooting powders to promote quick root growth in plant cuttings.**

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