Edexcel Biology GCSE

Topic 2: Cells and Control

Notes

(Content in bold is for higher tier only)

Contents

2.1, 2.2, 2.3 - Mitosis and its Importance

Chromosomes

The nucleus contains your genetic information.

- This is found in the form of **chromosomes**, which contain coils of **DNA**.
- A **gene** is a short section of DNA that codes for a protein and as a result controls a characteristic- therefore each chromosome carries many genes.
- There are **23 pairs** of chromosomes in each cell of the body, as you inherit one from your mother and one from your father - resulting in **46 chromosomes in total** in each cell.
- Sex cells (gametes) are the exception: there are half the number of chromosomes, resulting in **23 chromosomes in total** in each gamete cell.
- A **diploid** number of chromosomes is the amount found in body cells (46 in humans)
- A **haploid** number of chromosomes is half this amount (23 in humans), and is found in gametes (sperm and egg cells), which combine to form the diploid amount.

Mitosis and the Cell Cycle

The cell cycle is a series of steps that the cell has to undergo in order to divide. **Mitosis** is a step in this cycle- the stage when the cell divides.

Stage 1 (Interphase): In this stage the cell grows, organelles (such as ribosome and mitochondria) grow and increase in number, the synthesis of proteins occurs, DNA is replicated (forming the characteristic 'X' shape) and energy stores are increased

Stage 2 (Mitosis): The chromosomes line up at the **equator** of the cell and **cell fibres** pull each chromosome of the 'X' to either side of the cell.

Stage 3 (Cytokinesis): Two identical **daughter cells** form when the cytoplasm and cell membranes divide

Cell division by mitosis in multicellular organisms is important in their **growth** and **development**, and when **replacing damaged cells**. Mitosis is also a vital part of **asexual reproduction**, as this type of reproduction only involves one organism, so to produce offspring it simply replicates its own cells.

Mitosis produces **2 daughter cells,** each with identical sets of chromosomes to the parent cell.
Because the sets of chromosomes in the daughter cell's nucleus are the same as in the parent cell's nucleus, mitosis produces **2 genetically identical diploid daughter cells.**

2.4, 2.5 and 2.6 - Growth, Differentiation and Cancer

In animals, growth occurs via **cell division and differentiation.** Cell division occurs by mitosis as described above, after which cells can **differentiate** to specialised forms, specially adapted to their function. For example, cells of the muscular system can bring about movement, and cells of the circulatory system are specialised to transport substances.

In animals, almost all cells differentiate at an early stage and then lose this ability. Most specialised cells can make more of the same cell by undergoing mitosis (the process that involves a cell dividing to produce 2 identical cells). Others such as red blood cells (which lose their nucleus) cannot divide and are replaced by adult stem cells (which retain their ability to undergo differentiation).

In mature animals, cell division mostly only happens to repair or replace damaged cells, as they undergo little growth.

In plants, growth occurs by cell division and differentiation, but also by a unique process called **elongation.** Plant cells can grow longer in a specific direction by absorbing water into their vacuoles, and this is controlled by substances called **auxins.** (See Topic 1.6.15 for more information)

In plants, many types of cells retain the ability to differentiate throughout life. They only differentiate when they reach their final position in the plant, but they can still re-differentiate when it is moved to another position.

Cancer occurs as a result of small changes in cells, that lead to **uncontrolled cell division**. The group of cells that results from this uncontrolled division is called a **tumour**.

2.7 - Monitoring Growth using Percentiles

It is often important to measure the growth of an organism - whether for a farmer to check on the progress of their crops, or for doctors to check whether a child is growing at a normal rate. To do so we use **percentiles charts,** which can tell us the rate at which an organism of interest is growing.

The growth of babies can be measured using **mass, length** or **head circumference.**

A baby born at the **50th percentile** for mass is heavier than **50% of babies.**
A baby born at the **25th percentile** for mass is heavier than **75% of babies.**
A baby born at the **75th percentile** for mass is heavier than **25% of babies.**

Another way to think about this is that for every 100 babies born, a baby in the 75th percentile will be heavier than 25 of them.
Being in a high percentile (e.g 90th percentile or higher) can indicate a health problem.

2.8 and 2.9 Stem Cells in Embryos, Animals and Plants and Benefits/Risks of their Use in Medicine

A stem cell is an undifferentiated cell which can undergo division to produce many more similar cells, of which some will differentiate to have different functions.

Types of stem cells

1. Embryonic stem cells
    - Form when an egg and sperm cell fuse to form a **zygote**
    - They can differentiate into any type of cell in the body
    - Scientists can clone these cells (though culturing them) and direct them to differentiate into almost any cell in the body
    - These could potentially be used to replace insulin-producing cells in those suffering from diabetes, new neural cells for diseases such as Alzheimer's, or nerve cells for those paralysed with spinal cord injuries
2. Adult stem cells
    - If found in **bone marrow** they can form many types of cells including blood cells
3. Meristems in plants
    - Found in root and shoot tips
    - They can differentiate into any type of plant, and have this ability throughout the life of the plant
    - They can be used to make **clones** of the plant- this may be necessary if the parent plant has certain desirable features (such as disease resistance), for research or to save a rare plant from extinction

Therapeutic cloning involves an embryo being produced with the same genes as the patient.

- The embryo produced could then be harvested to obtain the embryonic stem cells.
- These could be grown into any cells the patient needed, such as new tissues or organs.
- The advantage is that they would not be rejected as they would have the exact same genetic make-up as the individual.

Benefits vs. problems of research with stem cells

Benefits	Problems
Can be used to replace damaged or diseased body parts.	We do not completely understand the process of differentiation, so it is hard to control stem cells to form the cells we desire.
Unwanted embryos from fertility clinics could be used as they would otherwise be discarded.	Removal of stem cells results in destruction of the embryo.
Research into the process of differentiation.	People may have religious or ethical objections as it is seen as interference with the natural process of reproduction.
	If the growing stem cells are contaminated with a virus, an infection can be transferred to the individual.
	Money and time could be better spent on other areas of medicine.

2.10B Structure and Function of the Brain

The brain, along with the spinal cord, makes up our Central Nervous System, or CNS. The CNS is responsible for controlling consciousness, movements thoughts and emotions, among other things.

The brain is made up of several important structures, each contributing their own function.

Cerebral hemispheres: The most recognisable part of the brain, the two large cerebral hemispheres take up most of the skull and sit on the left and right-hand sides. Together, these two parts are known as the **cerebrum** (not to be confused with cerebellum!) and perform a huge variety of functions, including **consciousness, memory, intelligence** as well as **visual and sensory processing**.

Cerebellum: The cerebellum is a large 'lump-like' structure found at the bottom of the brain, on the rear side.
It is responsible for controlling fine movements of muscles, so we can move in complex ways. For example, when you catch a ball, your cerebellum **(responsible for your co-ordination**) will be highly active.

Medulla oblongata: The medulla oblongata, as the name suggests, is a small 'elongated' structure, and is found in the **brainstem,** at the base of the brain. It is responsible for maintaining basic **autonomic** ('automatic) bodily functions, such as **breathing**, **digestion, swallowing** and **sneezing.**

2.11B and 2.12B - CT and PET Scanning, Treating Brain Injury (Higher)

Doctors often need to look inside the brain to examine brain tissue for injury and disease. Usually, they are not able to cut the skull open and physically examine the brain as this is highly invasive - and often does not provide any clues about brain function.

In this case, we can use CT (Computerised Tomography) and PET (Positron Emission Tomography) scans to look inside the brain much more easily.

CT scans fire X-Ray radiation at the brain from several different angles to generate a 3D image of the brain. This is useful for examining bleeding within the skull, and damage to brain structures. This is usually not recommended for pregnant women and children, as it exposes the patient to higher doses of radiation than a normal X-ray.

For PET scans, a radioactive 'tracer' is injected into the blood before the scan. The scan itself is sensitive to the tracer, so areas where the tracer builds up (which will also be areas with greater blood flow) will be highlighted more brightly on the resulting scan. This is useful for identifying cancerous tumours, as these use more blood than normal tissue.

Investigating brain function and treating brain damage and disease is difficult because:

- **It is complex and delicate**
- **It is easily damaged**
- **Drugs given to treat diseases cannot always reach the brain because of the membranes that surround it**
- **It is not fully understood which part of the brain does what.**

Cancerous tumours can form in the brain as in any other part of the body (recall that changes in cells leading to uncontrolled cell division is what results in a cancerous tumour).

These tumours can push against other structures and blood vessels in the brain, restricting their function. Often, tumours can be buried deep in the brain or spinal cord, making them especially difficult to remove.

2.13 and 2.14 - Structure and Function of the Nervous System and The Reflex Arc

The nervous system allows us to react to our surroundings, and coordinate actions in response to stimuli.

1. Receptor cells convert a stimulus into an electrical impulse.
2. This electrical impulse travels along cells called **sensory neurons** to the central nervous system (CNS).
3. Here, the information is processed and the appropriate response is coordinated, resulting in an electrical impulse being sent along **motor neurones** to effectors.
4. The effectors carry out the **response** (this may be muscles contracting or glands secreting hormones).

Automatic responses which take place before you have time to think are called **reflexes**. They are important as they prevent the individual from getting hurt. This because the information travels down a pathway called a **reflex arc**, allowing vital responses to take place quickly. This pathway is different from the usual response to stimuli because the impulse does not pass through the conscious areas of your brain.

1. A stimulus is detected by receptors.
2. Impulses are sent along a sensory neuron.
3. In the CNS the impulse passes to a **relay neuron**.
4. Impulses are sent along a motor neuron.
5. The impulse reaches an effector resulting in the appropriate response.
6.

Examples of reflex arcs are: pupils getting smaller to avoid damage from bright lights, moving your hand from a hot surface to prevent damage.

Synapses are the gaps between two neurons.

- When the impulse reaches the end of the first neuron, a chemical called a **neurotransmitter** is released into the synapse.
- This neurotransmitter diffuses across the synapse.
- When the neurotransmitter reaches the second neuron, it triggers the impulse to begin again in the next neuron. Different neurotransmitters have different effects on the frequency and speed of the impulse in the second neuron.

Some nerves are **myelinated,** i.e they are surrounded by a **myelin sheath.** The advantage of having nerves surrounded by myelin is that it allows the nerve transmission (or **action potential**) to travel faster. Myelin is produced by cells called **Schwann cells.**

2.15, 2.16 and 2.17 - Structure and Function of the Eye and Defects of the Eye and their Treatment

The eye is a sense organ containing receptors sensitive to light intensity and colour. It has many different structures within it. They are adapted to allow the eye to change its shape in order to focus on near or distant objects (a process called **accommodation**), and to dim light.

1. **Retina**: Layer of light sensitive cells found at the back of the eye.
   When light hits this, the cells are stimulated. Impulses are sent to the brain, which interprets the information to create an image.
   The retina contains **rod cells** and **cone cells,** each of which convert light to nerve impulses destined for the brain. Rod cells are more sensitive to light so they are better for seeing in **low light**, whereas cone cells allow **colour vision**.
2. **Cornea**: The see-through layer at the front of the eye.
   It allows light through and the curved surface bends and focuses light onto the retina.
3. **Iris**: Muscles that surround the pupil.
   They contract or relax to alter the size of the pupil.
   In bright light, the circular muscles contract and radial muscles relax to make the pupil smaller- avoiding damage to the retina.
   In dim light, the circular muscles relax and the radial muscles contract to make the pupil larger- so more light can enter to create a better image.
4. **Ciliary muscles** and **suspensory ligaments**: Hold the lens in place.
   They control its shape and allow us to focus on objects nearer or further away.
5. **Lens:** Transparent, curved surface on the front of the eye.
   The lens, like the cornea, reflects light onto the retina.

The process of **accommodation**:

To focus on a near object:

- The ciliary muscles contract
- The suspensory ligaments loosen
- The lens is then thicker and more curved- this refracts the light more

To focus on a distant object

- The ciliary muscles relax
- The suspensory ligaments tighten
- The lens then becomes thinner - light is refracted less.

Some eye defects occur when light cannot focus on the retina.

1. Short sightedness is called **myopia**.
   - The lens is too curved, so distant objects appear blurry.
2. Long sightedness is called **hyperopia**.
   - The lens is too flat, so it cannot refract light enough.

Other eye defects include **cataracts** and **colour blindness:**

Cataracts means clouding of the lens of the eye. This can often occur congenitally (from birth) but can also develop over time. It restricts vision and can be treated by replacing the lens of the eye in surgery.

Colour blindness is the inability to see certain colours. Full colour blindness is rare, whereas specific colour blindness (e.g red-green) is very common. This usually occurs because people with the condition do not have enough **cone cells** in their retina. This is usually genetic.

There are a number of treatment methods:

- They can be treated with **spectacle lenses** - concave lenses to spread out the light to treat myopia and convex lenses to bring the rays together to treat hyperopia
- **Contact lenses** - work in the same way as glasses but allow activities such as sport to be carried out, hard or soft contact lenses last for different lengths of time
- **Laser eye surgery** - lasers can be used to either reduce the thickness of the cornea (so it refracts light less) to treat myopia or change its curvature (so it refracts light more strongly) to treat hyperopia
- **Replacement lens** - Hyperopia can be treated by replacing the lens with an artificial one made of clear plastic (or adding the plastic on top of the natural lens). The risks include damage to retina or cataracts developing.