

Topic 2 – Cells

Key words

Magnification – How much larger an object appears.

Resolution – The shortest distance between two points that a user can still see as separate points under the microscope.

Antigens – A protein on the surface of cell that initiates an immune response.

Antibody – A protein produced in response to a specific antigen.

Cytokinesis – When cytoplasm divides into 2 daughter cells.

- 1) **Eukaryotic** cells have **membrane-bound organelles** and genetic material within a nucleus.
- 2) **Prokaryotic** cells have **no membrane-bound** organelles.
- 3) The cell surface membrane is described as a **fluid mosaic model** – this is because it is fluid (moves) and mosaic it contains intrinsic and extrinsic proteins.
- 4) The organelles within a eukaryotic cell and
 - a. **Nucleus** – containing chromosomes and protein bound linear DNA (the proteins are called histones)
 - b. **Nucleoli** – For making ribosomes.
 - c. **Mitochondria** – the site of aerobic respiration
 - i. Mitochondria have an **inner and outer membrane**.
 - ii. They have folds in the inner membrane called **cristae**.
 - iii. Inside the cristae is called the **matrix**.
 - iv. They have **circular DNA** and **smaller ribosomes** like prokaryotes.
 - v.
 - d. **Chloroplasts** – the site of photosynthesis (found in plants and algae)
 - i. Chloroplasts have an **inner and outer membrane**.
 - ii. They are filled with **stroma**.
 - iii. They have stacks of **thylakoid** membranes which make up **granum**.
 - iv. They have **circular DNA** and **smaller ribosomes** like prokaryotes.
 - e. **Golgi apparatus** – transporting, modifying and packaging proteins and lipids to transport them around the cell.
 - i. Golgi vesicles – transports proteins and lipids around the cell.
 - f. **Lysosomes** – a type of vesicles that releases lysozymes (that hydrolyse molecules)
 - g. **Ribosomes** – Site of protein synthesis
 - i. Ribosomes have 2 subunits
 - ii. They are made of protein and RNA
 - iii. Eukaryotic ribosomes are larger than prokaryotic ribosomes.

- h. **Rough endoplasmic reticulum** – manufacturing and modifying proteins
 - i. **Smooth endoplasmic reticulum** – manufacturing and modifying lipids
 - j. **Cell wall**
 - k. **Cell vacuole** – to store cell sap
- 5) Groups of similar specialised cells are grouped together into **tissues**, tissues work together to form **organs**, organs work together to form **organ systems**.
- 6) **Prokaryotes**:
- a. Smaller than eukaryotes
 - b. They have much smaller ribosomes (but they are still made from 2 subunits, protein and RNA)
 - c. Singular circular DNA molecule that has no associated proteins (no histones)
 - d. Plasmids – genetic material that replicates independently of the circular DNA
 - e. **Capsule** surrounding the cell – outside of the cell wall
 - f. Flagella – helps with movement
- 7) Cell walls are made from different components and structures:
- a. Plants – **Cellulose**
 - b. Algae – **Cellulose**
 - c. Fungi – **Chitin**
 - d. Prokaryotes – **murein** (a glycoprotein)
- 8) To study cells we use a microscope and use the formula $\text{magnification} = \frac{\text{Size of image (picture)}}{\text{Actual size}}$
- a. **Optical (light) microscope**
 - i. Low resolution
 - ii. Low magnification
 - iii. Cheaper to run
 - iv. Live specimens can be used
 - b. **TEM (transmission electron microscope)**
 - i. High magnification
 - ii. High resolution
 - iii. You can observe the outside structures, shapes of cells and organisms.
 - iv. Dead specimens inside a vacuum.
 - c. **SEM (scanning electron microscope)**
 - i. Higher magnification
 - ii. Higher resolution
 - iii. You can use it to see organelles inside cells
 - iv. Dead specimens inside a vacuum.
- 9) To convert from mm to μm you **x1000**

10) To convert from μm to nm you need to **x1000**

11) **Cell fractionation** and **ultracentrifugation** are used to separate organelles so they can be studied one at a time.

- a. First you homogenise the cell (break it up)
- b. It needs to be stored under the following conditions
 - i. **Isotonic** – so the water potential isn't affected, and water doesn't move in or out of the organelles by osmosis.
 - ii. **Cold** – so enzymes don't function, and lysozymes don't hydrolyse organelles.
 - iii. **Buffered** – to maintain the pH.
- c. You then must **filter** to remove a **debris**.
- d. Next **ultracentrifugation**
- e. The homogenate is spun using a centrifuge. Each time the **pellet** is removed and the **homogenate** is spun again in the centrifuge.
 - i. In the pellet at the bottom there will be different organelles.
 1. 1st pellet – Nuclei
 2. 2nd pellet – mitochondria (chloroplasts in plants)
 3. 3rd pellet – lysosomes and ER
 4. 4th pellet – Endoplasmic reticulum
 5. 5th pellet – Ribosomes

12) Viruses are **acellular** – this means they aren't classed as a cell. They are also **non-living** because they need a host cell to replicate (they don't undergo cell division).

- a. They have genetic material that is either RNA or DNA
- b. Capsid
- c. Attachment proteins – viruses use these to bind to the outside of cells.

13) **HIV** – human immunodeficiency virus replicates and destroys T-Helper cells. By destroying the T-helper cells this leads to AIDS.

- a. HIV binds to **T-Helper** cells and inserts the viral RNA
- b. It also has a **reverse transcriptase** that joins free DNA nucleotides to the RNA and forms the phosphodiester bond.
- c. **Integrase** then inserts the DNA into the nucleus of the T-helper cells.
- d. The genetic material from the virus is then transcribed and translated to make new viruses

14) In multicellular organisms **SOME** cells retain the ability to divide.

15) The cell cycle is split into stages **interphase** (G_1 , S and G_2) **prophase, metaphase, anaphase and telophase**.

16) During interphase:

- a. **G₁**- gap
- b. **S**- DNA Synthesis takes place
- c. **G₂**- Gap

17) During mitosis

- a. **Prophase** – chromosomes condense and become **visible**
- b. **Metaphase** – chromosomes line up down the equator of the cell, **spindle fibres** attach to **centromeres**.
- c. **Anaphase** – chromosomes are separated at their **centromere**. **Chromatids** are pulled by **spindle fibres** to the **poles** of the cell.
- d. **Telophase** – **cytokinesis** occurs and a new nucleus forms.

18) **Mitosis** produces 2 **genetically identical daughter cells**.

19) **Uncontrolled** mitosis leads to **cancers**.

- a. Cancers can be treated by disrupting the cell cycle
 - i. Causing DNA not to be replicated
 - ii. Causing chromatids not to move to opposite poles to create non- genetically identical daughter cells.

20) **Prokaryotes** replicated by **binary fission**.

- a. First prokaryotes replicate the circular DNA and the plasmids
- b. Next the cytoplasm divides to produce two daughter cells, each have a single copy of the circular DNA but the have a variable number of plasmids.

21) The cell surface membrane consists of different parts

- a. **Phospholipids** – The heads are hydrophilic so they face outwards, they fatty acid tails are hydrophobic so face inwards to form a phospholipid bilayer.
- b. **Proteins**
 - i. **Intrinsic** – these proteins go all the way through the 2 sides of the phospholipid bilayer.
 - ii. **Extrinsic** – these proteins only go through one layer of phospholipids.
- c. **Glycoproteins** – proteins that have a carbohydrate attached.
- d. **Glycolipids** – proteins that have a lipid group attached.
- e. **Cholesterol** – maintains the integrity of the membrane, the more cholesterol the more ridged the membrane will be.

22) There are different ways that molecules can move across the membrane

- a. **Simple diffusion** – for molecules moving from high concentration to low concentration
 - i. Non-polar (apart from water which is polar can move through the phospholipid membrane)
 - ii. Small
- b. **Facilitated diffusion** – for movement of molecules (ions and small molecules) from high concentration to low concentration
 - i. **Channel proteins** – channels are specific for molecules allowing them to move down the concentration gradient.
 - ii. **Carrier proteins** – carrier proteins are specific. The molecule will bind to the carrier, the carrier will then change shape and then it allows the molecules to move down their concentration gradient.
- c. **Osmosis** – this is the movement of water molecules from a higher water potential to a lower water potential through a partially permeable membrane.
 - i. **Pure** water has the **water potential of 0**
 - ii. The more solutes added to the water the more negative the water potential will become.
 - iii. Water potential can be shown by using the symbol Ψ
- d. **Active transport** – is the movement of molecules against their concentration gradient.
 - i. Carrier proteins – specific molecules bind. ATP is hydrolysed which provides the energy for the carrier protein to change shape and allow the molecules to move against their concentration gradient.
- e. **Co-transport** – this is the movement of 2 molecules at the same time.

23) The movement of **glucose** (and amino acids) is by co-transport in the lining of the ileum (small intestine).

- a. There are 3 proteins involved
 - i. **Na⁺/glucose transporter** – this co-transporter moves glucose and Na⁺ from the lumen (inside) of the small intestine into the epithelial cell.
 - ii. **Glucose channel proteins** – Glucose then moves by facilitated diffusion from the epithelial cell into the capillary

- iii. **Na⁺/K⁺ co-transporter** – to maintain the Na⁺ gradient (high concentration in the lumen and low concentration in the epithelial cell) Na⁺ is removed from the cell by the Na⁺/ K⁺ pump but in exchange K⁺ moves into the epithelial cells.

24) Cells can be adapted to efficient transport across the cell membrane by:

- a. Increasing their surface area by more folds
- b. By having more channel or carrier proteins in their membrane.

25) **Antigens** help the immune system identify:

- a. Pathogens
- b. Cells from other organisms of the same species (organ transplants)
- c. Abnormal body cells (potential cancerous cells)
- d. Toxins (from bacterial cells).

26) Some pathogens can change the shape of their antigens. This is called **antigenic variability**. This means our immune system will not have a memory response for the new antigen and it makes it difficult to create a vaccine.

27) There are three main cells of the immune system:

a. **Phagocytes**

- i. They **engulf** pathogens
- ii. A **phagocytic vacuole** will form around the pathogen.
- iii. **Lysosomes** that contain **lysozymes** fuse with the phagocytic vacuole
- iv. Lysozymes are released into the **phagocytic vacuole** and they hydrolyse the pathogen
- v. The antigens from the pathogen are then presented on the surface of the phagocyte.
- vi. The phagocyte has become an **antigen-presenting cell**

b. **T-cells** – they are part of the cellular response

- i. **T- helper cells** become activated when an antigen-presenting cells are present.
 - 1. T-Helper cells activate, phagocytes, T-cells and B-cells
- ii. **Cytotoxic T-cells**
 - 1. Cause any cells that have the foreign antigen to become freely permeable (destroyed).

c. **B-cells** - the humoral response

- i. Once a B-cell is activated by a T-Helper cell they undergo **clonal selection**.
- ii. Clonal selection is when the B-cell interacts with the antigen on an antigen presenting cell (which could be a phagocyte, toxin, abnormal cell or pathogen) to find a receptor that will bind to the antigen.
- iii. Once a match has been found the B-cell will start to divide by mitosis to produce **plasma cells**.
- iv. The plasma cells produce identical antibodies because they are identical, they are called **monoclonal antibodies**.
- v. The antibodies are released and bind to the antigen, forming an **antigen-antibody** complex
- vi. This causes **agglutination**.
- vii. A phagocyte will then engulf the pathogen.

28) Antibodies are made up of **2 heavy chains** and **2 light chains** held together with **disulphide bonds**. Each chain has a **constant** region and a **variable** region that binds with the antigen.

- 29) A **primary response** is when the first time an organism comes into contact with an antigen.
- 30) A **secondary response** is more rapid and is more vigorous and is caused by the second time the organism is introduced to the antigen this is because there are already memory cells in the blood. Memory cells can quickly recognise the specific antigen on the same pathogen. It is quicker because no
- Memory B-cells** can rapidly differentiate into plasma cells to produce antibodies
 - Memory T-cells** can rapidly activate T- helper cells a cytotoxic T-cells
- 31) **Vaccinations** are when the organism is introduced to a dead or weaken form of the pathogen in order to generate memory cells.
- 32) **Active immunity** – is naturally acquired by introducing antigens to the body, this means a memory cells are created. Or artificially acquired by a vaccine.
- It is slower acting the first time you respond to the pathogen
 - It is long lasting 0 the second time the organism sees the same pathogen the immune system will respond.
- 33) **Passive immunity** – is naturally acquired when a mother gives antibodies to a foetus via placenta or milk. Or artificially given by injecting antibodies into a patient.
- This is fast acting
 - It isn't long lasting as there a no memory cells produced.
- 34) **Monoclonal antibodies** are used to:
- Target medication to specific sell types by attaching a drug to an antibody
 - Medical diagnosis
- 35) **ELIZA test**
- Direct** (looking for the presence of **antigens**)
 - Antibodies are at the bottom of the well
 - Add the antigens to be measured.
 - Wash** to remove any unbound antigens
 - Add an antibody with an enzyme attached. The antibody will bind to the antigen.
 - Wash** to remove any unbound antibodies.
 - Add a substrate that changed colour when the enzyme is present.
 - Indirect** (looking for the presence of **antibodies**)
 - Antigens are at the bottom of the well.
 - Add the serum with the antibodies to be measured
 - Wash** to remove any unbound antibodies
 - And a second antibody with an enzyme joined to it. The second antibody will bind to any antibodies present in the well.
 - Wash** to remove any unbound antibodies
 - Add a substrate that changed colour when the enzyme is present.