Cell Structure

- AQA Biology (Oxford): pp. 58–81
- AQA Biology (Hodder Education): pp. 36–44, 50–52, 78–83.

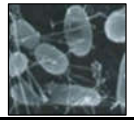
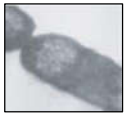
Eukaryotic and Prokaryotic Cells

- All life exists as **single or multicellular organisms**, and all cells have certain features in common.
- **Eukaryotic cells** divide by **mitosis** and **meiosis**.
- **Prokaryotic cells** (bacteria) divide by **binary fission**.
- **Viruses** are not alive and must use **host cells** to replicate.
- Cells have **specialised organelles**, a large quantity of a particular organelle or **specialised structures** to adapt them to **different roles**.
- Cells can be studied with **optical** or **electron microscopes**.

Microscopy

Optical microscopy uses light and can look at living samples, but at **low magnification**.

Electron microscopes use electrons for greater magnification, but use a dead sample in a vacuum.

	Scanning electron microscope	Transmission electron microscope
Magnification	Medium	High
Resolution	Medium	High
Looks at…	3D surface view 	Internal cross section 

Cell organelles need to be separated by **fractionation** and **ultracentrifugation**, using buffers and low temperatures to stop enzymes destroying the organelles.

Magnification

Magnification = (eyepiece lens)×(objective lens)

$$\text{Actual} = \frac{\text{Image size}}{\text{Magnification}}$$

Eukaryotic Cells

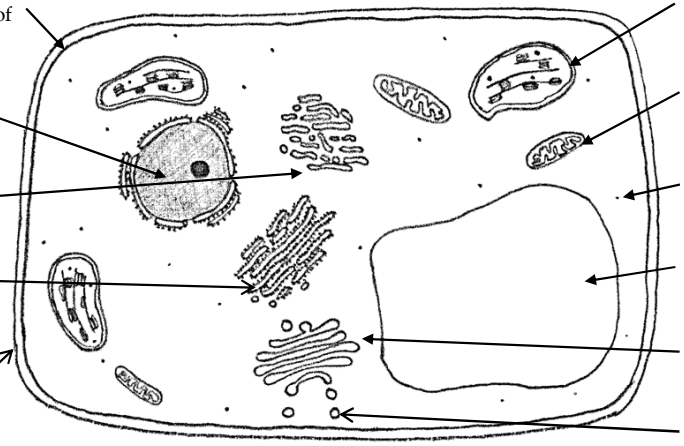
Cell surface membrane – phospholipid bilayer with membrane proteins, controls movement of substances into and out of the cell

Nucleus – surrounded by a double membrane with pores, contains a nucleolus

Smooth endoplasmic reticulum – synthesises, stores and transports lipids and carbohydrates

Rough endoplasmic reticulum – coated in ribosomes, provide a large surface area for protein synthesis and transport

Cell wall – rigid wall with cellulose polymers that provides protection and support



Chloroplasts – contains own DNA and chlorophyll to carry out photosynthesis

Mitochondria – have folded inner cristae and own DNA, respire to produce ATP

80s Ribosomes – carry out protein synthesis

Permanent vacuole – sac of liquid that stores salts and sugars and maintains turgidity.

Golgi apparatus – modifies and sorts substances

Lysosomes – contain digestive enzymes which are secreted to destroy harmful substances inside and outside the cell

Specialised eukaryotic cells include:

- Red blood cells: no nucleus or organelles to increase volume for haemoglobin
- Ciliated epithelia: increases surface area for absorption
- Leaf palisade cells: contain dense chloroplasts for photosynthesis

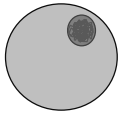
Mitotic Index

Mitotic index is the ratio of cells undergoing mitosis to the number of all cells in a sample:

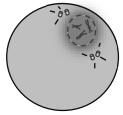
$$\text{Mitotic Index} = \frac{\text{Number of cells undergoing mitosis}}{\text{Total number of cells in a sample}}$$

Eukaryotic Cell Division: Mitosis

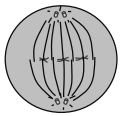
Interphase contains the first growth phase (proteins and organelles are produced), synthesis phase (DNA replication) and second growth phase (energy is stored and organelles divide).



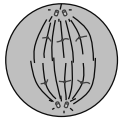
Prophase: chromosomes become visible and nuclear envelope disintegrates.



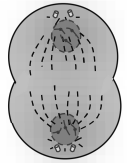
Metaphase: chromosomes line up on the cell's equator.



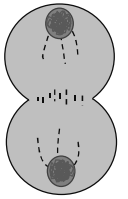
Anaphase: chromatids are pulled to opposite poles by spindle fibres.



Telophase: nuclear envelope reforms around the chromatids.



Cytokinesis: the cytoplasm divides.



Prokaryotic Cells

Plasmid – small pieces of DNA

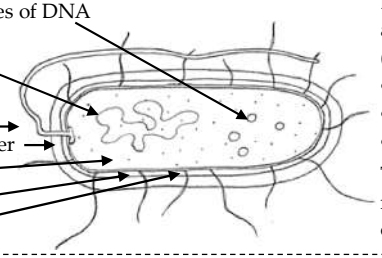
Circular DNA

Flagella – used for locomotion

Capsule – mucus layer

70s Ribosomes

Cell wall and membrane



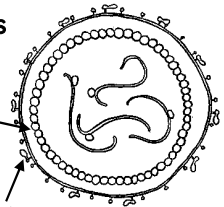
Bacteria divide by asexual reproduction (binary fission):

- DNA replicates
- plasmids replicate
- cytoplasm divides

They have no membrane-bound organelles

Viruses

Viral DNA is enclosed in a protein coat called the **capsid**, and has enzymes attached ready to convert DNA into RNA once in a host cell.



The lipid envelope contains **attachment proteins** that allow the virus to identify and attach to a host cell.

Once attached, the virus replicates, killing the cell.

Cancer

- Uncontrolled mitosis of cells causing a tumor.
- Drugs disrupt division of fast-replicating cells.
- However, these include other cells, e.g. hair follicles, as well as cancerous cells.

Word cloud

Capsid, Lysosomes, Vacuole, Interphase, Organelle, Golgi apparatus, Prophase, Capsule, Eukaryotic, Metaphase, Flagella, Prokaryotic, Anaphase, Chloroplasts, Endoplasmic reticulum, Attachment proteins, Telophase, Electron microscopy, Plasmid, Cytokinesis

Transport across Cell Membranes

- AQA Biology (Oxford): pp. 84–98
- AQA Biology (Hodder Education): pp. 1–18, 64–65, 183–185, Inorganic ions: pp. 26, 57, 64, 161.

Transport across Membranes

- All cells and many internal organelles have membranes.
- Phospholipid membranes **regulate movement** into and out of the cell or organelle, and provide **internal transport**, e.g. vesicles of enzymes that need to be secreted.
- **Water** passes through membranes **by osmosis** down a **water potential gradient**.
- **Small, non-polar** molecules can pass through the membrane by **diffusion**.
- **Larger, polarised** molecules or molecules moved **down their concentration gradient** need to be transported by **facilitated diffusion**, **active transport or co-transport**.

Diffusion

Diffusion is the net movement of molecules or ions from a region of higher concentration to a region of lower concentration.

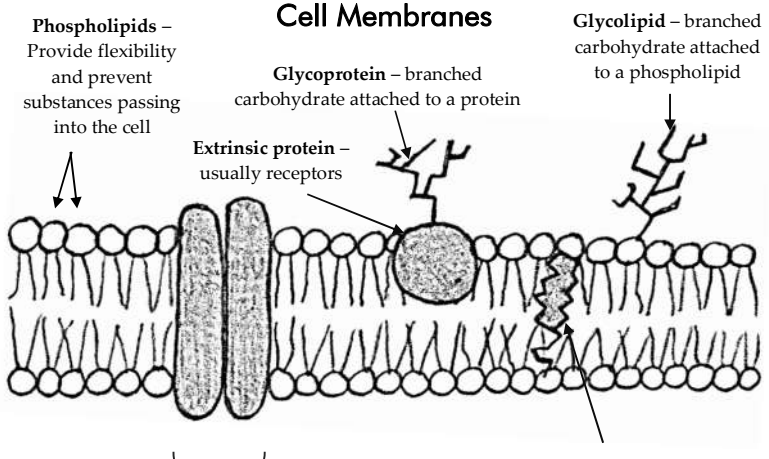
Fick's Law shows how the rate of diffusion can increase:

$$Rate\ of\ diffusion = \frac{surface\ area \times difference\ in\ concentration}{thickness\ of\ diffusion\ surface}$$

Many cells are **specialised** for diffusion, e.g. epithelium in alveoli in the lungs or the lining of the gut are thin with a large surface area.

Facilitated diffusion relies on **kinetic energy** of molecules to move through **carrier or channel proteins**, ATP is not involved. Channels and carrier proteins are **molecule-specific** and will only open or change shape in response to that molecule.

Cell Membranes



Phospholipid bilayer membranes contain many protein molecules and are flexible with their components moving through the molecule. This is called the **fluid-mosaic model**.

Glycoproteins and glycolipids allow cells to **recognise and attach to each other**.

Increasing **cholesterol** increases membrane rigidity and makes the membrane **less fluid at high temperatures**.

Osmosis

Osmosis is the movement of **water molecules** from an area of high **water potential (Ψ)** to an area of low water potential across a **selectively permeable membrane**.

Pure water: Ψ = 0 kPa

Hypotonic solution: relatively few solutes; therefore, a high water potential, so water will leave the solution. A cell in a hypotonic solution gains water. The vacuole of plant cells expand and cause the cell to become **turgid**. A red blood cell will burst; this is called **haemolysis**.

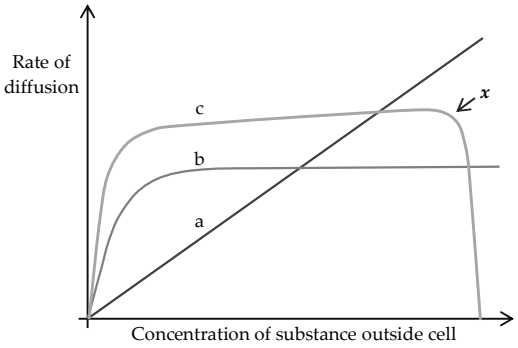
Hypertonic solution: relatively more solutes; therefore, a lower water potential, so water will enter the solution. A cell in a hypertonic solution loses water. Plant cells become **plasmolysed** and the outer surface membrane pulls away from the cell wall. Red blood cells shrivel and become **crenated**.

Increasing solutes: Ψ = Negative kPa

Active Transport

Active transport uses **ATP** to move **substances against their concentration gradient**.

ATP is **hydrolysed** and a **phosphate ion** binds to the channel or carrier protein. This causes it to either open or change shape and move the bound substances into or out of the cell.



Line *a*: movement of water by osmosis, since it can pass through the membrane by **simple diffusion** it is **not limited**.

Line *b*: movement by **facilitated diffusion**, rate is **limited by number of carrier or channel proteins** in the membrane.

Line *c*: movement by active transport. **ATP use** means molecules can be transported at **low concentrations**. It is limited again by the availability of membrane proteins. Dependency on ATP means that if **respiration** is limited at point *x*, active transport stops.

Co-transport in the Small Intestine

Glucose and **amino acids** are absorbed by co-transport with **sodium ions**.

- Sodium ions are **actively transported** out of epithelial cells into the blood to maintain low concentration within the epithelium.
- Sodium ions **bind to a carrier protein** to move into the epithelium by **facilitated diffusion**.
- **Glucose** binds to the **same carrier protein** so is transported into the cell.
- **Water** then enters the epithelium by **osmosis**. This means **rehydration fluids** need both glucose and sodium ions to be effective.

Exam Tip!

Remember the differences between types of cell transport:

Type	Molecule	Concentration	Energy source
Diffusion	Small, non-polar	High to low	Kinetic
Facilitated diffusion	Larger, polar	High to low	Kinetic
Osmosis	Water	High to low Ψ	Kinetic
Active transport	Any	Low to high	ATP

Word cloud

Extrinsic and intrinsic, Glycoprotein, Glycolipid, Cholesterol, Fluid-mosaic model, Diffusion, Rehydration, Facilitated diffusion, Osmosis, Hypotonic, Plasmolysis, Hypertonic, Haemolysis, Active transport, ATP, Respiration, Co-transport, Water potential

The Immune System

- AQA Biology (Oxford): pp. 102–121
- AQA Biology (Hodder Education): pp. 87–105.

THE BASICS

Cell Recognition and Immunity

- White blood cells include **phagocytes**, **T-lymphocytes** and **B-lymphocytes**.
- The immune response destroys **pathogens** and **abnormal body cells**.
- They are **highly specific** and only stimulated by certain glycolipids and glycoproteins so they do not destroy normal body cells.
- **Memory cells** help the body 'remember' the response to an infection, giving immunity to a disease.
- **Immunity** can be active or passive and natural or artificial.
- Many **ethical issues** surround disease treatment involving immunity.

Immunity

Active immunity stimulates production of antibodies and memory cells and, therefore, has a long-lasting effect due to secondary response.

Passive immunity introduces antibodies from an outside source; for example, colostrum in breast milk, but stimulates no production or memory cells and, therefore, immunity is short-lived.

Active immunity can be **natural**, i.e. from a body's own response to pathogen infection or **artificial**. Artificial immunity involves stimulating a response by introducing a dead or altered form of the pathogen to the immune system.

Vaccines are a form of artificial active immunity. A good vaccine must:

- be economical to vaccinate a whole population
- have few, if any, side effects
- be easy to produce, store, transport and administer

Ethical concerns include whether vaccination should be compulsory.

Herd immunity: when the majority of a population are immunised a non-immunised individual is unlikely to encounter the disease.

ELISA and Monoclonal Antibodies

Enzyme-linked immunosorbant assaying uses antibodies to detect proteins, e.g. antigens. **Direct**: labelled antibodies bind to antigens and trigger the signal. **Indirect:** capture antibodies hold antigens in place, secondary antibodies bind to the antigen, producing a **stronger signal**.

Monoclonal antibodies: a collection of one isolated and cloned antibody, used to enable quick and specific detection of antigens.

- ✓ Could treat life-threatening diseases
- ✓ Used in simple tests, e.g. pregnancy
- × Produced by causing tumours in mice
- × Can have severe side effects during testing

Antigens

Antigens: **foreign** substances that are part of / produced by pathogens and recognised by the immune system as non-self.

Phagocytes and T-helper cells absorb and **display antigens** to stimulate further immune responses. (1)

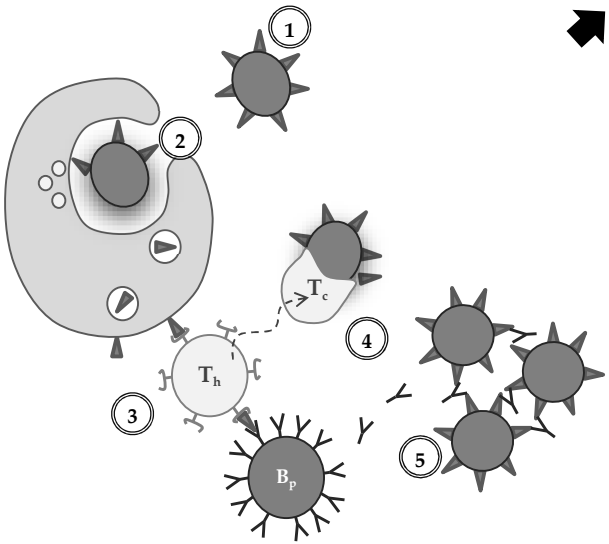
The antigens produced by a pathogen can be **highly variable**, so the full immune response needs to occur even if the same pathogen has been encountered before. **New strains** of pathogens complicate medical treatment.

Phagocytosis

Phagocytes detect chemicals produced by pathogens. They then bind and project their membrane to engulf the pathogen. (2)

Lysosomes release **lysozymes** to digest the pathogen. Breakdown products are absorbed and **antigens are presented** to trigger lymphocyte response. (3)

Phagocytes are **non-specific** and will target any antigen-bearing pathogen.



Response Order

Primary response: initial response of T- and B-lymphocytes.

Secondary response: memory cells can live for decades and allow a **rapid response to reinfection** by the same pathogen, much quicker than another primary response.

Exam Tip!

T-lymphocytes mature in the thymus gland and target pathogens. B-lymphocytes mature in the bone marrow and produce antibodies.

T-lymphocytes

T-lymphocytes attack **specific** pathogens or infected cells in the **cell-mediated immune response**.

T-helper cells recognise antigens displayed on pathogens and activate other T-cells to **divide by mitosis**. They also stimulate B-cells.

Cytotoxic T-cells bind to a pathogen and make a hole in their membrane. (4)

Memory T-cells are found in blood, tissue fluid and the lymphatic system.

B-lymphocytes

When stimulated by T-helper cells, **specific B-lymphocytes** undergo **clonal selection**. This is the **antibody-mediated / humoral immune response**.

Plasma B-cells produce **antibodies**. These bind to the pathogen's complementary antigens, cause **agglutination** and attract phagocytes. (5)

Memory B-cells remain in the blood.

HIV and AIDS

HIV viruses can lay **dormant** in T-helper cells for years: **HIV positive**.

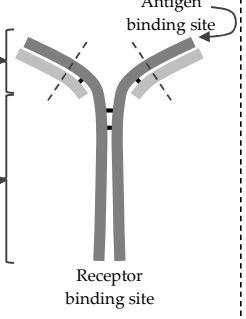
AIDS: when the viruses activate their DNA, replicate within and **destroy T-helper cells**. This halts the cell-mediated and antibody-mediated immune systems and the person is exposed to many diseases.

Antibiotics are designed to affect bacterial metabolism and, therefore, have **no effect** on viruses which hijack a cell's metabolism.

Antibody Structure

Antibodies have:

- two **binding sites**
- **variable regions** that are complementary to different antigens
- **constant region**
- four polypeptide chains called immunoglobins



Word cloud

Natural and artificial immunity
Antigen presentation
Antigen
Phagocytes
Vaccines
Lysozymes
Herd immunity
Cell-mediated
ELISA test
Antibody-mediated / humoral
Monoclonal
Lymphocytes
HIV positive
Antibodies
Binding sites
Agglutination
Variable region
Memory cells
Active and passive immunity
AIDS