**St. Ambrose College**

**A Level Biology (Year 12)**

# Knowledge Organiser: Unit 2 Cells (2.1 – 2.3)

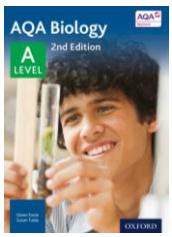
2.1 Cell Structure

2.2 Cell division

2.3 Transport across cell membranes

**For every 1 hour A Level Biology lesson you are expected to spend at least 1 hour independently reviewing the subject content. The following resources should be referred to regularly to support your independent work.**


You have been provided with a printed copy of the full subject specification (also available on the AQA website https://www.aqa.org.uk/subjects/science/as-and-a-level/biology-7401-7402/specification-at-a-glance). Use this to follow the learning in lessons…track your progress and be aware of what is still to come.




kerboodle

Use the textbook on www.kerboodle.com after every lesson to develop your understanding. Read the relevant pages, add detail to your class notes and complete the summary tasks. Create your own summary notes/flashcards for future use in the run up to exams.

**Unit 2 Cells on pages 56-127**

Cell Structure **(pg58-83)** Cell division **(pg77-81)** Transport across membranes **(pg84-101)**

SENECA
www.senecalearning.com

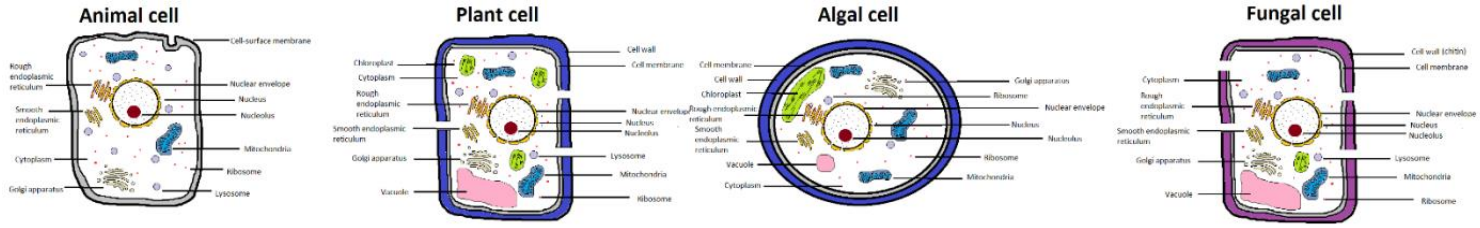
Use regularly between lessons to review basic content and to become more familiar with key terminology. https://senecalearning.com/en-GB/

PMT
resources • tuition • courses

Access detailed revision notes, key definitions, flash cards, past paper questions and mark schemes.
https://www.physicsandmathstutor.com/biology-revision/a-level-aqa/

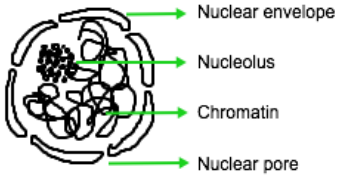
**As an A Level student you are expected to take a proactive approach to your studies; arrive to lessons fully equipped and prepared for what you will be learning about (read ahead in the specification/textbook), focus and participate in lessons, ask for help/clarification when you are unsure and spend time after the lesson consolidating/embedding new learning.**

# 2.1.1 Structure of eukaryotic cells




## Structure and function – cell-surface membrane

- Phospholipid bilayer with embedded proteins etc.
- Selectively permeable – enables control of passage of substances in and out of cell
- Barrier between internal and external environment of cell

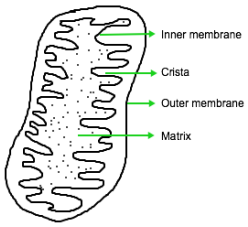



## Structure and function – nucleus

- Nuclear envelope, nuclear pores, nucleolus, DNA / chromatin
- Controls the cells activity though transcription on mRNA
- Nuclear pores allow substances e.g. mRNA to move between the nucleus and cytoplasm
- Nucleolus makes ribosomes which are made up of proteins and ribosomal RNA

## Structure and function – mitochondria

- Double membrane – inner membrane folded to form cristae.
- Matrix containing small 70S ribosomes, small circular DNA and enzymes involved in aerobic respiration (glycolysis).
- Site of aerobic respiration producing ATP for energy release




## Structure and function – Golgi apparatus

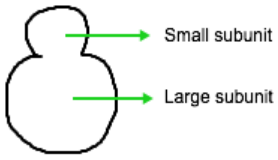
- 3 or more fluid filled membrane bound sacs with vesicles at edge
- Receives protein from rough endoplasmic reticulum
- Modifies/processes protein e.g. add carbohydrates/sugars
- Packages into vesicles e.g. for transport to cell surface membrane for exocytosis
- Also makes lysosomes


## Structure and function – lysosomes

- Type of Golgi vesicle containing lysozymes – hydrolytic enzymes
- Release of lysozymes to break down / hydrolyse pathogens or worn out cell components

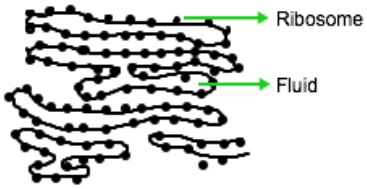
## Structure and function – ribosomes

- Float free in cytoplasm or bound to rER.
- Not membrane bound.
- Made from 1 large and 1 small subunit.
- Site of protein synthesis, specifically, translation



## Structure and function – rough endoplasmic reticulum

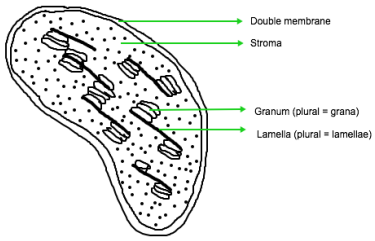
- Ribosomes bound by a system of membranes
- Folds polypeptides to secondary / tertiary structure
- Packages to vesicles, transport to the Golgi apparatus etc.




## Structure and function – smooth endoplasmic reticulum

- Similar to rER but without ribosomes – system of membranes
- Synthesises and processes lipids

## Structure and function – chloroplasts (plants and algae)



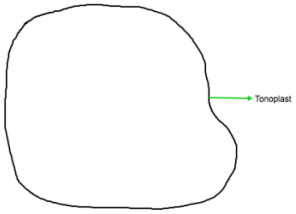

- Thylakoid membranes are stacked up in some parts to form grana, which are linked by lamellae. These sit in the stroma (fluid) and are surrounded by a double membrane. Also contains starch granules and circular DNA.
- (Chlorophyll) absorbs light for photosynthesis to produce organic substances

## Structure and function – cell wall (plants, algae and fungi)

- Made mainly of cellulose in plants and algae, and of chitin in fungi
- Rigid structure surrounding cells in plants, algae and fungi. Prevents the cell changing shape and bursting (lysis)

## Structure and function – cell vacuole (plants)

- Contains cell sap – a weak solution of sugars and salts.
- Surrounding membrane is called the tonoplast.
- Maintains pressure in the cell (stop wilting)
- Stores/isolates unwanted chemicals in the cell

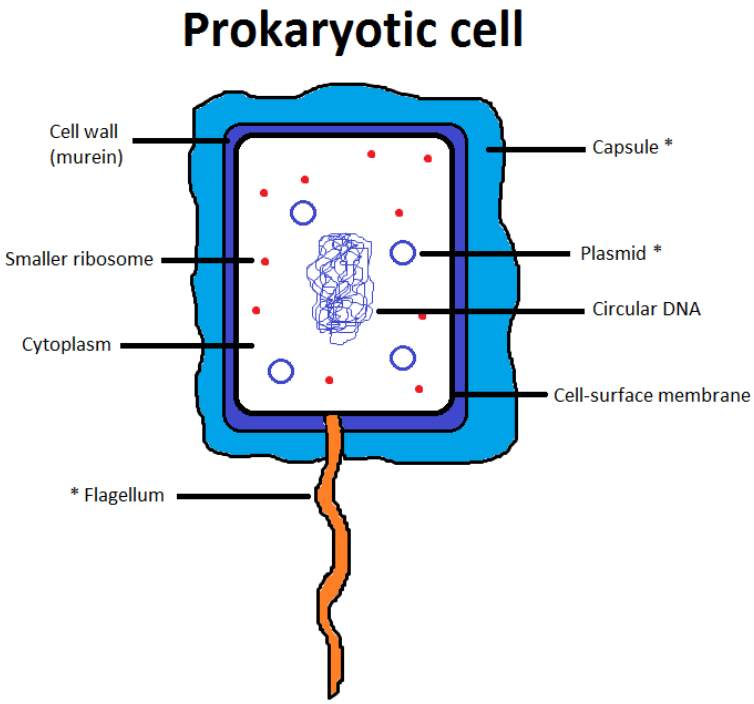



## Organisation of specialised cells in complex multicellular organisms

- Specialised cell – the most basic structural/functional subunit in all living organisms; specialised for a particular function
- Tissue – Group of organised specialised cells; joined and working together to perform a particular function; often with the same origin
- Organ – Group of organised different tissues; joined and working together to perform a particular function
- Organ system – Group of organised organs; working together to perform a particular function

***Exam tip:*** *You should be able to* ***apply your knowledge*** *to explain adaptations of eukaryotic cells with particular functions.*
*For example epithelial cells lining the small intestine are adapted for efficient absorption by having microvilli to increase surface area and lots of mitochondria to provide ATP(energy) e.g. for active transport.*

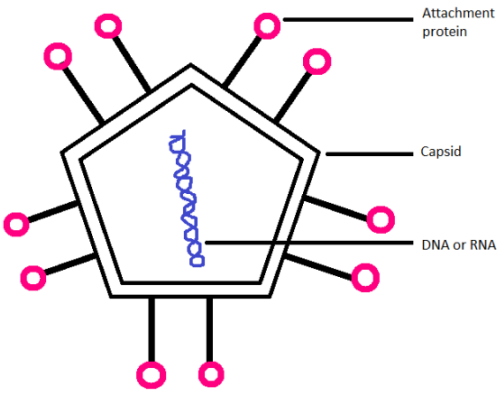
# 2.1.2 Structure of prokaryotic cells and of viruses




## How prokaryotic cells differ from eukaryotic cells

- Prokaryotic cell cytoplasm contains no membrane bound organelles e.g. mitochondria **WHEREAS** eukaryotic cell contains membrane bound organelles
- Prokaryotic cell has no nucleus / contains free floating DNA **WHEREAS** eukaryotic cell has a nucleus containing DNA
- Prokaryotic DNA is circular and isn't associated with proteins **WHEREAS** eukaryotic DNA is linear and is associated with proteins
- Prokaryotic cell wall contains murein and peptidoglycan **WHEREAS** eukaryotic cell wall is made of cellulose
- Prokaryotic cells have smaller 70s ribosomes **WHEREAS** eukaryotic cells have larger ribosomes
- *Prokaryotic cells may have…. one or more plasmids, a capsule, and/or one or more flagella

## Viruses




- Acellular → not made of or able to be divided into cells
- Non-living → unable to exist/reproduce without a host cell
- basic structure genetic material wrapped in a protein coat

# 2.1.3 Methods of studying cells - microscopy

## Principles and limitations of optical microscopes, transmission electron microscopes and scanning electron microscopes

| Optical microscope | Scanning electron microscope | Transmission electron microscope |
|---|---|---|
| - Use light to form a 2D image<br>- Visible light longer wavelength so lower resolution 200nm<br>- Low magnification x1500 | - Use electrons to form a 2D image<br>- Beams of electrons scan surface, knocking off electrons from the specimen, which are gathered in a cathode ray tube to form an image<br>- Electrons shorter wavelength (so higher resolution 0.2nm)<br>- High magnification x1500000 | - Use electrons to form a 3D image<br>- Electromagnets focus beam of electrons onto specimen, transmitted, more dense = more absorbed = darker appearance<br>- Electrons shorter wavelength (so higher resolution 0.2nm)<br>- High magnification x1500000 |
| ☹ 2D image<br>☹ Only used on thin specimens<br>☹ Low resolution; can't see internal structures of organelles or organelles smaller than 200nm e.g. ribosomes<br>☹ Low magnification | ☹Vacuum; can't see living organisms<br>☹ Lower resolution than TEM | ☹ 2D image<br>☹ Only used on thin specimens<br>☹ Vacuum; can't see living organisms |
| ☺ Can see living organisms. | ☺ 3D image<br>☺ High resolution; can see internal structures of organelles<br>☺ High magnification<br>☺ Used on thick specimens | ☺ High resolution; see internal structures of organelles<br>☺ High magnification |

## The difference between magnification and resolution

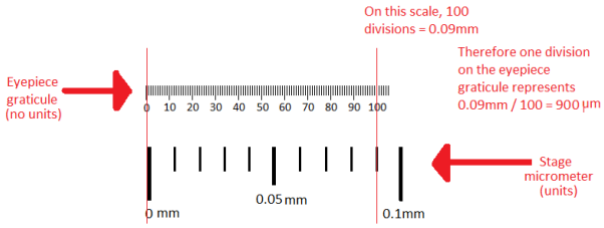
- Magnification **-** how much bigger the image of a sample is compared to the real size, measured by $\textbf{Magnification} = \frac{\textbf{Size of image}}{\textbf{Size of real object}}$
- Resolution **-** how well distinguished an image is between 2 points; shows amount of detail; limited by wavelength of radiation used e.g. light

***Exam tip:*** *You should always use a ruler with mm divisions when physically measuring an image.*
*Remember the rules for* ***unit conversions***
*changing to a 'bigger' unit produces a smaller number value*
*changing to a 'smaller' unit produces a bigger number value*

*m --> mm --> Um --> nm -> pm*
*1000x difference between each*

## Measuring the size of an object viewed with an optical microscope

- Line up eyepiece graticule with stage micrometer
- Use stage micrometer to calculate the size of divisions on eyepiece graticule at a particular magnification
- Take the micrometer away and use the graticule to measure how many divisions make up the object




- Calculate the size of the object by multiplying the number of divisions by the size of division
- Recalibrate eyepiece graticule at different magnifications

## Preparing a 'temporary mount' of a specimen on a slide

- Use tweezers to place a thin section of specimen e.g. tissue on a water drop on a microscope slide
- Add a drop of a stain e.g. iodine in potassium iodide solution used to stain starch grains in plant cells
- Add a cover slip by carefully tilting and lowering it, trying not to get any air bubbles

## Principles of cell fractionation and ultracentrifugation as used to separate cell components

1. Homogenise tissue using a blender
   - Disrupts cell membrane / break open cell
   - Release contents / organelles
2. Place in a cold, isotonic, buffered solution
   - Cold reduces enzyme activity so organelles aren't broken down
   - Isotonic so water doesn't move in/out of organelles by osmosis so they don't burst / shrivel
   - Buffered keeps pH constant so enzymes don't denature
3. Filter homogenate
   - Remove large, unwanted debris e.g. whole cells, connective tissue
4. Ultracentrifugation
   a) Centrifuge homogenate in a tube at a low speed
   b) Remove pellet of heaviest organelle and spin supernatant at a higher speed
   c) Repeated at higher and higher speeds until organelles separated out, each time pellet is made of lighter organelles
   d) Separated in order of mass/density: nuclei → chloroplasts → mitochondria → lysosomes → endoplasmic reticulum → ribosomes

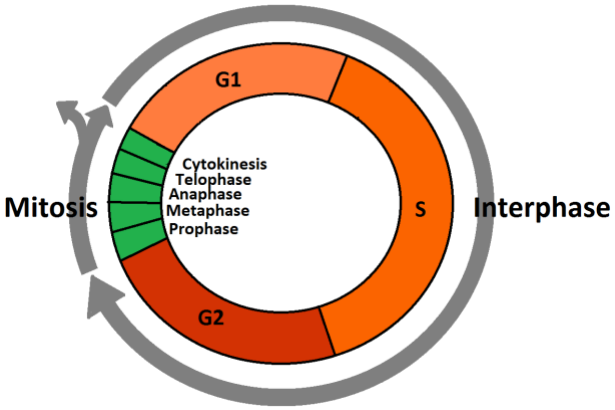
## There was a considerable period of time during which the scientific community distinguished between artefacts and cell organelles

- Repeatedly prepared specimens in different ways
- If an object could only be seen with one preparation technique, but not another it was more likely to be an artefact than an organelle

# 2.2 All cells arise from other cells (cell division)

## Cell cycle

- In multicellular organisms, not all cells keep their ability to divide. Eukaryotic cells that do retain the ability to divide show a cell cycle.




## Interphase

- S phase – DNA replicates semi-conservatively leading to two sister chromatids
- G1 and G2 – Number of organelles and volume of cytoplasm increases; protein synthesis; ATP content increased

## Mitosis

- Division of the nucleus (followed by cytokinesis = division of the cytoplasm and cell contents)
- Stages - 'PMAT'
  Results in two genetically identical daughter cells, containing identical/exact copies of DNA of the parent cell.

## Stages of mitosis (the behaviour of chromosomes and the role of spindle fibres attached to centromeres in the separation of chromatids)

**Prophase**

- Chromosomes condense, becoming shorter and thicker = appear as two sister chromatids joined by a centromere
- Nuclear envelope breaks down and centrioles move to opposite poles forming spindle network

**Metaphase**

- Chromosomes align along equator
- Spindle fibres attach to chromosomes by centromeres

**Anaphase**

- Spindle fibres contract, pulling sister chromatids to opposite poles of the cell
- Centromere divides

**Telophase**

- Chromosomes uncoil, becoming longer and thinner
- Nuclear envelope reforms = two nuclei
- Spindle fibres and centrioles break down

## The importance of mitosis in the life of an organism

Parent cell divides to produce 2 genetically identical daughter cells for:

- Growth of multicellular organisms by increasing cell number
- Repairing damaged tissues / replacing cells
- Asexual reproduction

## Uncontrolled cell division can lead to the formation of tumours and of cancers

- Malignant tumour – cancer – spreads and affects other tissues / organs
- Benign tumour – non-cancerous

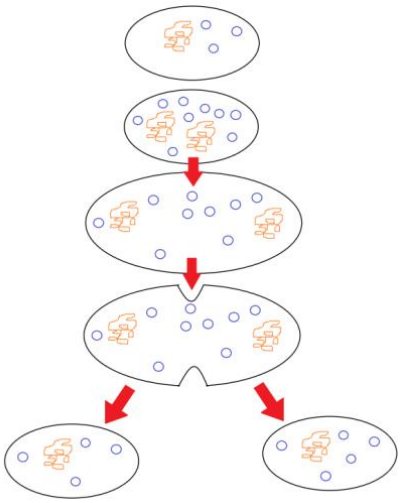
## Many cancer treatments are directed at controlling the rate of cell division

eg.
Disrupt the cell cycle – cell division / mitosis slows – tumour growth slows
Prevent DNA replication → prevent / slows down mitosis
Disrupts spindle activity / formation → chromosomes can't attach to spindle by their centromere so sister chromatids can't be pulled to opposite poles of the cells which prevent/slow mitosis

☹ Disrupt cell cycle of normal cells too, especially rapidly dividing ones e.g. cells in hair follicles

☺ Drugs more effective against cancer cells because dividing uncontrollably / rapidly

## Prokaryotic cells replicate by binary fission

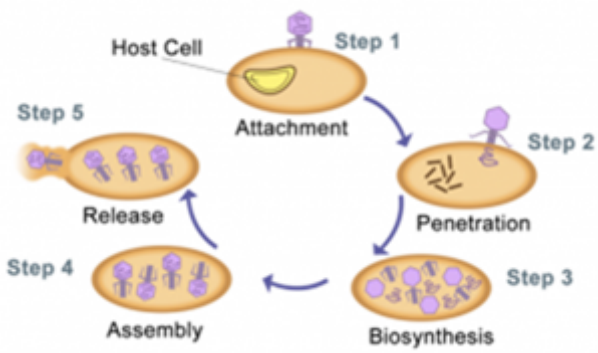


- Circular DNA and plasmids replicate (circular DNA replicates once, plasmids can be replicated many times)
- Cytoplasm expands (cell gets bigger) as each DNA molecule moves to opposite poles of the cell
- Cytoplasm divides
- = 2 daughter cells, each with a single copy of DNA and a variable number of plasmids

## Viral replication

Viruses don't undergo cell division because they are non-living

1. Attachment protein binds to complementary receptor protein on surface of host cell
2. Inject nucleic acid (DNA/RNA) into host cell
3. Infected host cell replicates the virus particles
4. viral paricles are assembled into new viruses that then burst out of the host cell.



# 2.3 Transport across cell membranes

## Fluid-mosaic model of membrane structure

- Molecules within membrane can move laterally (fluid) e.g. phospholipids
- Mixture of phospholipids, proteins, glycoproteins and glycolipids

## The structure of a cell membrane

- Phospholipid bilayer
    - Phosphate heads are hydrophilic so attracted to water – orientate to the aqueous environment either side of the membrane
    - Fatty acid tails are hydrophobic so repelled by water – orientate to the inside/interior of the membrane
- Embedded proteins (intrinsic or extrinsic)
    - Channel and carrier proteins (intrinsic)
- Glycolipids (lipids and attached polysaccharide chain) and glycoproteins (proteins with polysaccharide chain attached)
- Cholesterol (binds to phospholipid hydrophobic fatty acid tails)

## The fluid mosaic model of membrane structure can explain how molecules can enter/leave a cell

**Phospholipid bilayer**

- Allows movement of non-polar small/lipid-soluble molecules e.g. oxygen or water, down a concentration gradient (simple diffusion)
- Restricts the movement of larger/polar molecules

**Channel proteins (some are gated) and carrier proteins**

- Allows movement of water-soluble/polar molecules / ions, down a concentration gradient (facilitated diffusion)

**Carrier proteins**

- Allows the movement of molecules against a concentration gradient using ATP (facilitated diffusion or active transport)

## Features of the plasma membrane adapt it for its other functions

**Phospholipid bilayer = barrier**

- Maintains a different environment on each side of the cell or compartmentalisation of cell

**Phospholipid bilayer = fluid**

- Can bend to take up different shapes for phagocytosis / to form vesicles

**Surface proteins** / extrinsic / glycoproteins / glycolipids

- Cell recognition / act as antigens / receptors

**Cholesterol**

- Makes the membrane more rigid / stable / less flexible, by restricting lateral movement of molecules making up membrane e.g. phospholipids (binds to fatty acid tails causing them to pack more closely together) [Note: not present in bacterial cell membranes]

## Movement across membranes by simple diffusion and factors affecting rate

- Net movement of small, non-polar molecules e.g. oxygen or carbon dioxide, across a selectively permeable membrane, down a concentration gradient
- Passive / no ATP / energy required
- Factors affecting rate – surface area, concentration gradient, thickness of surface / diffusion distance

## Movement across membranes by facilitated diffusion, factors affecting rate and role of carrier/channel proteins

- Net movement of larger/polar molecules e.g. glucose, across a selectively permeable membrane, down a concentration gradient
- Through a channel/carrier protein
- Passive /no ATP/energy required
- Factors affecting rate – surface area, concentration gradients (until the number of proteins is the limiting factor as all are in use / saturated), number of channel/carrier proteins
- Role of carrier and channel proteins:
    - Carrier proteins transport large molecules, the protein changes shape when molecule attaches
    - Channel proteins transport charged/polar molecules through its pore (some are gated so can open/close e.g. Voltage-gated sodium ion channels)
    - Different carrier and channel proteins facilitate the diffusion of different specific molecules

## Movement across membranes by active transport and factors affecting rate

- Net movement of molecules/ions against a concentration gradient
- Using carrier proteins
- Using energy from the hydrolysis of ATP to change the shape of the tertiary structure and push the substances though
- Factors affecting rate – pH/temp (tertiary structure of carrier protein), speed of carrier protein, number of carrier proteins, rate of respiration (ATP production)

## Movement across membranes by osmosis and factors affecting rate

- Net movement of water molecules across a selectively permeable membrane down a water potential gradient
- Water potential is the likelihood (potential) of water molecules to diffuse out of or into a solution; pure water has the highest water potential and adding solutes to a solution lowers the water potential (more negative)
- Passive
- Factors affecting rate – surface area, water potential gradient, thickness of exchange surface / diffusion distance

## How might cells be adapted for transport across their internal or external membranes?

- By an increase in surface area (microvilli)
- Increase in number of protein channels / carriers
- many mitochondria (lots of ATP/energy for active transport)