# CIE A Level Biology

Your notes

## 1.2 Cells as the Basic Units of Living Organisms

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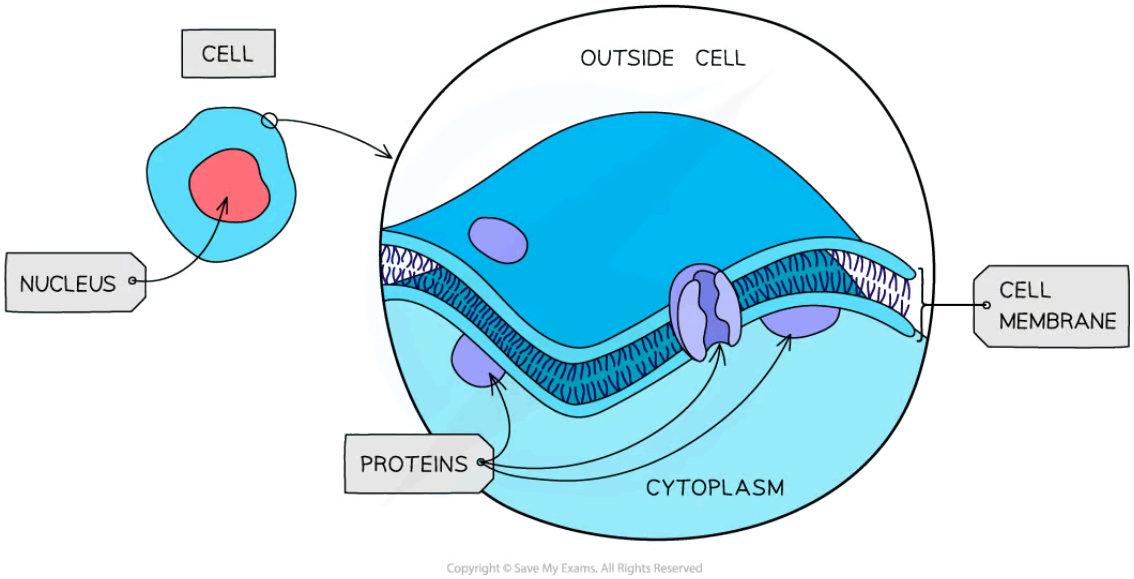

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# 1.2.1 Eukaryotic Cell Structures & Functions

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## Eukaryotic Cell Structures & Functions

### Cell surface membrane



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***The structure of the cell surface membrane – although the structure looks static the phospholipids and proteins forming the bilayer are constantly in motion***

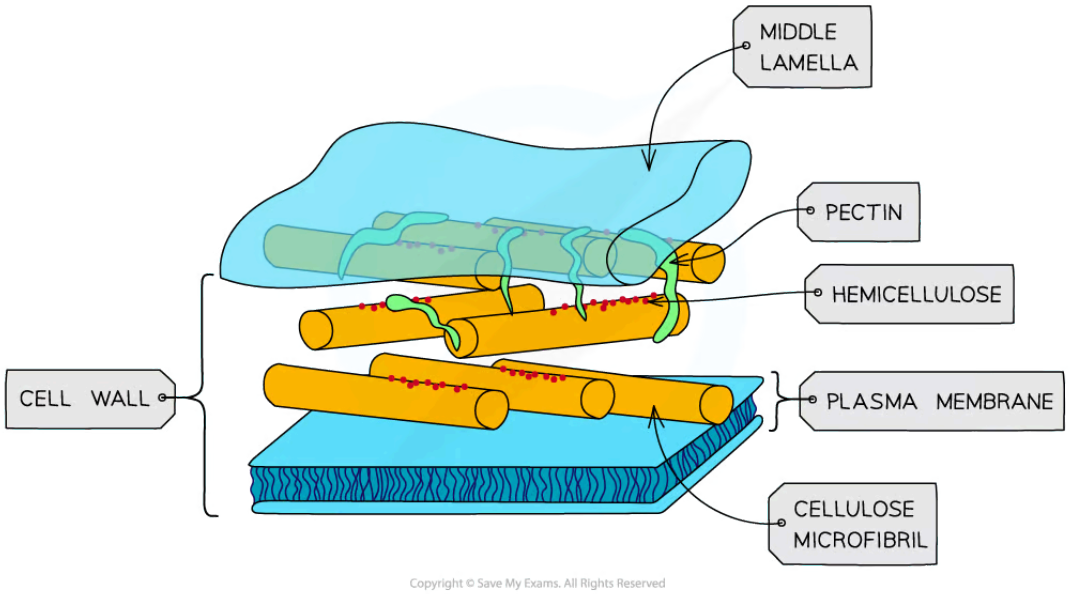
- All cells are surrounded by a cell surface membrane which controls the exchange of materials between the internal cell environment and the external environment
  - The membrane is described as being 'partially permeable'
- The cell membrane is formed from a **phospholipid bilayer** of phospholipids spanning a diameter of around 10 nm

### Cell wall



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***The cell wall is freely permeable to most substances (unlike the plasma membrane)***

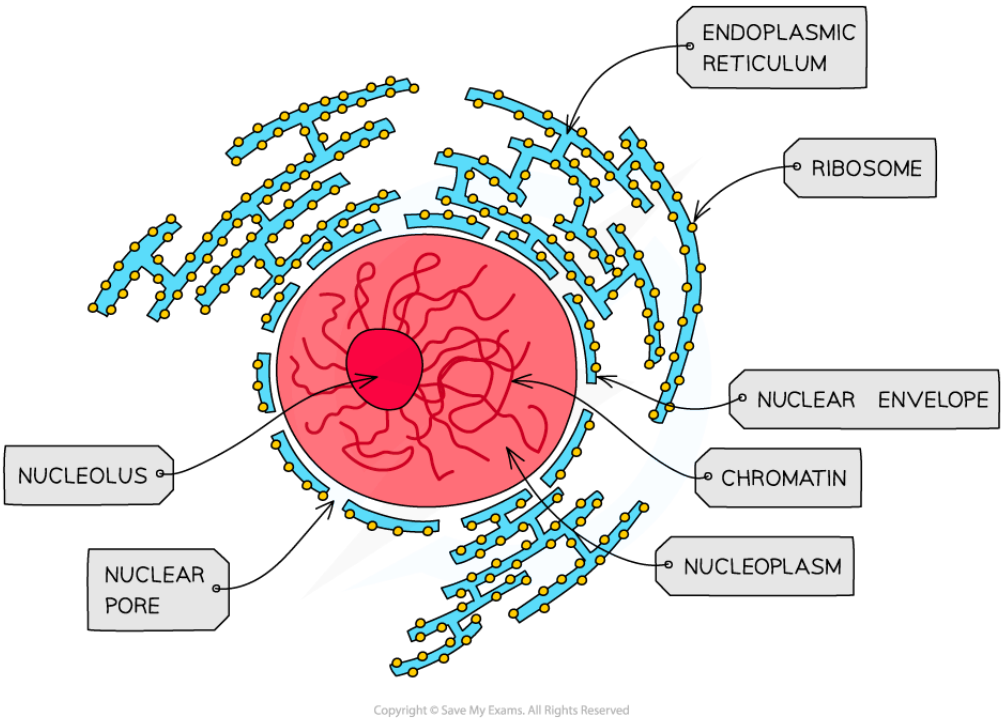
- Cell walls are formed outside of the cell membrane and offer structural support to cell
- Structural support is provided by the polysaccharide cellulose in plants, and peptidoglycan in most bacterial cells
- Narrow threads of cytoplasm (surrounded by a cell membrane) called **plasmodesmata** connect the cytoplasm of neighbouring plant cells

## Nucleus



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***The nucleus of a cell contains chromatin (a complex of DNA and histone proteins) which is the genetic material of the cell***

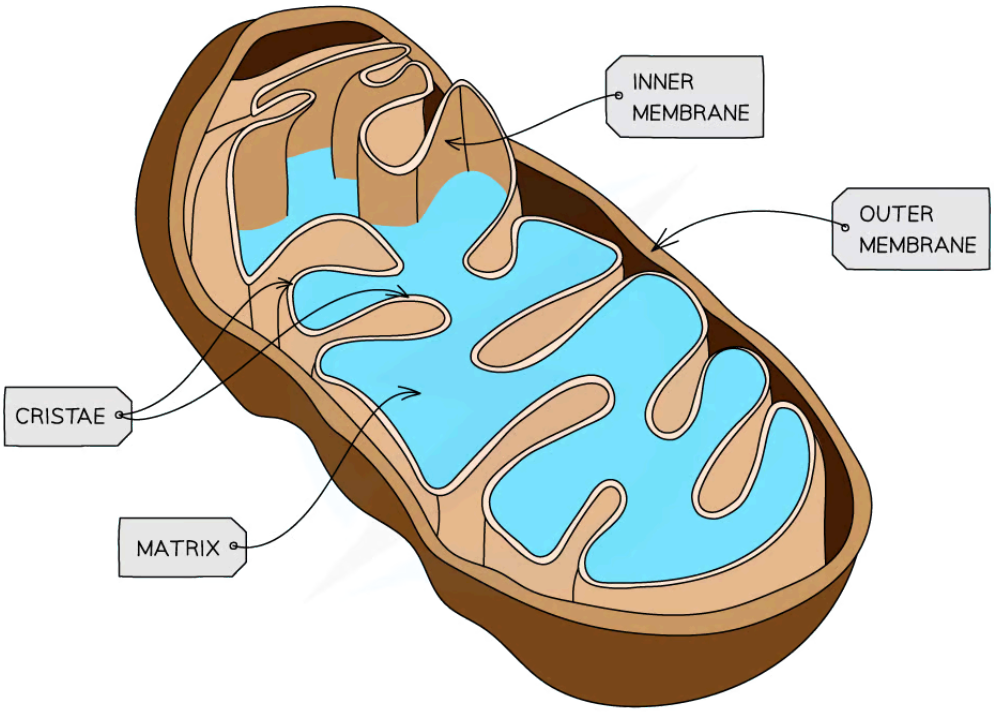
- Present in all eukaryotic cells, the nucleus is relatively large and separated from the cytoplasm by a double membrane (the **nuclear envelope)** which has many pores
- Nuclear pores are important channels for allowing mRNA and ribosomes to travel out of the nucleus, as well as allowing enzymes (eg. DNA polymerases) and signalling molecules to travel in
- The nucleus contains **chromatin** (the material from which chromosomes are made)
- Usually, at least one or more darkly stained regions can be observed – these regions are individually termed 'nucleolus' and are the sites of ribosome production

## Mitochondria



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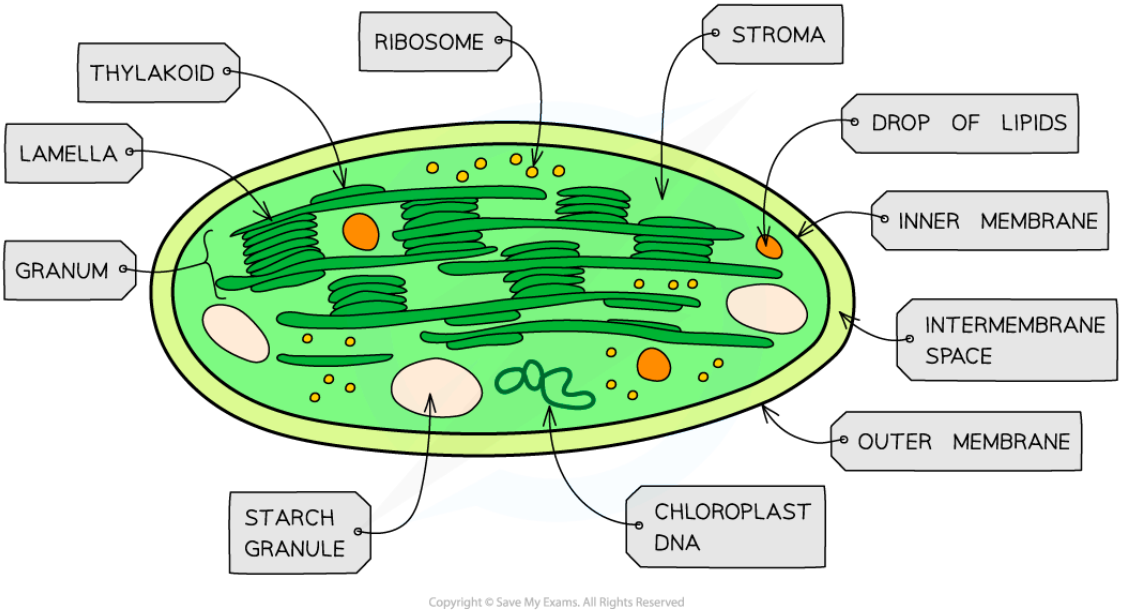
***A single mitochondrion is shown – the inner membrane has protein complexes vital for the later stages of aerobic respiration embedded within it***

- The site of aerobic respiration within eukaryotic cells, mitochondria are just visible with a light microscope
- Surrounded by double-membrane with the inner membrane folded to form **cristae**
- The matrix formed by the cristae contains enzymes needed for **aerobic respiration,** producing **ATP**
- Small circular pieces of **DNA** (mitochondrial DNA) and ribosomes are also found in the matrix (needed for replication)

## Chloroplast



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***Chloroplasts are found in the green parts of a plant – the green colour a result of the photosynthetic pigment chlorophyll***

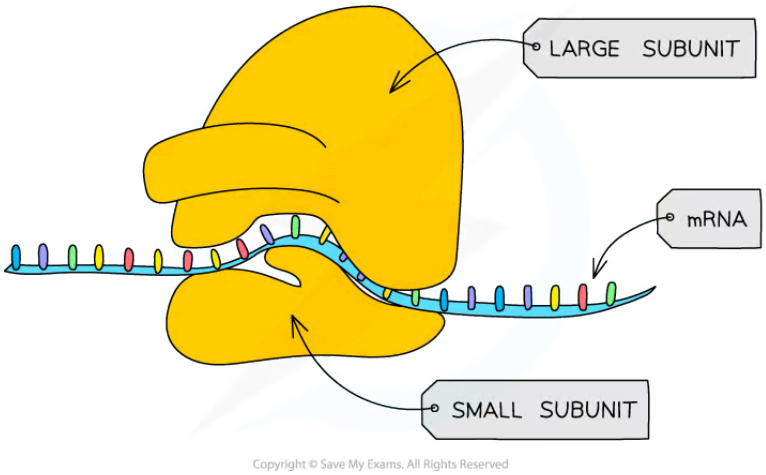
- Larger than mitochondria, also surrounded by a **double-membrane**
- Membrane-bound compartments called **thylakoids** containing chlorophyll stack to form structures called **grana**
- Grana are joined together by **lamellae** (thin and flat thylakoid membranes)
- Chloroplasts are the site of **photosynthesis**:
  - The **light-dependent stage** takes place in the thylakoids
  - The **light-independent stage** (Calvin Cycle) takes place in the **stroma**
- Also contain small circular pieces of **DNA** and ribosomes used to synthesise proteins needed in chloroplast replication and photosynthesis

## Ribosome

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***Ribosomes are formed in the nucleolus and are composed of almost equal amounts of RNA and protein***

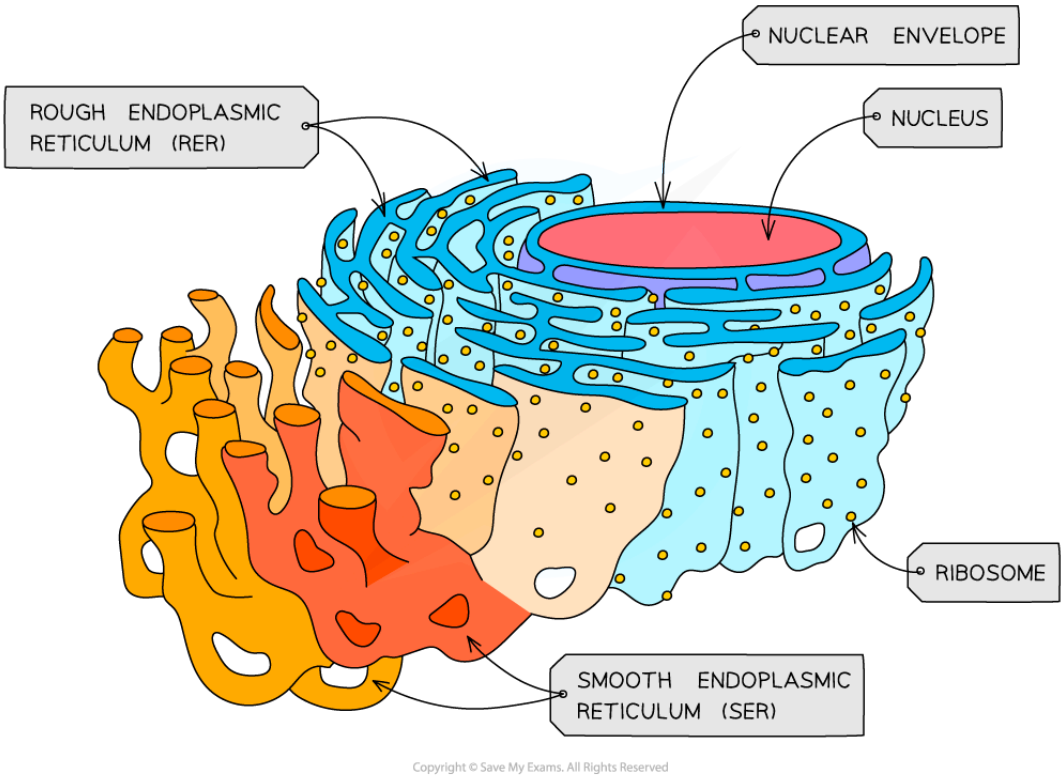
- Found freely in the cytoplasm of all cells or as part of the **rough endoplasmic reticulum** in eukaryotic cells
- Each ribosome is a complex of **ribosomal RNA (rRNA)** and proteins
- 80S ribosomes (composed of 60S and 40S subunits) are found in eukaryotic cells
- 70S (composed of 50S and 30S subunits) ribosomes in prokaryotes, mitochondria and chloroplasts
- Site of translation (**protein synthesis)**

## Endoplasmic reticulum



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***The RER and ER are visible under the electron microscope – the presence or absence of ribosomes helps to distinguish between them***

**Rough Endoplasmic Reticulum (RER)**

- Surface covered in **ribosomes**
- Formed from continuous folds of membrane continuous with the **nuclear envelope**
- Involved in the processing and transportation of proteins made by the **ribosomes**

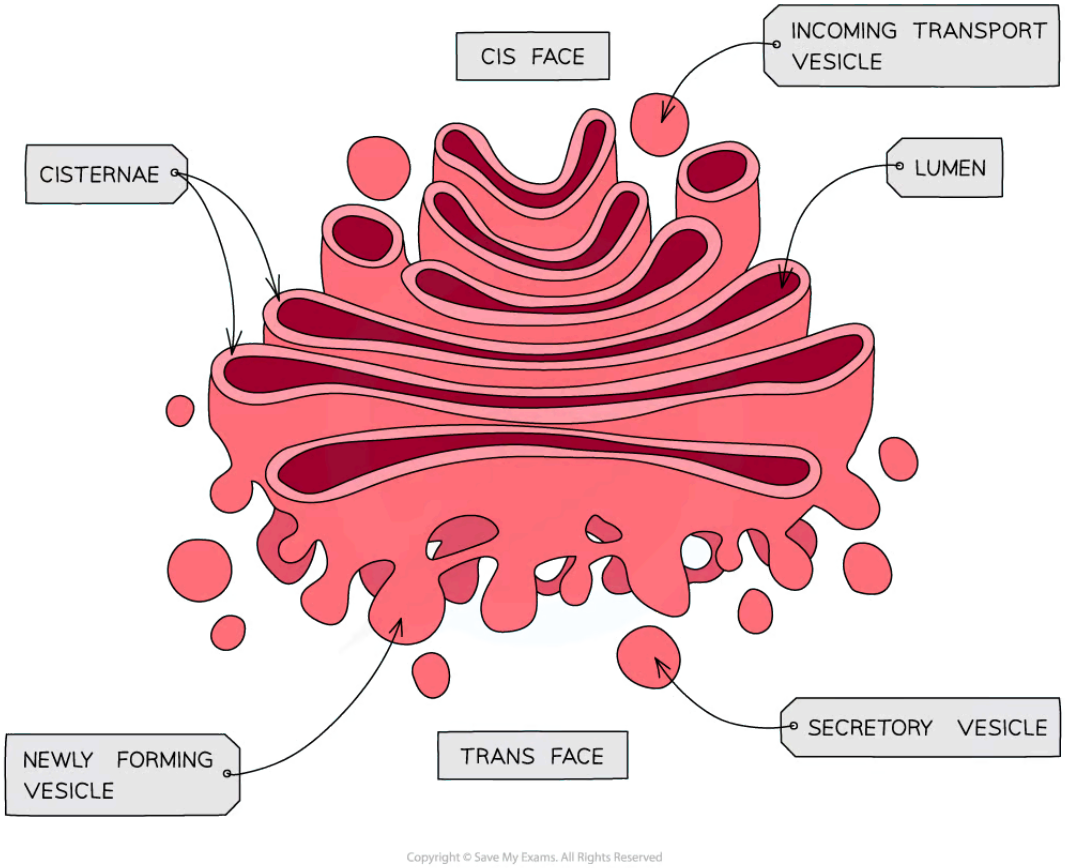
**Smooth Endoplasmic Reticulum (ER)**

- Does not have ribosomes on the surface, its function is distinct to the RER
- Involved in the production, processing, transportation and storage of **lipids, carbohydrates** and **steroids**

## Golgi apparatus (golgi complex)



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*The structure of the Golgi apparatus*

- Flattened sacs of membrane similar to the smooth endoplasmic reticulum
- Modifies proteins and packages them into vesicles or lysosomes

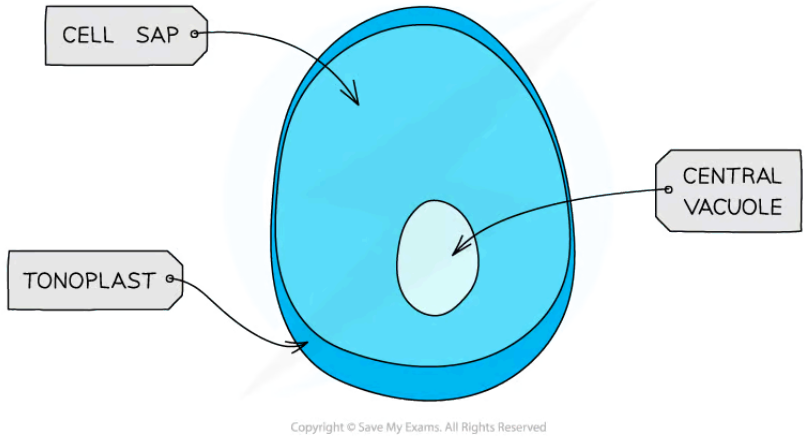
## Large permanent vacuole

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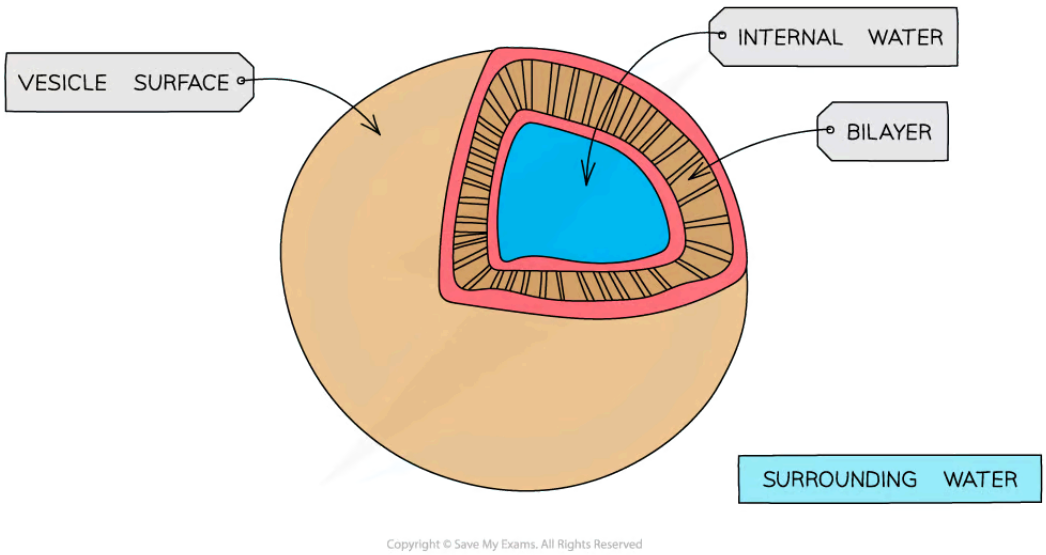


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*The structure of the vacuole*

- Sac in plant cells surrounded by the **tonoplast**, selectively permeable membrane
- Vacuoles in animal cells are not permanent and small

## Vesicle



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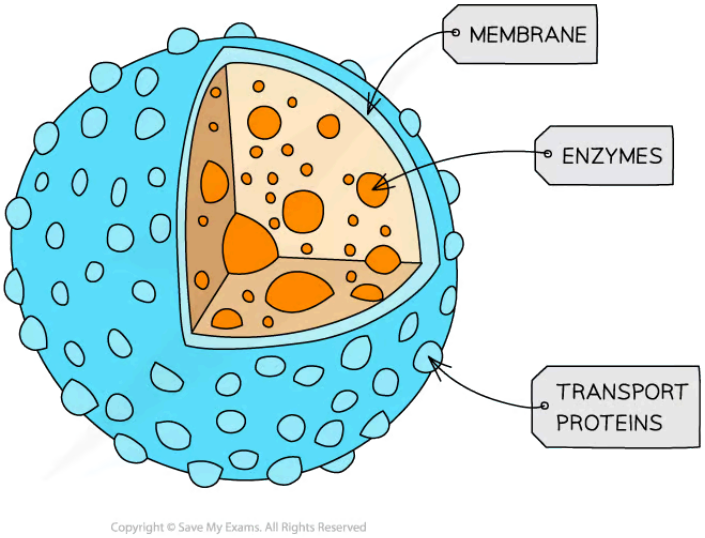
*The structure of the vesicle*

- Membrane-bound sac for transport and storage

## Lysosome



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*The structure of the lysosome*

- Specialist forms of vesicles which contain **hydrolytic enzymes** (enzymes that break biological molecules down)
- Break down waste materials such as worn-out organelles, used extensively by cells of the **immune system** and in **apoptosis** (programmed cell death)

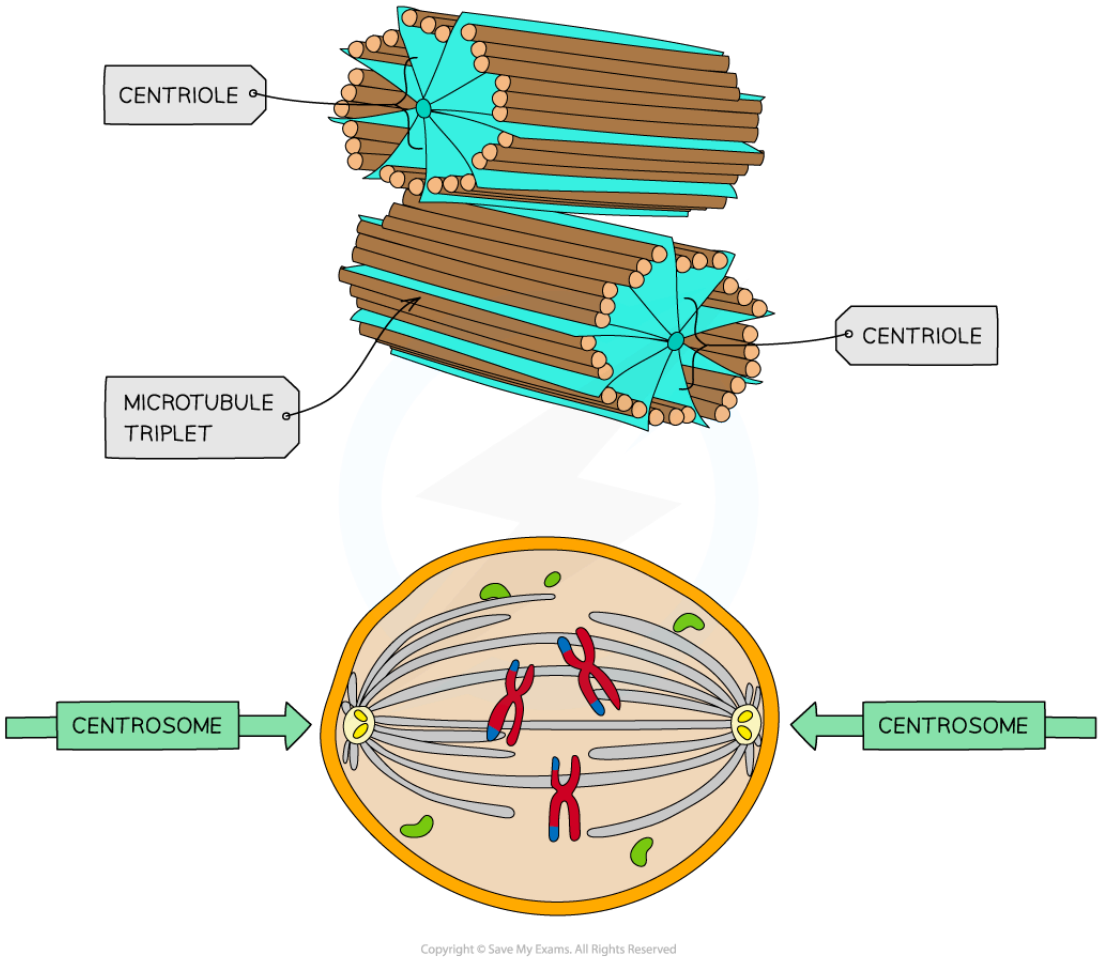
## Centriole

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*The structure of the centriole*

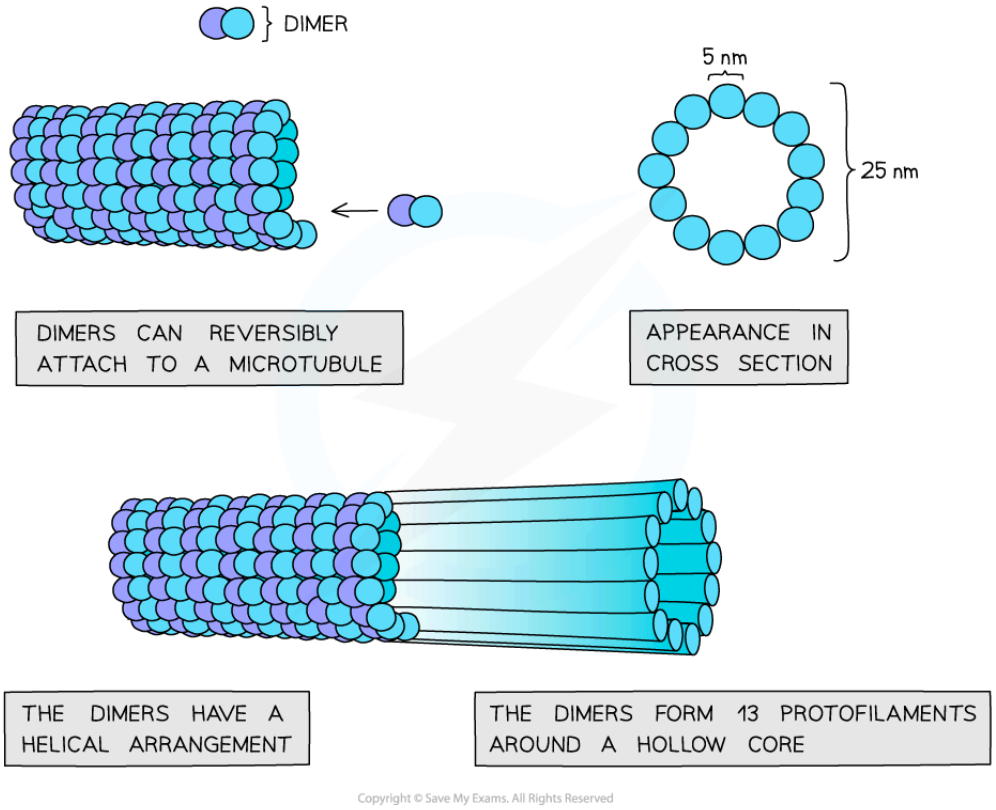
- Hollow fibres made of **microtubules,** two centrioles at right angles to each other form a **centrosome**, which organises the **spindle fibres** during cell division
- Not found in flowering plants and fungi

## Microtubules



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***The structure of the microtubule***

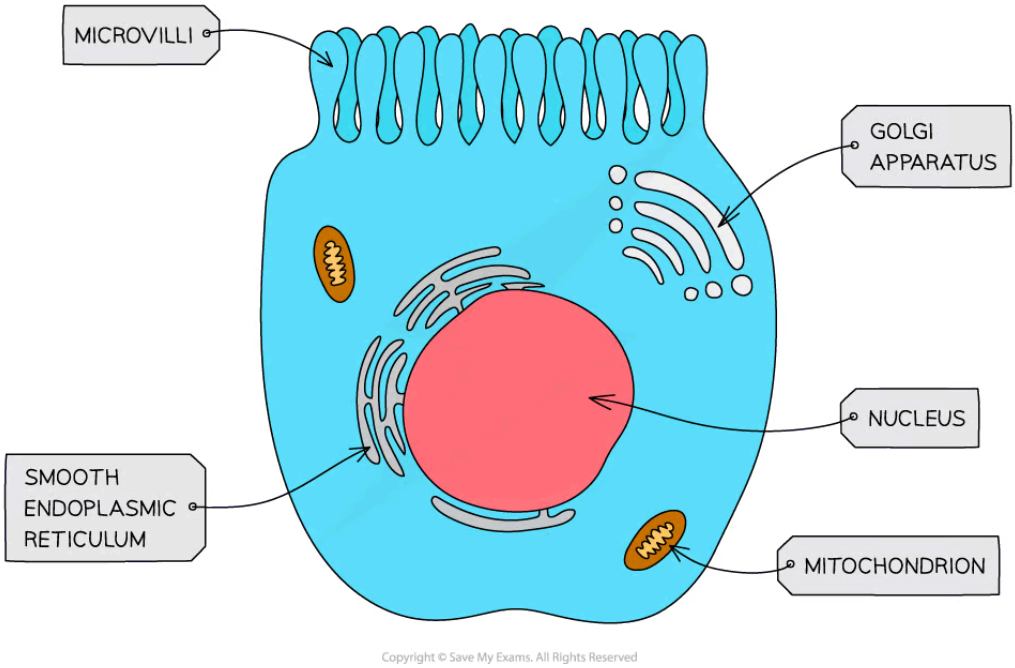
- Makes up the cytoskeleton of the cell about 25 nm in diameter
- Made of α and β tubulin combined to form dimers, the dimers are then joined into protofilaments. Thirteen protofilaments in a cylinder make a microtubule
- The cytoskeleton is used to provide support and movement of the cell

## Microvilli



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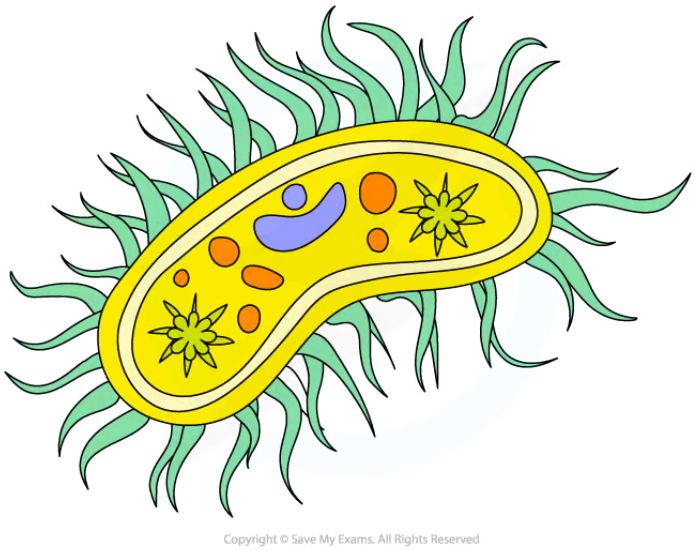


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*The structure of the microvilli*

- Cell membrane projections that increase the **surface area** for absorption

### Cilia


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*The structure of the cilia*

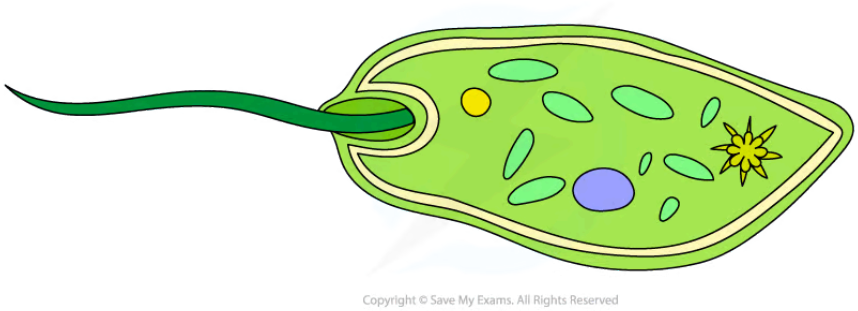


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- Hair-like projections made from **microtubules**
- Allows the movement of substances over the cell surface

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## Flagella




***The structure of the flagella***

- Similar in structure to **cilia**, made of longer **microtubules**
- Contract to provide cell movement for example in **sperm cells**

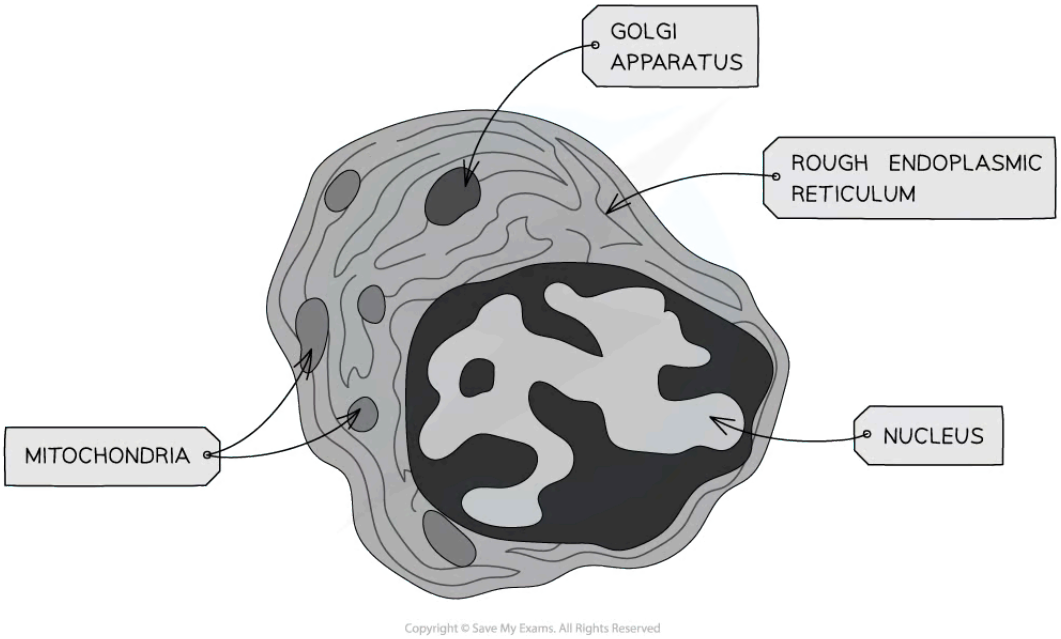


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# 1.2.2 Animal & Plant Cells

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## Electron Micrographs: Animal Cells




*TEM electron micrograph of an animal cell showing key features*

### Examiner Tip

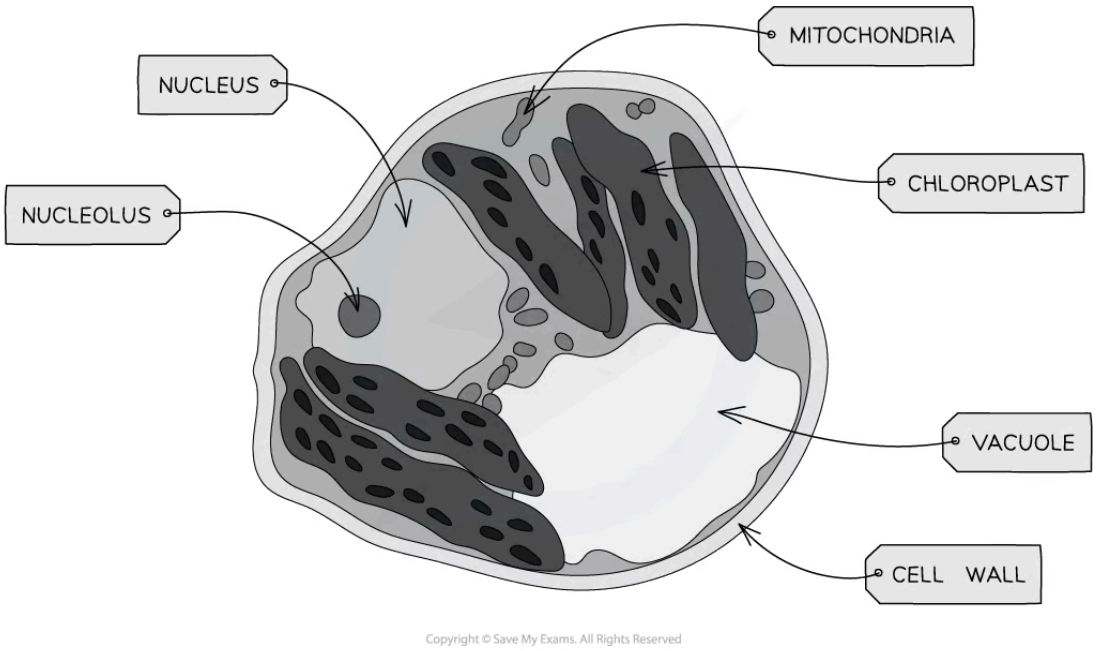
You should be able to describe and interpret photomicrographs, electron micrographs and drawings of typical animal cells.



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## Electron Micrographs: Plant Cells

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*TEM electron micrograph of a plant cell showing key features*

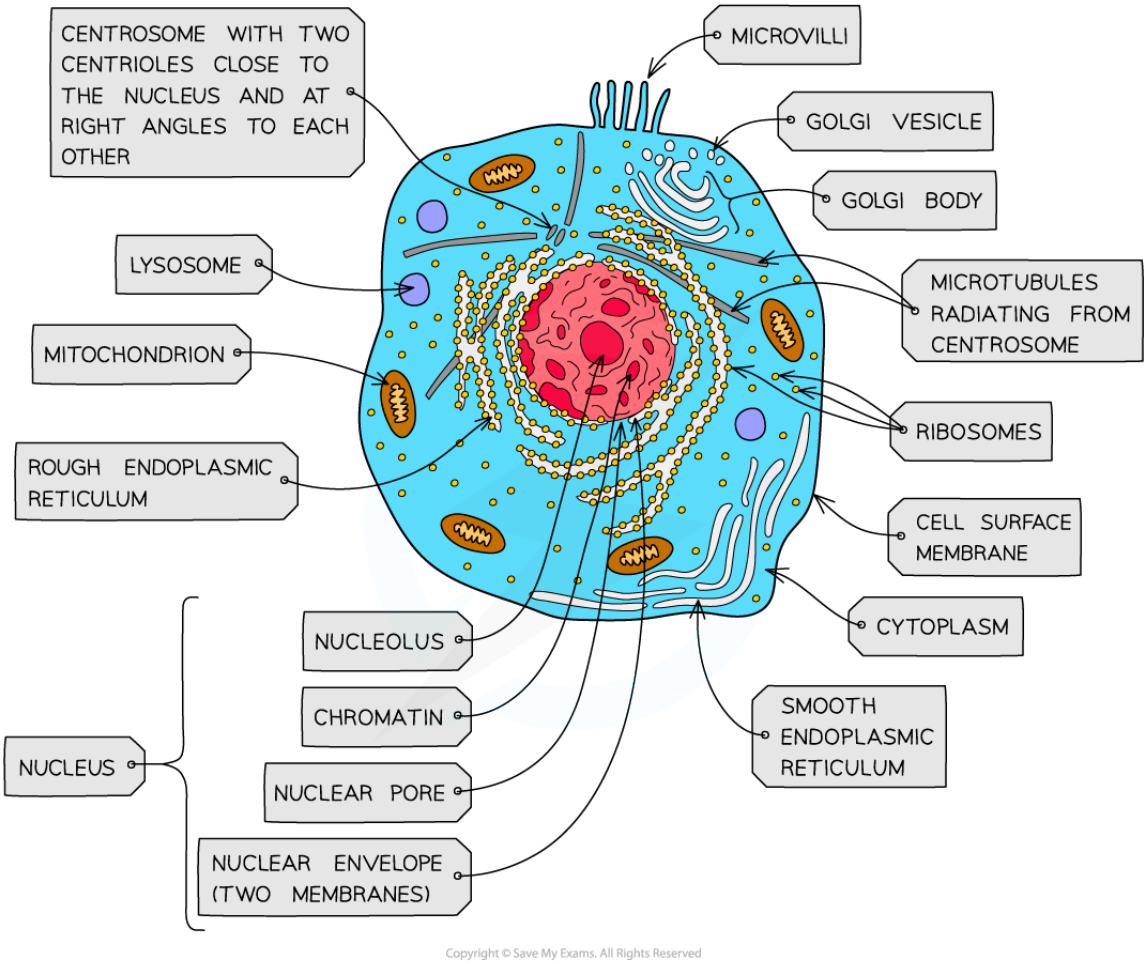


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## Structure of Animal & Plant Cells

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- The only structures found in animal cells but not plant cells are the **centrioles** and **microvilli**
- Plant cells also have additional structures: the cellulose cell wall, large permanent **vacuoles** and **chloroplasts**

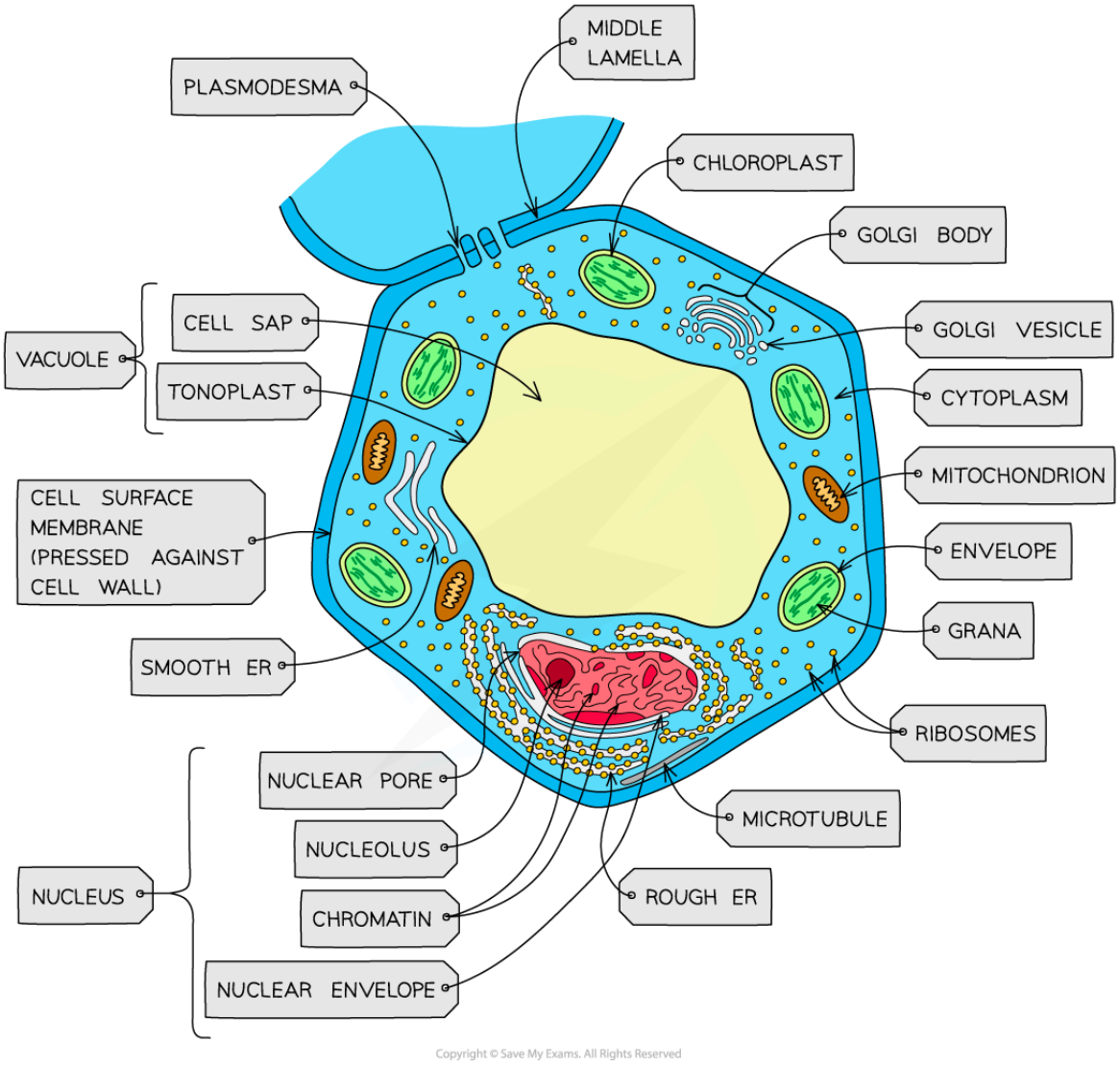



***The ultrastructure of an animal cell shows a densely packed cell – the ER and RER and ribosomes form extensive networks throughout the cell in reality***



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*Plant cells have a larger, more regular structure in comparison to animal cells*



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# 1.2.3 The Vital Role of ATP


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## The Vital Role of ATP

- All organisms require a **constant supply of energy** to maintain their cells and stay alive
- This energy is required:
  - In **anabolic** reactions – building larger molecules from smaller molecules
  - To **move substances** across the cell membrane (active transport) or to move substances within the cell
  - In animals, energy is required:
    - For **muscle contraction** – to coordinate movement at the whole-organism level
    - In the **conduction of nerve impulses**, as well as many other cellular processes
- In all known forms of life, ATP from respiration is used to transfer energy in **all energy-requiring processes** in cells
- This is why ATP is known as the **universal energy currency**
- **Adenosine Triphosphate (ATP)** is a nucleotide
  - The monomers of DNA and RNA are also nucleotides



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# 1.2.4 Prokaryotic v Eukaryotic Cells


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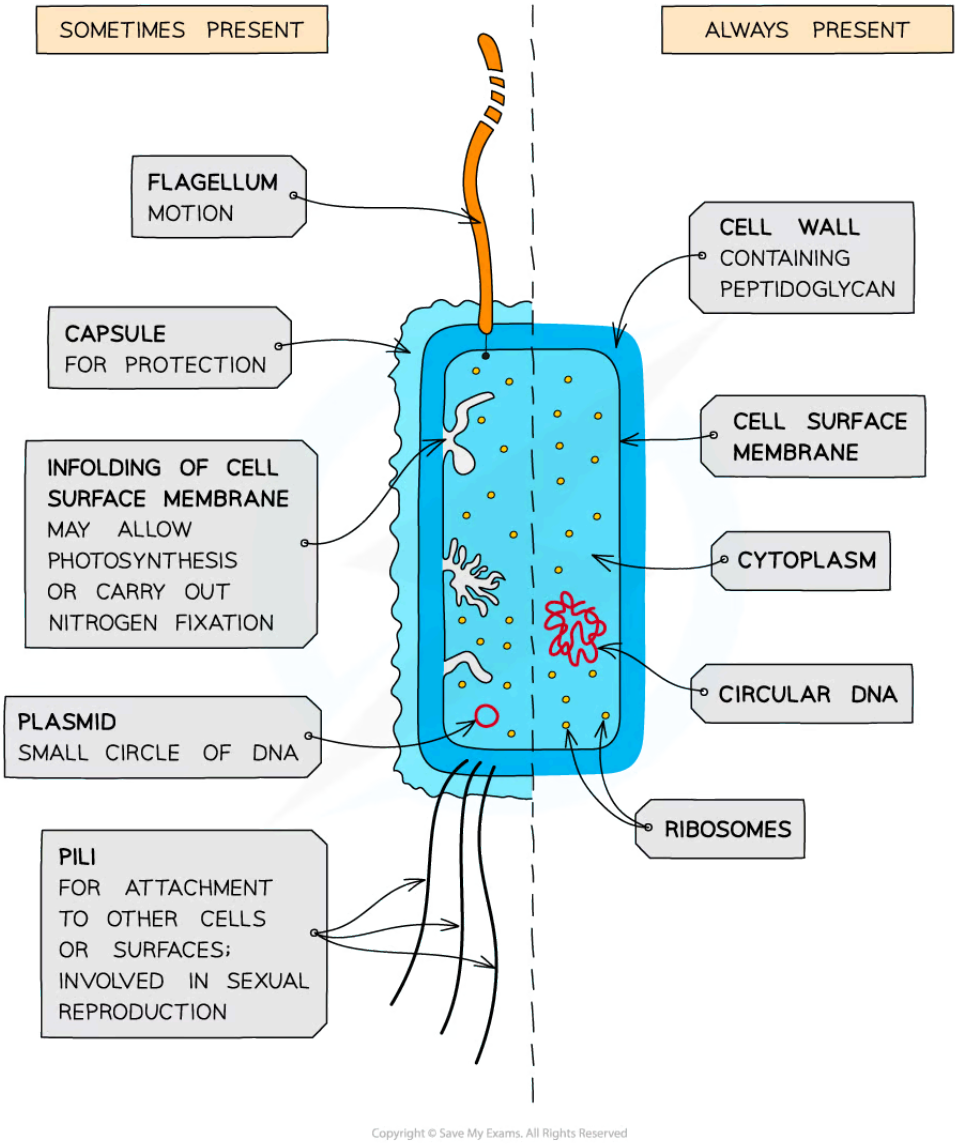
## Structural Features of Typical Prokaryotic Cells

- Animal and plant cells are types of **eukaryotic** cells, whereas bacteria are a type of **prokaryote**
- Prokaryotes have a cellular structure distinct from eukaryotes:
  - Their **genetic material** is not packaged within a membrane-bound nucleus and is usually circular (eukaryotic genetic material is packaged as linear chromosomes)
  - Prokaryotes lack membrane-bound **organelles**
  - They are many (100s/1000s) of times smaller than eukaryotic cells
  - Their **ribosomes** are structurally smaller (70 S) in comparison to those found in eukaryotic cells (80 S)



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*Prokaryotic cells are often described as being 'simpler' than eukaryotic cells, and they are believed to have emerged as the first living organisms on Earth*



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# Prokaryotic v Eukaryotic Cell Structures

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**Prokaryotic & Eukaryotic Cells Comparison Table**

| FEATURE | PROKARYOTES | EUKARYOTES |
|---|---|---|
| SIZE | 0.5 – 5 μm DIAMETER | UP TO 100 μm DIAMETER |
| GENOME | DNA CIRCULAR WITH NO PROTEINS, IN THE CYTOPLASM | DNA IS ASSOCIATED WITH HISTONES (PROTEINS) FORMED INTO CHROMOSOMES |
| CELL DIVISION | OCCURS BY BINARY FISSION, NO SPINDLE INVOLVED | OCCURS BY MITOSIS OR MEIOSIS AND INVOLVES A SPINDLE TO SEPARATE CHROMOSOMES |
| RIBOSOMES | 70S RIBOSOMES | 80S RIBOSOMES |
| ORGANELLES | VERY FEW<br>NO MEMBRANE-BOUND ORGANELLES. | NUMEROUS TYPES OF ORGANELLES<br>MEMBRANE-BOUND<br>SINGLE MEMBRANES: LYSOSOMES, GOLGI COMPLEX, VACUOLES<br>DOUBLE MEMBRANES: NUCLEUS, MITOCHONDRIA, CHLOROPLAST<br>NO MEMBRANE: RIBOSOMES, CENTRIOLES, MICROTUBULES |
| CELL WALL | MADE OF PEPTIDOGLYCAN (POLYSACCHARIDE AND AMINO ACIDS) AND MUREIN | PRESENT IN PLANTS (MADE OF CELLULOSE OR LIGNIN) AND FUNGI (MADE OF CHITIN, SIMILAR TO CELLULOSE BUT CONTAINS NITROGEN) |

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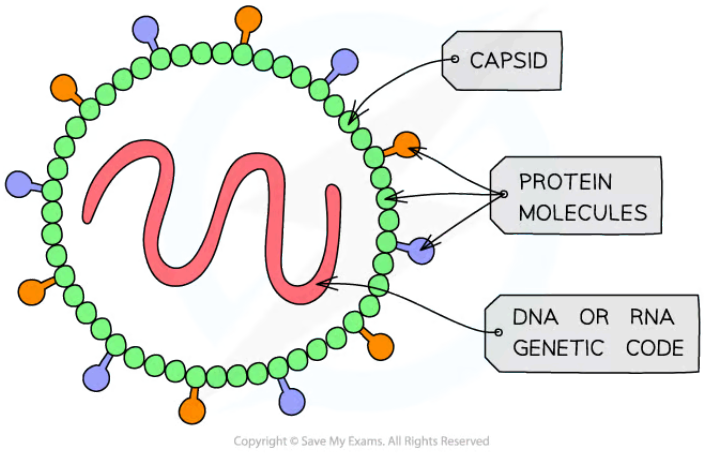
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# 1.2.5 Viruses

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## Key Features of Viruses

- **Viruses** are **non-cellular infectious particles** that straddle the boundary between 'living' and 'non-living'
- They are relatively simple in structure; much smaller than prokaryotic cells (with diameters between 20 and 300 nm)
- Structurally they have:
  - **A nucleic acid core** (their genomes are either DNA or RNA, and can be single or double-stranded)
  - **A protein coat called a 'capsid'**
- Some viruses have an outer layer called an envelope formed usually from the **membrane-phospholipids** of a cell they were made in
- All viruses are **parasitic** in that they can only reproduce by infecting living cells and using their protein-building machinery (ribosomes) to produce new viral particles



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***Viruses are not cellular like prokaryotes and eukaryotes – this is just one example of a virus structure***


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