TOPIC: CELL STRUCTURE

Key Knowledge:

- Cells as the basic structural unit of life, including the distinction between prokaryotes and eukaryotes
- The structure and specialisation of plant and animal cell organelles for distinct functions, including chloroplasts and mitochondria

CELLS

All cells share four basic features:

- They are enclosed by a **membrane**, which separates internal contents from the external environment
- They contain an internal fluid called the **cytosol**, in which various biological processes are able to occur
- There is **genetic material**, which functions as a set of instructions (i.e. a blueprint) for cellular activity
- They possess **ribosomes**, which function to translate specific genetic instructions within the cell

TYPES OF CELLS

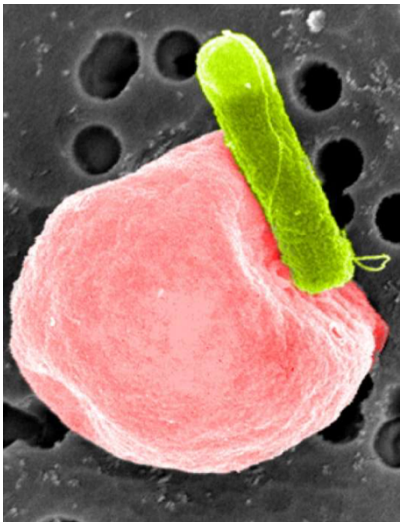
Cells can be categorised into either of two main groups:

Prokaryotes:

- Usually unicellular and lack compartmentalisation
- Do not possess a nucleus or membrane bound organelles
- DNA is circular, unpackaged (naked) and usually lacks introns
- Cells are smaller in size (~1–5μm) and contain 70S ribosomes

Eukaryotes:

- Have compartmentalised structures and may be multicellular
- Possess a nucleus and numerous membrane bound organelles
- DNA is linear, packaged with histone proteins and contain introns
- Cells are larger in size (~10–100μm) and contain 80S ribosomes



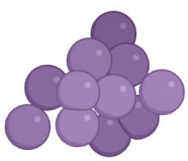
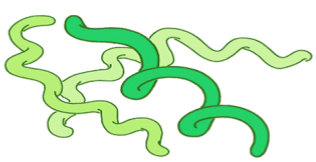
Eukaryotic vs **Prokaryotic** Cell

PROKARYOTIC CLASSIFICATION

Prokaryotes are typically unicellular organisms that are classified into two distinct domains:

- **Bacteria:** A diverse domain that includes all traditional bacterial species (including all pathogenic forms)
- **Archaea:** Includes most extremophiles (found in adverse environments – like high temperatures)

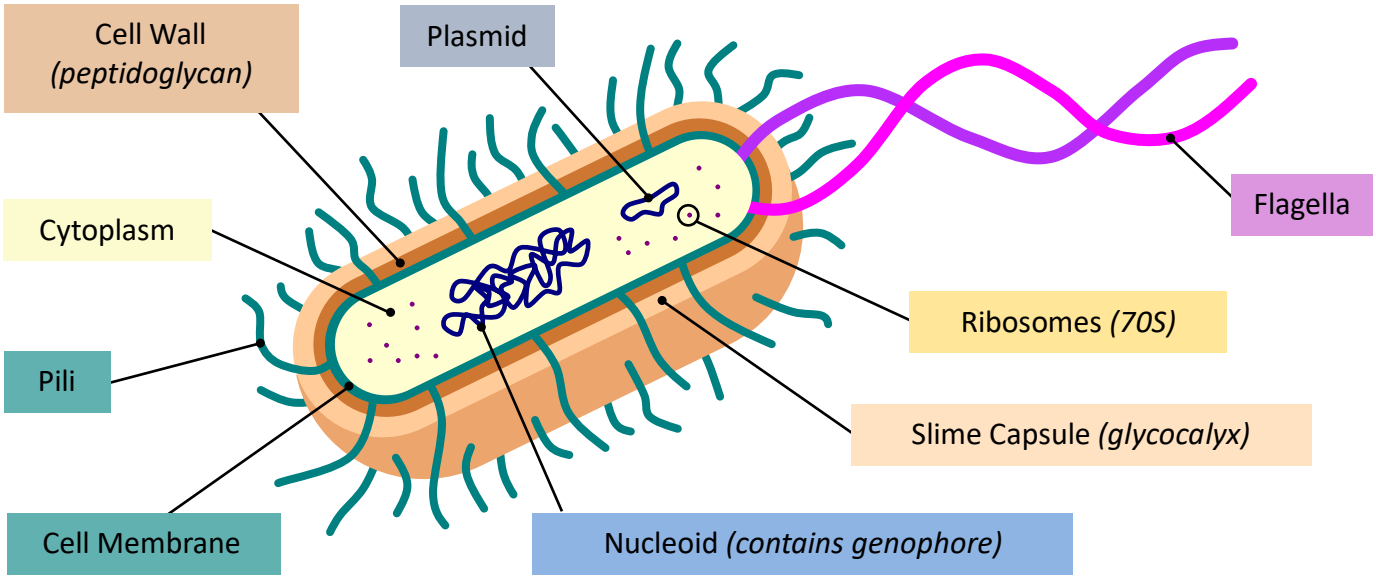
Bacterial species can be further categorised according to a variety of structural or functional conditions; including **shape** *(spheres vs rods vs spirals vs other)*, **nutritional patterns** *(autotrophic vs heterotrophic)*, **gaseous requirements** *(anaerobic vs aerobic)* and **cell wall composition** *(Gram negative vs Gram positive)*

COMMON BACTERIAL SHAPES		
		
Coccus *(spherical)*	**Bacillus** *(rod)*	**Spirillus** *(spiral)*

PROKARYOTIC ULTRASTRUCTURE

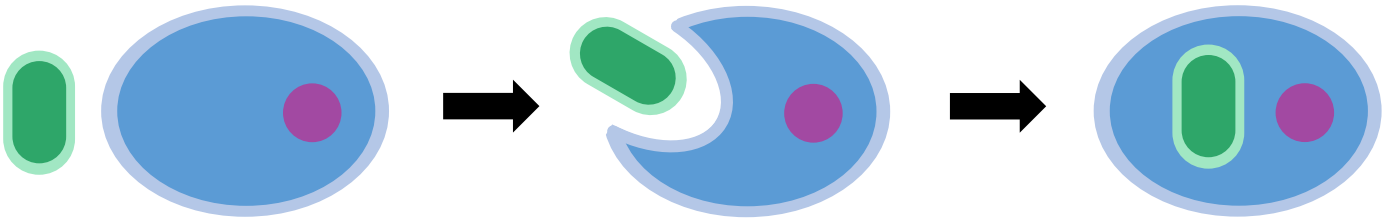
Prokaryotic cells will typically demonstrate a number of distinctive cellular components:

- Prokaryotes contain a single circular chromosome *(genophore)* located in a region called the **nucleoid**
- Bacteria may also contain autonomous circular DNA molecules called **plasmids** that can be transferred
- Hair-like extensions called **pili** enable surface attachments or facilitate plasmid exchange *(conjugation)*
- Long, slender projections called **flagella** contain motor proteins that allow for bacterial movement
- They possess a rigid **cell wall** that is made of peptidoglycan in bacteria *(helps to maintain cell shape)*
- Some bacteria may contain an additional protective surface layer called a **slime capsule** *(glycocalyx)*



ENDOSYMBIOSIS

Eukaryotic cells are believed to have evolved from prokaryotic cells via the theory of endosymbiosis. According to this theory, an early bacterium was engulfed by another prokaryote via phagocytosis, but the engulfed cell **remained undigested** and contributed **new functionality** to the cell. Over time, the engulfed cell lost some of its independent utility and became an organelle (e.g. chloroplast or mitochondrion).



EVIDENCE FOR ENDOSYMBIOSIS

Mitochondria and chloroplasts both contain evidence that supports the concept that these organelles were once independent prokaryotic cells

- **Membranes:** They have double membranes (consistent with phagocytosis)
- **Antibiotics:** They are susceptible to chemicals that harm bacterial cells
- **Division:** Both organelles divide via a fission-like process (similar to bacteria)
- **DNA:** They have their own DNA (which is circular and unpackaged)
- **Ribosomes:** Both organelles contain 70S ribosomes (found in prokaryotes)

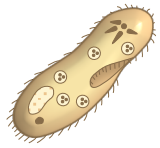
Hint: MAD DR

EUKARYOTIC CLASSIFICATION

Eukaryotes are organisms whose cells contain a **nucleus** and belong to the domain **Eukarya**. They may be unicellular or multicellular, and their cells are compartmentalised by **membrane-bound organelles**.

Eukaryotic organisms can be divided into four distinct kingdoms:

- **Protists:** Includes various unicellular organisms and multicellular organisms that lack specialised tissue
- **Fungi:** Have cell walls made of chitin and obtain nutrition via heterotrophic absorption *(decomposers)*
- **Plants:** Have cell walls made of cellulose and obtain nutrition autotrophically via photosynthesis
- **Animals:** Lack a cell wall and obtain nutrition via heterotrophic ingestion *(consumers)*

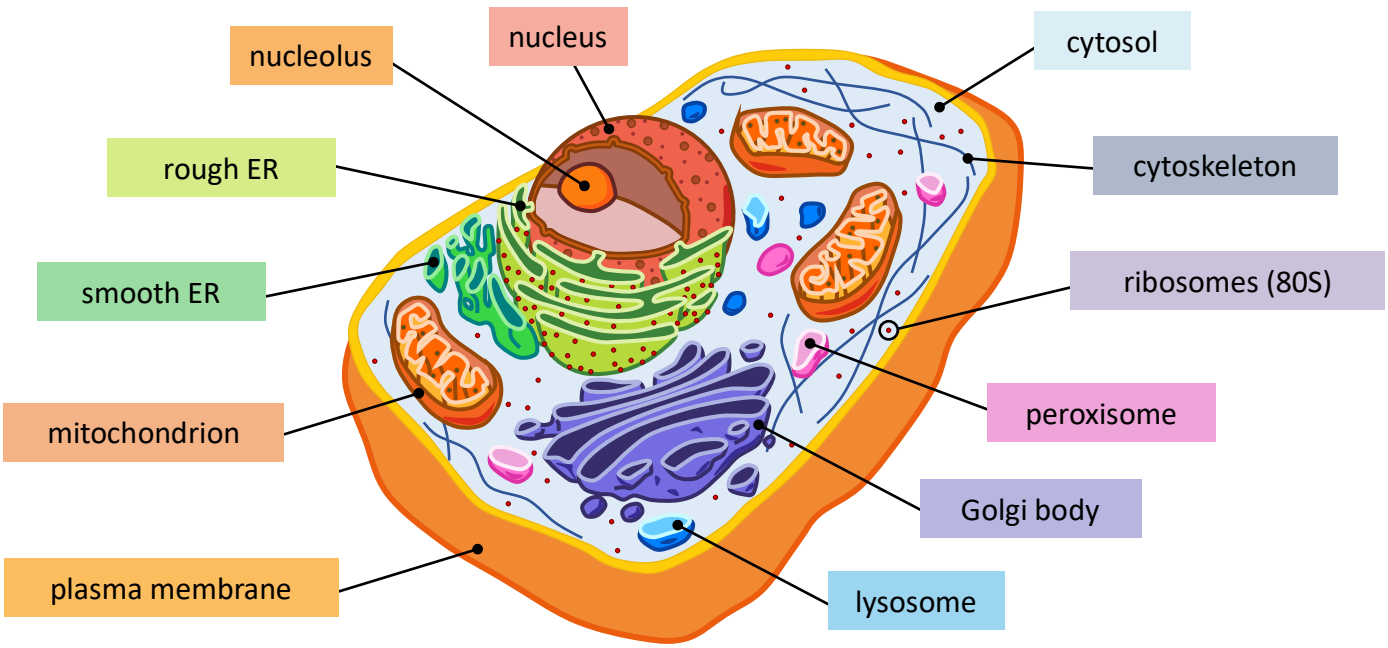
EUKARYOTIC KINGDOMS			
			
Protist	**Fungi**	**Plant**	**Animal**

ANIMAL CELL ULTRASTRUCTURE

Animal cells will typically demonstrate a number of distinctive cellular components:

- Eukaryotic cells have a double-membrane **nucleus** that stores the genetic material as chromatin
- Within the nucleus is a region called the **nucleolus**, which is the site of ribosome assembly
- The **mitochondrion** is the site of aerobic respiration and is responsible for ATP production
- **Lysosomes** break down cell components, whereas **peroxisomes** break down toxic metabolites
- **Centrosomes** produce microtubule spindle fibres and are involved in the process of cell division
- A membrane network called the **endoplasmic reticulum** transports materials between organelles
- The **rough ER** is embedded with ribosomes and transports proteins, while **smooth ER** transports lipids
- The **Golgi complex** is a series of membrane stacks and vesicles that act to export materials from cells

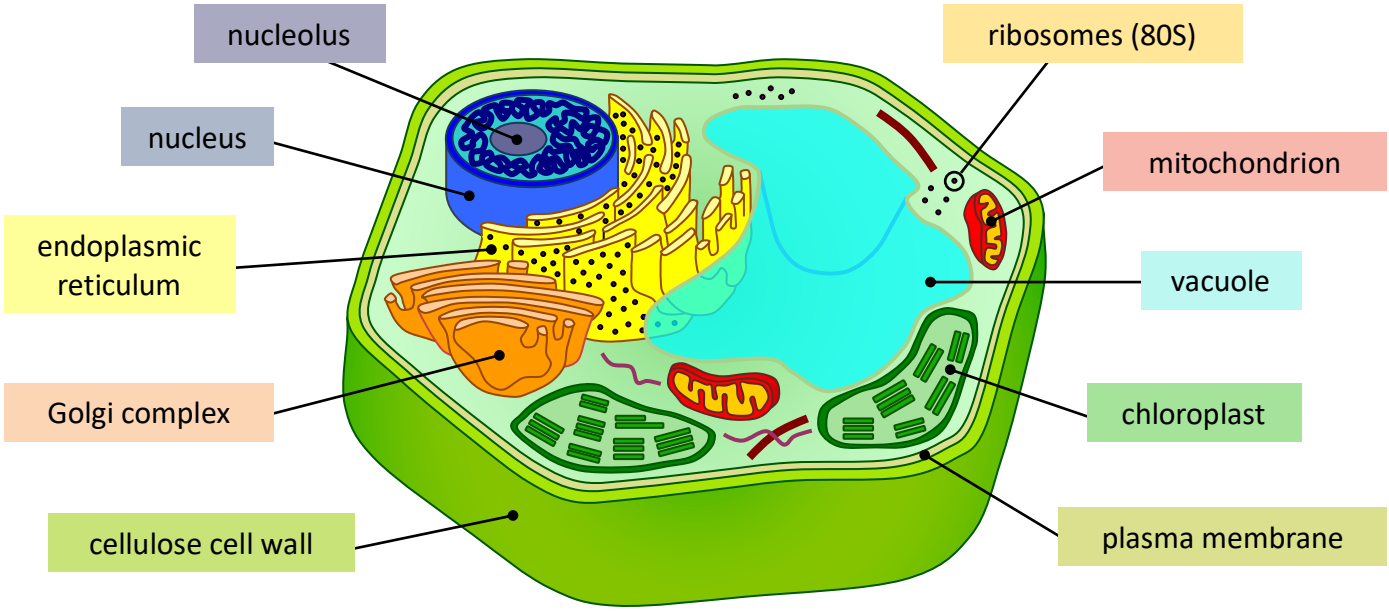
Certain organelles may be more frequent in specific animal tissues, in order to optimise the tissue function



PLANT CELL ULTRASTRUCTURE

Plant cells possess a number of additional cellular components that are distinctive to animal cells:

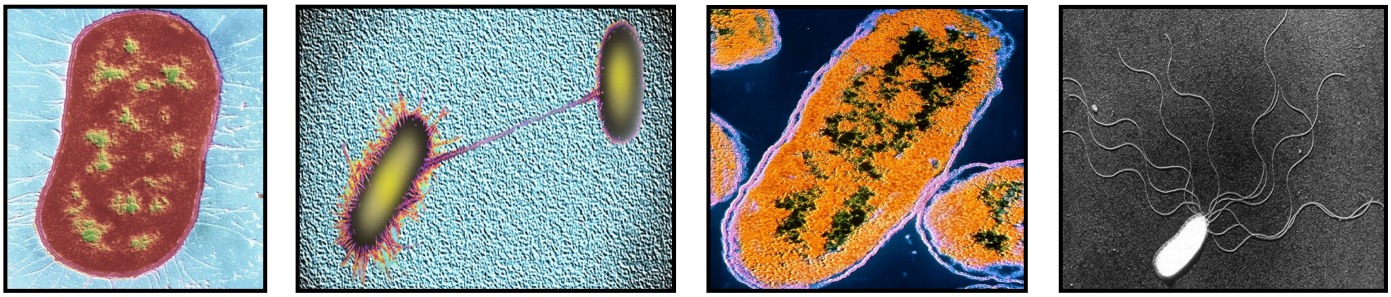
- They contain a rigid **cell wall** made of cellulose to provide support and prevent excess water uptake
- They have a **large, central vacuole** that helps to maintain hydrostatic pressure within the cell
- The leaf tissue will contain **chloroplasts** which are responsible for the process of photosynthesis



CELL MICROGRAPHS

Sub-cellular structures can be identified using electron microscopes and used to determine types of cells.

Prokaryotic Cell Micrographs: **1** = Nucleoid **;** **2** = Sex Pili *(Conjugation)* **;** **3** = Cell Wall **;** **4** = Flagella



Eukaryotic Cell Micrographs: **L**eft = Animal Cell **;** **R**ight = Plant Cell