4. CELL BIOLOGY

4.1.1 Cell structure

4.1.1.1 Eukaryotes and prokaryotes

Prokaryotic cell

- **Definition**: Simple, small cells with **no nucleus** or membrane-bound organelles.
- **Examples**: Bacteria and Archaea.
- **Key Features**:
    - DNA is free in the cytoplasm (in a single circular chromosome, sometimes plasmids).
    - Cell wall (made of peptidoglycan in bacteria).
    - No mitochondria or chloroplasts.
    - Ribosomes are smaller (70S).
    - Divide by **binary fission**.
    - Generally much smaller (1–5 μm).

🧬 Eukaryotic Cells

- **Definition**: Larger, more complex cells with a **true nucleus** and membrane-bound organelles.
- **Examples**: Plant cells, animal cells, fungi, protists.
- **Key Features**:
    - DNA enclosed within a **nucleus**.
    - Membrane-bound organelles (mitochondria, chloroplasts, ER, Golgi, etc.).
    - Ribosomes are larger (80S).

- Some have a cell wall (plants: cellulose; fungi: chitin).
- Divide by **mitosis or meiosis**.
- Larger in size (10–100 μm).

📊 Comparison Table

Feature	Prokaryotic Cells	Eukaryotic Cells
Size	Small (1–5 μm)	Larger (10–100 μm)
Nucleus	No (DNA free in cytoplasm)	Yes (DNA inside nucleus)
DNA form	Circular, plasmids present	Linear chromosomes
Organelles	No membrane-bound organelles	Many membrane-bound organelles
Ribosomes	Small (70S)	Large (80S)
Cell wall	Present (peptidoglycan)	Plants (cellulose), fungi (chitin), animals (none)
Division	Binary fission	Mitosis or meiosis
Examples	Bacteria, Archaea	Animals, Plants, Fungi, Protists

Order of Magnitude

Definition:
An **order of magnitude** is a way of expressing the size or scale of something in powers of ten.
It shows how many times bigger or smaller one object is compared with another.

📏 Key Points

- If one object is about **10 times bigger** than another, it is **one order of magnitude** larger.
- If it is about **100 times bigger**, it is **two orders of magnitude** larger.

- If it is about **1000 times bigger**, it is **three orders of magnitude** larger.

🧪 Examples

- A typical **animal cell ≈ 10–30 µm**.
- A typical **bacterium (prokaryotic cell) ≈ 1 µm**.
    - So, animal cells are roughly **10 times bigger → one order of magnitude larger**.
- A **nucleus ≈ 6 µm**, compared to a **mitochondrion ≈ 1–2 µm**.
    - The nucleus is around **10 times bigger → one order of magnitude larger**.

⚡ Simple Rule

- **10 times difference → 1 order of magnitude**
- **100 times difference → 2 orders of magnitude**
- **1000 times difference → 3 orders of magnitude**, and so on.

🦠 Bacterial Cell Structure

🔑 Main Features

1. **Cell Wall**
    - Made of **peptidoglycan (murein)** (not cellulose like plants).
    - Provides strength and support, stops the cell bursting in dilute solutions.
2. **Cell Membrane**
    - Controls movement of substances in and out of the cell.
3. **Cytoplasm**
    - Jelly-like fluid where most chemical reactions take place.

- Contains ribosomes for protein synthesis.

4. **Ribosomes**
    - Smaller than in eukaryotes (70S).
    - Site of protein synthesis.
5. **DNA (Genetic Material)**
    - **No nucleus** → DNA is free in the cytoplasm.
    - Usually a **single circular chromosome**.
    - May also contain **plasmids** (small, extra loops of DNA that carry useful genes e.g. antibiotic resistance).
6. **Plasmids**
    - Independent small DNA molecules.
    - Can be transferred between bacteria.
7. **Slime Capsule** (in some bacteria)
    - A protective layer outside the cell wall.
    - Helps bacteria stick to surfaces.
    - Protects from drying out and attack by white blood cells.
8. **Flagellum (plural: Flagella)** (in some bacteria)
    - A whip-like tail used for movement.
9. **Pili** (in some bacteria)
    - Hair-like structures for attaching to surfaces or other cells.
    - Can also help in transferring DNA between bacteria.

📊 Summary Table

Structure	Function
Cell wall	Strength and protection (peptidoglycan).
Cell membrane	Controls entry/exit of substances.
Cytoplasm	Site of reactions.
Ribosomes (70S)	Protein synthesis.
DNA (chromosome)	Stores genetic instructions.
Plasmids	Extra genes (e.g., antibiotic resistance).
Slime capsule	Protection, helps stick to surfaces.
Flagella	Movement.
Pili	Attachment, DNA transfer.

⚡ **Exam tip (AQA GCSE)**:

- **Bacterial cells DO NOT have**: a nucleus, mitochondria, or chloroplasts.
- Instead, everything happens in the **cytoplasm** (including respiration).

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