Eukaryotes and prokaryotes

4.1.1.1 · Cell biology · revision notes

Every cell is either eukaryotic, with its genetic material enclosed in a nucleus (animal and plant cells), or prokaryotic, with no nucleus (bacteria). Expect recall and 'compare' questions on cell structure, and short calculations on cell sizes using μm, nm, standard form and orders of magnitude.

Key facts

- Eukaryotic cell: genetic material enclosed in a nucleus (animal and plant cells)
- Plasmid = small ring of DNA in some bacterial cells
- Bacterial cells have a cell wall, but no mitochondria or chloroplasts
- 1 μm = 10^{-6} m; 1 nm = 10^{-9} m
- Prokaryotic cell: no nucleus; a single loop of DNA; may have plasmids (bacteria)
- Both kinds of cell have a cell membrane, cytoplasm and ribosomes
- 1 mm = 1000 μm; 1 μm = 1000 nm
- 10 times bigger = 1 order of magnitude; 100 times = 2; 1000 times = 3

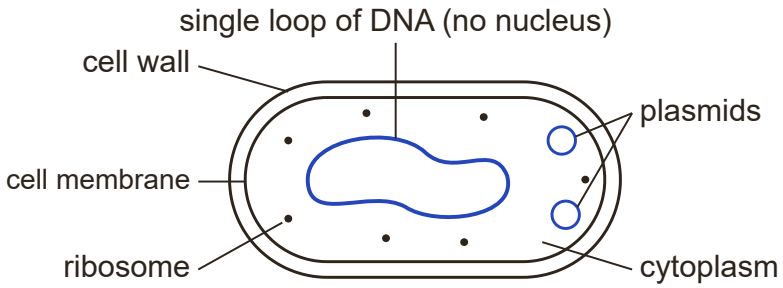
Notes

Two kinds of cell

- **Eukaryotic cells** have a cell membrane, cytoplasm and genetic material enclosed in a **nucleus**. Animal and plant cells are eukaryotic.
- **Prokaryotic cells** are bacterial cells. Their genetic material is **not** enclosed in a nucleus.
- Prokaryotic cells are much smaller. Most bacteria are a few micrometres long (about 1 to 10 μm), while most animal and plant cells are about 10 to 100 μm across.

Inside a bacterial cell

- Cytoplasm and a cell membrane, surrounded by a **cell wall**. This wall is not made of cellulose (only plant and algal cell walls are).
- The genetic material is a **single loop of DNA**, free in the cytoplasm.
- There may also be one or more **plasmids**: small rings of DNA, separate from the main loop.
- Bacteria have ribosomes, but no nucleus, no mitochondria and no chloroplasts.



A bacterial (prokaryotic) cell. Its DNA is free in the cytoplasm, not in a nucleus.

Units, standard form and orders of magnitude

- 1 mm = 1000 μm (micrometres) and 1 μm = 1000 nm (nanometres).
- In metres: 1 cm = 10^{-2} m, 1 mm = 10^{-3} m, 1 μm = 10^{-6} m, 1 nm = 10^{-9} m.
- To compare two sizes, first put them in the same unit, then divide the larger by the smaller.
- Each factor of 10 is one **order of magnitude**. An egg cell 100 μm across is 10^{2} times, or 2 orders of magnitude, bigger than a bacterium 1 μm long.

How to answer each type of question

Classify a cell as prokaryotic or eukaryotic 2 marks **Grade 4**

1. Look for a nucleus: genetic material inside a nucleus means eukaryotic.
2. A single loop of DNA, or plasmids, means prokaryotic (a bacterium).
3. Give your answer, then the reason, using the words 'nucleus' and 'loop of DNA'.

Example. Cell **X** has a cell wall, a cell membrane and cytoplasm. Its DNA is a single loop and it contains two plasmids.
Is cell **X** prokaryotic or eukaryotic? Give a reason for your answer.

Model answer. Prokaryotic (1). Its genetic material is not enclosed in a nucleus / it has a single loop of DNA and plasmids (1).

Describe differences between bacterial and eukaryotic cells

2 to 3 marks | Grade 5

1. Make each point clearly about the bacterial cell, or write it as a comparison.
2. Use the key features: nucleus, single loop of DNA, plasmids, cell wall.
3. Do not give structures that both cells have, such as cytoplasm or a cell membrane.

Example. Describe **two** differences between the genetic material in a bacterial cell and the genetic material in a human liver cell.

Model answer. In the bacterial cell the DNA is not enclosed in a nucleus, but in the liver cell it is inside a nucleus (1). The bacterial DNA is a single loop, and the bacterium may also have small rings of DNA called plasmids, which the liver cell does not have (1).

Convert units and use standard form

1 to 2 marks | Grade 6

1. Write down the conversion you need, e.g. 1 mm = 1000 µm.
2. Going to a smaller unit makes the number bigger, so multiply.
3. For metres in standard form, use 1 µm = 10^{-6} m and check that the first number is between 1 and 10.

Example. A bacterium is 0.0025 mm long.
(a) Give this length in micrometres (µm).
(b) Give this length in metres. Write your answer in standard form.

Model answer.

(a) 0.0025 × 1000 = 2.5 µm (1)

(b) 2.5 × 10^{-6} m (1)

Calculate how many orders of magnitude bigger

2 marks | Grade 7

1. Convert both sizes to the same unit.
2. Divide the larger size by the smaller size.
3. Write the answer as a power of ten: the power is the number of orders of magnitude.

Example. A plant cell is 0.08 mm wide. A bacterium is 0.8 µm long.
How many orders of magnitude larger is the plant cell than the bacterium?

Model answer.

0.08 mm = 80 µm (1)

80 ÷ 0.8 = 100 = 10^2, so the plant cell is 2 orders of magnitude larger (1)

Don’t lose marks

- Saying bacteria have 'no DNA' or 'no genetic material'. They do: it is just not enclosed in a nucleus.

- ✗ Giving the cell membrane, cytoplasm or ribosomes as a difference. Both kinds of cell have them.
- ✗ Saying a bacterial cell wall is made of cellulose.
- ✗ Dividing instead of multiplying in a unit conversion, e.g. turning 5 μm into 0.005 nm instead of 5000 nm.
- ✗ Losing the minus sign in standard form: 3 μm is 3×10^{-6} m, not 3×10^{6} m.

More tips

Memory tricks

- **Pro**karyote: 'pro' means 'before' (before a nucleus). **Eu**karyote: 'eu' means 'true' (a true nucleus).
- Units ladder: m → mm → μm → nm. Each step down is × 1000; each step up is ÷ 1000.
- Sense check: a bacterium should come out at a few μm and an animal cell at tens of μm. If a bacterium comes out at 2500 μm, check your conversion.
- When the ratio is 10, 100, 1000 and so on, the number of zeros is the number of orders of magnitude.

Exam technique

- In 'compare' and 'difference' questions, make it clear which cell each feature belongs to. 'Has a cell wall' on its own may not score.
- Use the mark scheme words: 'not enclosed in a nucleus', 'single loop of DNA', 'plasmids'.
- Show each step of a unit conversion, so you can still earn a mark if the final answer is wrong.
- Give the unit with every size, and write the μm symbol clearly (or write 'micrometres').

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name eukaryotic and prokaryotic cells**
Animal and plant cells are eukaryotic; bacterial cells are prokaryotic.

Grade 4 — **Describe the structure of a bacterial cell**
Cytoplasm and a cell membrane inside a cell wall, a single loop of DNA not in a nucleus, and often plasmids.

Grade 5 — **Compare prokaryotic and eukaryotic cells**
Say what both have (cell membrane, cytoplasm, ribosomes) and how they differ, above all whether the DNA is enclosed in a nucleus.

Grade 5 — **Convert between mm, μm and nm**
Multiply by 1000 for each step down (mm → μm → nm) and divide by 1000 for each step up.

Grade 6 — **Write cell sizes in standard form**
Use 1 μm = 10^{-6} m and 1 nm = 10^{-9} m, e.g. 4 μm = 4×10^{-6} m.

Grade 7 — **Compare sizes using orders of magnitude**
Put both sizes in the same unit, divide, and write the ratio as a power of ten: 1000 times bigger is 3 orders of magnitude.

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