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Bacteria: one cell, one whole organism, and the parts of a bacterial cell

1. What is a bacterium?

A **bacterium** (plural **bacteria**) is a **single-celled organism** with a **prokaryotic cell**. Its one cell is the whole living thing: it takes in substances, releases energy, makes proteins and, in some bacteria, moves.

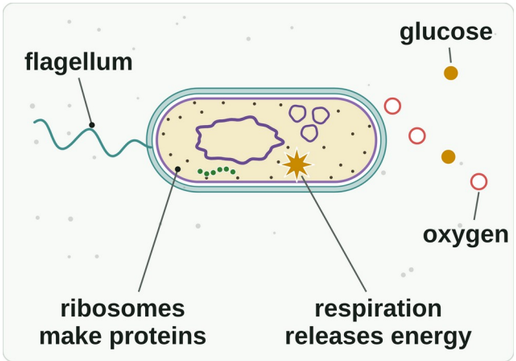
Bacteria are **microorganisms**: living things too small to see without a microscope. Most bacteria are about 1 to 5 µm long (1 mm = 1000 µm). They live almost everywhere: in soil, in water, on your skin and in your gut.

Bacterial cells are **prokaryotic**: their genetic material is not enclosed in a nucleus. Animal and plant cells are **eukaryotic**: their genetic material is enclosed in a nucleus (B1 L1 Animal and plant cells).

2. One cell, one whole organism

A bacterium is a **single-celled organism**: one cell does everything to stay alive.

- **Taking in:** substances such as glucose and oxygen pass through the cell wall and the cell membrane into the cytoplasm.
- **Releasing energy:** bacteria have no mitochondria, but they still **respire**. The reactions happen in the cytoplasm and on the cell membrane. Respiration releases energy.

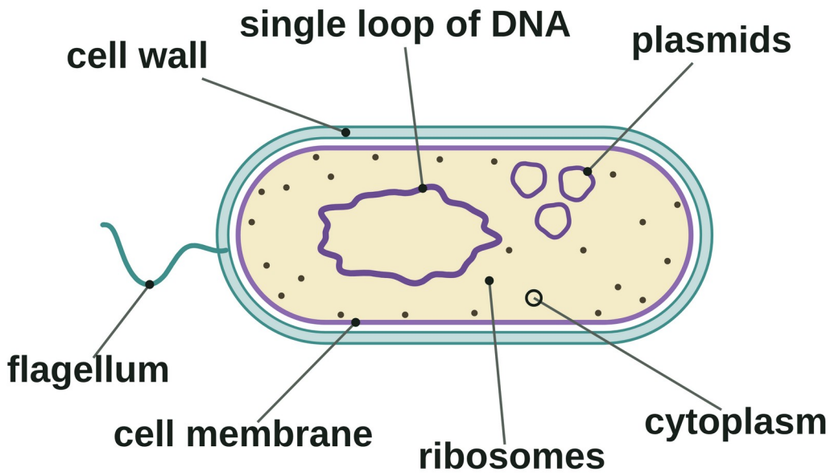


- **Making proteins:** the ribosomes make the proteins the cell needs.
- **Moving:** some bacteria swim by turning a **flagellum**.

Most bacteria are harmless or useful: they break down dead material in soil, help to make yoghurt and cheese, and help to break down some foods in your gut. A few are **pathogens**: microorganisms that cause infectious disease (B3 Infection and response). Bacteria are not viruses: viruses are not cells at all (B3).

> **Watch out:** no mitochondria does not mean no respiration. Energy is released by respiration: never write that energy is "made".

3. The parts of a bacterial cell



A diagram is simplified. The colours help you tell the parts apart.

Part	Its job
cell wall	strengthens the cell and helps it keep its shape; not made of cellulose
cell membrane	controls the movement of substances into and out of the cell
cytoplasm	a jelly-like substance where most of the chemical reactions happen
ribosomes	tiny structures where proteins are made
single loop of DNA	carries the genetic instructions; free in the cytoplasm, not in a nucleus
plasmids (some bacteria)	small rings of DNA that carry a few extra genes
flagellum (some bacteria)	a long, whip-like tail used to move

A bacterial cell has **no nucleus**, **no mitochondria** and **no chloroplasts**.

> **Watch out:** the bacterial cell wall is not made of cellulose. Only some bacteria have plasmids or a flagellum.

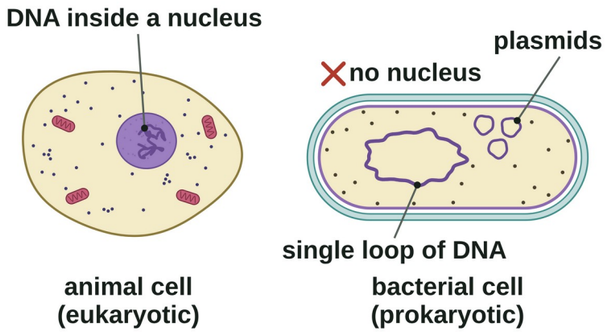
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DNA with no nucleus, plasmids, and prokaryotic and eukaryotic cells

4. DNA, but no nucleus

Bacteria, animal cells and plant cells all have **DNA**: the chemical that carries the genetic instructions for a cell.

- In animal and plant cells, the DNA is enclosed in a **nucleus**.
- A bacterial cell has **no nucleus**. Its main DNA is a **single loop**, free in the cytoplasm.



A diagram is simplified. Not to scale.

The loop is very long, so it is folded into a tangle. In a micrograph it shows as a pale area in the middle of the cell. Because they have no nucleus, bacteria do not divide by mitosis (B1 L6 Cell division: mitosis).

> **Watch out:** no nucleus does not mean no DNA. Write: "the DNA is a single loop, free in the cytoplasm".

5. Plasmids

Plasmids are small rings of DNA found in some bacterial cells, separate from the main loop of DNA.

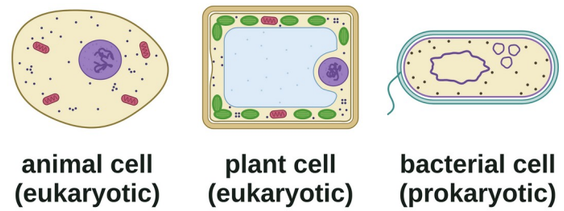
- The main loop carries most of the genes the bacterium needs to live.
- A plasmid carries a few **extra genes**. For example, some plasmids carry a gene that helps the bacterium survive an antibiotic (B6 Inheritance, variation and evolution).
- A bacterium may have no plasmids, one or several. It can live without them.
- Scientists can put useful genes, such as the human insulin gene, into bacteria, so the bacteria make that protein (B6).

> **Watch out:** plasmids are extras. The main DNA is the single loop, and not every bacterium has plasmids.

6. Prokaryotic and eukaryotic cells

Structure	Animal cell	Plant cell	Bacterial cell
nucleus	✔	✔	✖
DNA	✔ in the nucleus	✔ in the nucleus	✔ a single loop
cell membrane	✔	✔	✔
cytoplasm	✔	✔	✔
ribosomes	✔	✔	✔
mitochondria	✔	✔	✖
chloroplasts	✖	✔ (some)	✖
permanent vacuole	✖	✔	✖
cell wall	✖	✔ cellulose	✔ not cellulose
plasmids	✖	✖	✔ (some)
typical size	about 20 µm	up to about 100 µm	about 1 to 5 µm

- **Eukaryotic cell:** a cell whose genetic material is enclosed in a nucleus, such as an animal or plant cell.
- **Prokaryotic cell:** a cell whose genetic material is not enclosed in a nucleus, such as a bacterial cell.



A diagram is simplified. Not to scale.

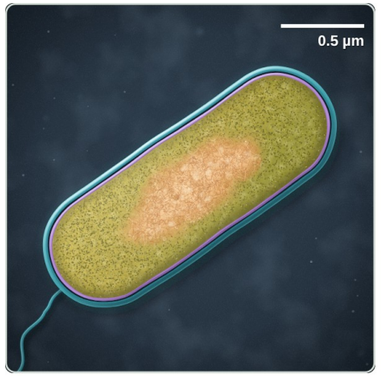
- Word clues: "pro-" means before and "karyon" means nucleus. "Eu-" means true: a true nucleus.
- All three kinds of cell have a cell membrane, cytoplasm, ribosomes and DNA.

> **Watch out:** single-celled does not mean prokaryotic. Yeast is a single-celled fungus with a nucleus, so its cell is eukaryotic.

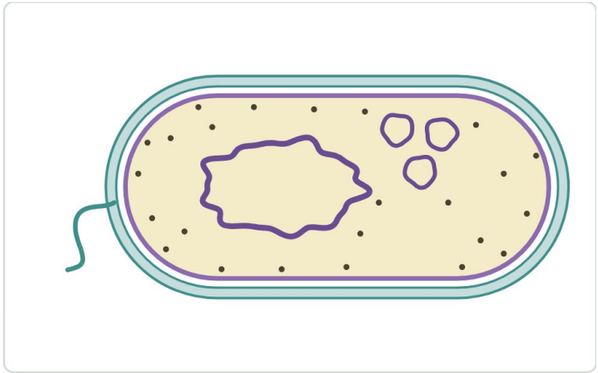
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A real bacterium and a diagram, how small bacteria are, and answering compare questions

7. A real bacterium and a diagram



A real bacterium (painting)



A diagram (simplified)

Electron micrographs are black and white: the colours are added. Real bacteria are almost colourless.

Bacteria are so small that the clearest pictures of them come from an **electron microscope** (B1 L3 Using a microscope). A picture taken with one is an **electron micrograph**. The painting is based on a coloured electron micrograph of a bacterium cut lengthways. Exam pictures are usually **diagrams**, simplified on purpose:

- **DNA:** in the micrograph, the DNA is a pale, tangled mass in the middle, with no membrane round it. The diagram draws one neat loop.
- **Plasmids:** too small to pick out in the micrograph. The diagram draws them as clear small rings.
- **Ribosomes:** thousands of tiny dots make real cytoplasm look grainy. The diagram draws only a few.
- **Colour:** electron micrographs are black and white; the colours are added. Real bacteria are almost colourless.
- **Wall and membrane:** in the micrograph, two thin layers pressed close together. The diagram draws two clear lines with a gap.

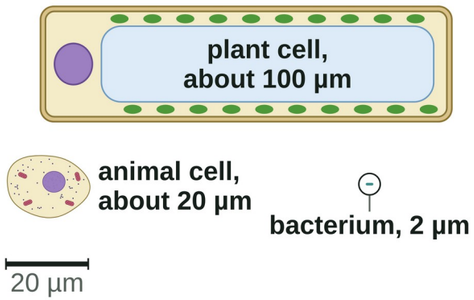
Both show a cell wall, a cell membrane, cytoplasm and DNA with no nucleus round it.

Watch out: the colours in a coloured electron micrograph are not real. They are added to make the parts easier to see.

8. How small are bacteria?

Cells are measured in **micrometres** (µm). A micrometre is one thousandth of a millimetre: 1 mm = 1000 µm.

- Most bacteria: about 1 to 5 µm long (a typical rod about 2 µm).
- An animal cell: about 20 µm across.
- A plant cell: up to about 100 µm long (most are 10 to 100 µm).



how many times bigger = bigger size ÷ smaller size (both in the same unit)

Worked example: a cheek cell is 0.05 mm across. A bacterium is 2.5 µm long. How many times bigger is the cheek cell?

Step 1: change mm into µm: 0.05 × 1000 = 50 µm.

Step 2: divide: 50 ÷ 2.5 = 20.

Answer: **20 times** bigger. Check: 20 × 2.5 µm = 50 µm.

An **order of magnitude** is a factor of 10: one order of magnitude bigger means about 10 times bigger. A bacterium is about one order of magnitude smaller than an animal cell. (Calculations with orders of magnitude and standard form: B1 L4 Magnification and cell size.)

Watch out: to find how many times bigger, divide. Do not subtract: 50 − 2.5 is not the answer. Change both sizes into the same unit first.

9. Answering "compare" questions

A compare question wants similarities **and** differences, with both cells named in each point. Use "both" for a similarity, and "but" or "whereas" for a difference.

- Model answer to "Compare the DNA in a bacterial cell with the DNA in an animal cell": "Both cells have DNA. An animal cell's DNA is enclosed in a nucleus, but a bacterial cell has no nucleus: its main DNA is a single loop, free in the cytoplasm. A bacterial cell may also have plasmids, small rings of DNA, whereas an animal cell has none."
- "A bacterium has no nucleus" on its own is only half a comparison: say what the other cell has.

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Key words, exam tips and check yourself

Key words

Bacterium (plural bacteria): a single-celled organism with a prokaryotic cell.

Cell membrane: a thin layer around the cell that controls the movement of substances into and out of the cell.

Cell wall: a layer outside the cell membrane that strengthens the cell; in plant and algal cells it is made of cellulose.

Cytoplasm: a jelly-like substance where most of the chemical reactions in the cell happen.

DNA: the chemical that carries the genetic instructions for a cell.

Electron micrograph: a picture of something seen through an electron microscope.

Eukaryotic cell: a cell whose genetic material is enclosed in a nucleus, such as an animal or plant cell.

Flagellum (plural flagella): a long, whip-like tail that some bacteria use to move.

Micrometre (µm): one thousandth of a millimetre (1 mm = 1000 µm).

Microorganism: a living thing that is too small to see without a microscope, such as a bacterium.

Order of magnitude: a factor of 10; one order of magnitude bigger means about 10 times bigger.

Pathogen: a microorganism that causes infectious disease.

Plasmids: small rings of DNA found in some bacterial cells, separate from the main loop of DNA.

Prokaryotic cell: a cell whose genetic material is not enclosed in a nucleus, such as a bacterial cell.

Ribosomes: tiny structures in the cytoplasm where proteins are made.

Single-celled organism: an organism made of only one cell, such as a bacterium.

Common mistakes

- **Wrong:** "Bacteria have no DNA." **Right:** their DNA is a single loop, free in the cytoplasm.
- **Wrong:** "Plasmids are the main DNA." **Right:** plasmids are small extra rings.
- **Wrong:** "The bacterial cell wall is made of cellulose." **Right:** it is not made of cellulose.
- **Wrong:** "No mitochondria, so no respiration." **Right:** bacteria still respire.
- **Wrong:** subtracting to find how many times bigger. **Right:** divide.

Check yourself

Cover the answers, then check.

1. What does prokaryotic mean?
2. Name four structures found in every bacterial cell.
3. Describe the main DNA of a bacterial cell.
4. What are plasmids, and do all bacteria have them?
5. Give two structures that plant cells have but bacterial cells do not.
6. Name two structures that a bacterial cell and a plant cell both have.
7. Why does a coloured electron micrograph not show the real colours of a bacterium?
8. A plant cell is 40 µm long and a bacterium is 5 µm long. How many times longer is the plant cell?

Answers

1. The cell's genetic material is not enclosed in a nucleus.
2. Any four: cell wall, cell membrane, cytoplasm, ribosomes, a single loop of DNA.
3. It is a single loop, free in the cytoplasm (not in a nucleus).
4. Small rings of DNA, separate from the main loop. No: only some bacteria have them.
5. Any two: a nucleus, chloroplasts, mitochondria, a permanent vacuole.
6. Any two: a cell wall, a cell membrane, cytoplasm, ribosomes, DNA.
7. Electron micrographs are black and white: the colours are added. Real bacteria are almost colourless.
8. 40 ÷ 5 = 8 times.

Exam tips

- Prokaryotic = no nucleus (bacteria). Eukaryotic = the genetic material is in a nucleus (animal and plant cells).
- Never write that bacteria have no DNA. Write "the DNA is a single loop, free in the cytoplasm".
- Plasmids are small extra rings of DNA. Do not call them the main DNA.
- For bacteria, say "the cell wall is not made of cellulose".
- In "how many times bigger" questions, put both sizes in the same unit, divide, and show your working.
- In "compare" questions, give similarities and differences, and say which cell has which feature.