1.1 Cell structure, specialisation and microscopy

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

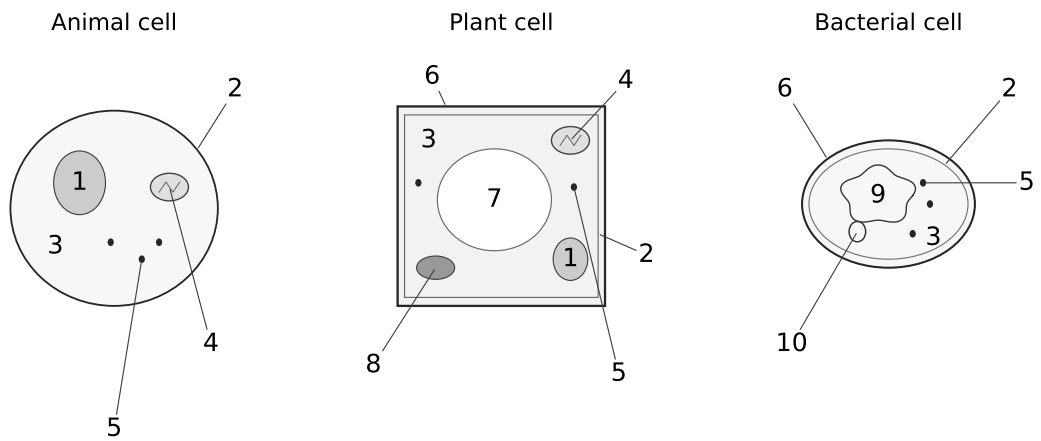
KEY WORDS eukaryotic • prokaryotic • Differentiation • binary fission • Aseptic technique

Objective

Label animal, plant and bacterial cells, relate structures to functions, calculate magnification and describe aseptic technique with reasons. Original questions for spec statements 4.1.1.1–4.1.1.6 and RP1/RP2.

1 Key knowledge and worked examples

Teacher cell models, not to scale; numbers match the key. The plant model is photosynthetic; the bacterial model includes an optional plasmid.



Key	Structure	Function
1	nucleus	DNA; controls cell activities
2	cell membrane	regulates entry and exit
3	cytoplasm	site of many reactions
4	mitochondrion	aerobic respiration
5	ribosome	protein synthesis
6	cell wall	support; cellulose in plants
7	permanent vacuole	cell sap; maintains firmness
8	chloroplast	photosynthesis
9	DNA loop	bacterial genetic material
10	plasmid	small DNA ring carrying genes

Bacteria have no nucleus; their main DNA is a loop and they may have plasmids. They have ribosomes, membrane, cytoplasm and a non-cellulose wall. Plants, animals and yeast are eukaryotic. Original 2025 Q08.2: yeast has a nucleus, vacuole and mitochondria; any two distinguish it from bacteria. A wall alone does not.

Structure → advantage: sperm tail → swimming; mitochondria → energy for swimming/contraction; ribosomes → protein synthesis, including muscle fibres. Nerve axon → impulses over distance; root hair projection → uptake surface; hollow xylem → water flow; phloem sieve plates → sugar flow. Most animal cell types differentiate early; many plant cells retain this ability. Division increases number; differentiation produces specialised structures/functions.

Microscopy: magnification enlarges an image; resolution distinguishes close structures. Electron microscopes provide greater magnification and resolution. RP1 drawings need clear outlines, labels and a magnification scale; draw observed structures. A scale bar stays meaningful if resized with the image.

$$M = \frac{I}{L} \qquad L = \frac{I}{M}$$

Use the same length units; magnification has no unit. 1 cm = 10 000 μm; 1 mm = 1000 μm = 1 000 000 nm. **Worked example:** 4.8 cm = 48 000 μm.

$$L = \frac{48\,000\ \mu\text{m}}{1200} = 40\ \mu\text{m}$$

Original 2024 Q08.3 [6]: volume 24 500 000 nm^3, radius 125 nm, image length 4 mm; $\pi = 3.14$.

$$L = \frac{V}{\pi r^2}$$

$$L = \frac{24\,500\,000\ \text{nm}^3}{3.14 \times (125\ \text{nm})^2} = 499.363\ldots\ \text{nm}$$

Convert I = 4 mm = 4 000 000 nm.

$$M = \frac{I}{L}$$

$$M = \frac{4\,000\,000 \text{ nm}}{499.363\ldots \text{ nm}} \approx 8010$$

Answer ×8010 with **no length unit**. Use the given image length, not a measurement from a resized PDF.

Bacterial growth: enough nutrients and a suitable temperature may allow division as often as every 20 minutes; use the question's stated rate. For constant doubling:

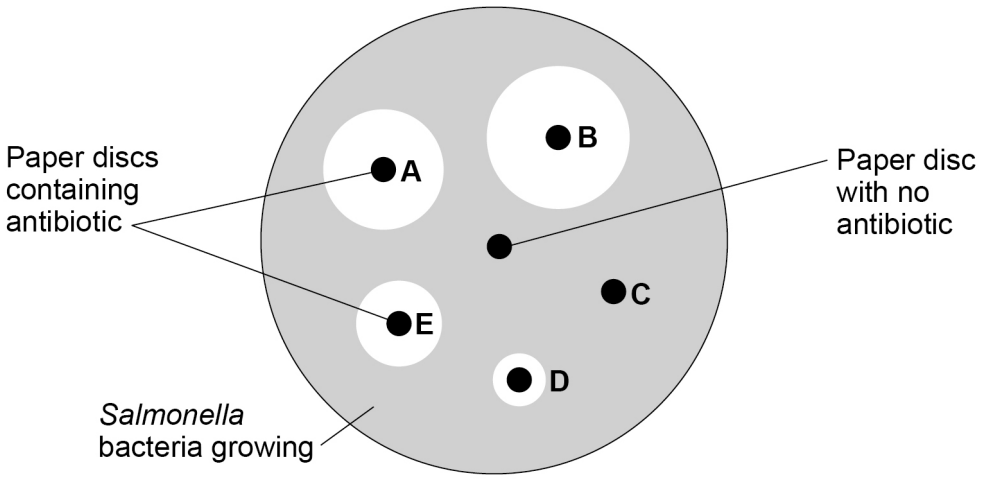
$$\text{divisions} = \frac{\text{elapsed time}}{\text{division time}}$$

$$\text{population} = \text{initial population} \times 2^{\text{divisions}}$$

One cell, 20-minute divisions, 3 hours: 180/20 = 9 divisions; population = 1×2^9 = **512**. For Q3.3 use 2 hours. The standard-form extension is HT; the basic population calculation is for both tiers.

Aseptic technique: sterilise dishes/media and the loop before use to kill contaminants; minimise lid opening and secure it with tape. Inversion reduces condensation dripping; it is not accepted on its own as an aseptic answer in original 2023 Q03.3. In school, a maximum of 25°C reduces growth of human pathogens; it does not guarantee that only non-pathogenic organisms grow. In the original Q03.4 context, 37°C is body temperature and the investigated bacteria grow better there.

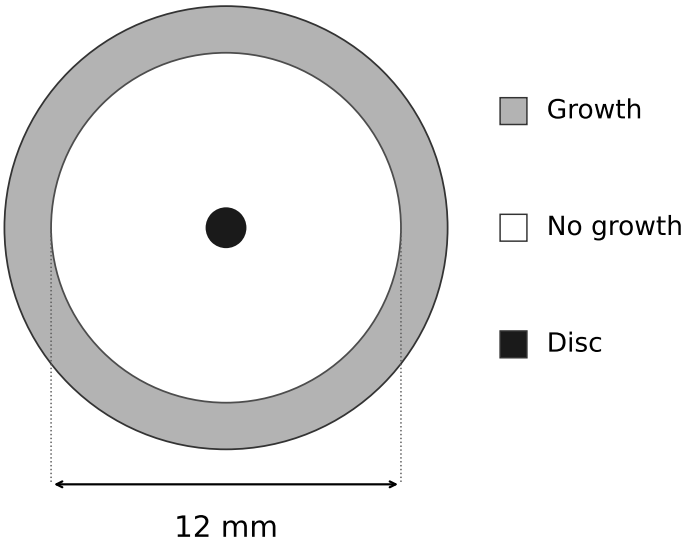
Figure 4



The no-antibiotic disc is a **control** for comparison, not a control variable. A and B show the largest inhibition zones for this bacterium. Measure diameters/radii

or calculate areas to compare quantitatively. Keep test conditions consistent and repeat/compare means. A small zone still shows inhibition; it does not establish resistance.

Teacher schematic – the stated 12 mm diameter, not measured exam data.



For Q3.2(c), halve the diameter before using area:

$$r = \frac{d}{2} = \frac{12 \text{ mm}}{2} = 6 \text{ mm}$$

$$A = \pi r^2$$

$$A = \pi \times (6 \text{ mm})^2 = 113.097\ldots \text{ mm}^2 \approx 113 \text{ mm}^2$$

The question asks for the stated clear-zone area, not an annulus excluding the disc. Radius 12 mm would give four times the correct area.

2 Practice

2.1 Name the structures present in a bacterial cell that are absent from an animal cell. [2]

2.2 Give one structural feature of a sperm cell and explain how it helps fertilisation. [2]

2.3 A cell image measures 2.4 mm at ×800. Calculate the real size in μm. [3]

3 Exam-style questions

3.1 Explain why muscle cells contain many mitochondria and many ribosomes. [4]

3.2 A student prepares an agar plate to test antiseptics (RP2).

(a) Explain why the inoculating loop is flamed before use. [2]

(b) Explain why the plate is incubated at 25 °C, not 37 °C. [2]

(c) The clear zone around one disc has a diameter of 12 mm. Calculate its area. [2]

3.3 A bacterium divides every 20 minutes starting from one cell.

(a) How many cells are present after 2 hours? [2]

(b) (HT) Write your answer to (a) in standard form. [1]

Solutions

2.1 Cell wall; plasmid / single DNA loop not in a nucleus.

2.2 A tail propels the sperm towards the egg. Alternatively, many mitochondria carry out aerobic respiration to release energy for swimming. Give one linked feature-and-function pair.

2.3 Convert: 2.4 mm = 2400 μm (C1).

$$\text{real size} = \frac{2400}{800} = \mathbf{3.0}\ \mu\text{m}$$

(division C1, answer with unit A1.)

3.1 Mitochondria carry out aerobic respiration releasing energy (ATP) for contraction; ribosomes synthesise proteins – the contractile protein fibres the cell needs.

3.2 (a) The flame kills any microorganisms already on the loop, so only the intended bacterium is transferred – no contamination. (b) 25 °C reduces growth of bacteria harmful to humans; 37 °C is body temperature and could support their growth better. It does not follow that all growth at 25 °C is harmless. (c) $r = 6$ mm (C1): $A = \pi \times 6^2 = \mathbf{113}$ mm$^2 \approx 110$ mm^2.

3.3 (a) 2 hours = 120 min = 6 divisions (C1): $2^6 = \mathbf{64}$ cells. (b) $\mathbf{6.4 \times 10^1}$.