2.1 Cell ultrastructure and microscopy

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS magnification • resolution • Golgi apparatus • plasmid • capsule

Objective

Practise Topic 3 statements 3.1-3.7 with Core Practical 5: eukaryotic and prokaryotic ultrastructure, levels of organisation, magnification and resolution, and the calculations the WBI12 paper always sets.

1 Key knowledge and worked examples

■ Organelle to function, no gaps

Nucleus (DNA; nucleolus makes ribosomes) → ribosomes (protein synthesis) → rough ER (folds and ships proteins) → Golgi (modifies, packages, exports) → mitochondria (ATP) → lysosomes (digestion). Plants add chloroplasts, a cellulose wall, plasmodesmata and a vacuole. Prokaryotes have a wall, capsule, plasmids, one circular DNA molecule, 70S ribosomes and sometimes a flagellum – and none of the membrane-bound organelles.

■ Magnification and resolution

M = image/actual; keep units the same before dividing. Resolution is the smallest separation that still looks like two objects: light ~200 nm, TEM ~1-2 nm. To see a double membrane or a ribosome you need the electron microscope's resolution, not just more magnification of a blurry light image.

■ Worked example: three-unit conversions

A cell appears 36 mm long at ×600. Actual = 36 000 μm/600 = 60 μm. A virus 0.2 µm across at the same magnification would appear $0.2 \times 600 = 120$ μm = 0.12 mm – barely a dot; to resolve its capsid you need an electron microscope.

2 Practice

2.1 Name the organelle that modifies and packages proteins for export, and the organelle that produces ATP. [2]

2.2 Give two structures present in a prokaryotic cell that are absent from a eukaryotic cell's nucleus, and one structure common to both cell types. [3]

2.3 Explain why staining is needed before cells can be usefully examined under a light microscope. [2]

3 Exam-style questions

3.1 The table gives four measurements from a photograph of a liver cell taken with an electron microscope. The photograph's magnification is ×8 000.

Feature	Width on photograph / mm
Nucleus	28
Mitochondrion	6.4
Lysosome	2.4
Cell membrane (single)	0.16

Calculate the actual width of each feature in µm, giving each answer to 2 significant figures, and state which feature could not have been resolved with a light microscope. [6]

3.2 Explain how the structures of a rough endoplasmic reticulum and a Golgi apparatus are suited to producing and exporting an extracellular enzyme, naming the route the enzyme takes. [5]

3.3 A student observes a cell with a cell wall but no mitochondria. The cell swims using a rotating filament. Identify the cell type, name three further structures you would expect to find in it, and explain why the absence of mitochondria does not mean the cell has no respiration. [5]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Golgi apparatus; mitochondrion.

2.2 Cell wall (murein) and capsule; also a single circular DNA strand without a nuclear membrane or plasmids (any two, B1, B1). Common: ribosomes / cell-surface membrane / cytoplasm.

2.3 Most cell structures are transparent and colourless, so contrast is near zero; stains bind different structures selectively, raising contrast so they can be distinguished.

3.1 Nucleus = 28 000/8 000 = 3.5 μm; mitochondrion = 6 400/8 000 = 0.80 μm; lysosome = 2 400/8 000 = 0.30 μm; membrane = 160/8 000 = 0.020 μm. A light microscope resolves about 0.2 µm: the membrane (0.02 µm = 20 nm) could not be resolved; (the lysosome at 0.30 µm is just resolvable).

3.2 Rough ER carries ribosomes on its surface, so the enzyme's polypeptide is synthesised and folded into the ER lumen; transport vesicles bud off to the Golgi; the Golgi's stacked cisternae modify (e.g. add sugar groups) and package the enzyme into secretory vesicles; the vesicles fuse with the cell-surface membrane and release the enzyme outside the cell.

3.3 A prokaryotic (bacterial) cell. Expected structures: plasmids, single circular DNA (nucleoid), 70S ribosomes, capsule (any three, B1, B1, B1). Respiration in prokaryotes happens on the cell-surface membrane and in the cytoplasm (glycolysis), which carry the same chemistry without mitochondria.