Unit 2 · The Cell

ANSWER KEY · FOR TEACHERS

Full marks 39

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. plasmodesmata → **g.** channels through cell walls joining the cytoplasm of neighboring cells
2. middle lamella → **j.** a layer of calcium and magnesium pectates cementing neighboring cell walls
3. cyclosis → **e.** the streaming of the cytoplasm round a plant cell
4. cristae → **c.** folds of the inner membrane of a mitochondrion
5. dictyosomes → **b.** the separate small Golgi stacks of a plant cell
6. autophagy → **i.** the digestion of a cell's own worn-out organelles by lysosomes
7. polysome → **a.** several ribosomes working along one strand of mRNA
8. heterochromatin → **d.** tightly packed, darkly staining chromatin whose genes are mostly inactive

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. outer membrane
2. thylakoid
3. inner membrane
4. stroma
5. stroma lamella
6. granum (a stack of thylakoids)

K · 3

Each carries 0.5 mark.

3 Multiple choice

i. **b.** ATP synthase (also called ATP synthetase, or ATPase) — K · 1

ATP is made by ATP synthase, the F_1 particles on the inner membrane. "ATPase" and "ATP synthetase" are two names for the same enzyme (it is called an ATPase because it can also run in reverse and split ATP), so they are one option here.

ii. **d.** Ribosome — K · 1

A ribosome is a particle of rRNA and protein with no membrane. Mitochondria, chloroplasts and other plastids all have double membranes. (If this question lists "centriole" among the options, it has two answers: a centriole has no membrane either.)

iii. **b.** 70S, in a bacterium or inside a mitochondrion — U · 1

50S + 30S make a **70S** ribosome: S values don't add, because a particle's sinking speed depends on its shape as well as its mass. 70S ribosomes are found in **prokaryotes** and in **mitochondria and chloroplasts**; the cytoplasm and rough ER of eukaryotes have 80S (60S + 40S).

iv. **c.** the dynein arms on the A tubules of the doublets — U · 1

The **dynein arms** are motor proteins (ATPases) that walk along the next doublet; held by the radial spokes, the doublets bend instead of sliding. All the microtubules, central ones too, are made of **tubulin**.

v. **b.** rough ER and the Golgi complex — A · 1

An enzyme is a protein: it is made on ribosomes of the **rough ER**, then modified, packed into vesicles and sent out by the **Golgi complex**. The acinar cells of the pancreas are packed with RER.

4 Very short answers

a. MARKING SCHEME — K · 1

✓ Mitochondria and chloroplasts.

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

b. MARKING SCHEME K · 1

✓ The plasma membrane and its contents, without the cell wall.

c. MARKING SCHEME U · 1

✓ Leucoplasts change into chloroplasts in the light.

5 Short answers

a. MARKING SCHEME U · 2

✓ The lysosome.

✓ Its hydrolytic enzymes, released when its membrane breaks, digest the cell itself (autolysis).

b. MARKING SCHEME U · 2

✓ Two correct differences.

✓ Two more correct differences.

c. MARKING SCHEME A · 2

✓ Can't make proteins, repair or divide: a short life (about 120 days).

✓ More room for hemoglobin (or flexibility, or not using the oxygen it carries).

d. MARKING SCHEME U · 3

✓ Primary: budded from the Golgi complex, enzymes not yet used.

✓ Secondary: fused with a food vacuole (heterophagosome) or the cell's own parts (autophagosome).

✓ Residual bodies: undigested remains, emptied by exocytosis.

6 Numerical problems

ANSWER A · 4

i. Side 1 μm: surface $6 \times 1^2 =$ **6 μm²**, volume $1^3 =$ **1 μm³**, ratio **6 per μm**. Side 10 μm: surface $6 \times 10^2 =$ **600 μm²**, volume $10^3 =$ **1000 μm³**, ratio $600 \div 1000 =$ **0.6 per μm**.

ii. Volume **1000 times**, surface only **100 times**: the surface for each unit of volume fell to a tenth.

iii. Everything a cell takes in and gets rid of passes **through its surface**, while its needs grow with its **volume**. A big cell would have too little surface to serve its volume, so cells stay small (or a big cell is long, thin or folded).

MARKING SCHEME

✓ Surface, volume and ratio of the 1 μm cube (6, 1, 6).

✓ Surface, volume and ratio of the 10 μm cube (600, 1000, 0.6).

✓ Volume ×1000, surface ×100.

✓ Exchange is through the surface, needs grow with volume: so cells are small.

7 Long answers

a. ANSWER U · 4

Proposed by **Singer and Nicolson** (1972). The membrane is a **fluid bilayer of phospholipids**: each molecule is amphipathic, with a hydrophilic head facing the water and two hydrophobic tails inside; the molecules drift sideways (lateral movement) and rarely flip-flop between layers.

Proteins are scattered in it like **icebergs in a sea**: **peripheral (extrinsic)** proteins on the surfaces, **integral (intrinsic)** proteins embedded in or right across the bilayer, many forming channels and carriers. Sugar chains on the outer face form glycoproteins and glycolipids; cholesterol in animal membranes controls fluidity.

The **sandwich model** of Danielli and Davson (1935) put **continuous layers of protein** on both faces of a fixed lipid bilayer (protein–lipid–protein). It could not explain the different jobs of membranes or active transport; the fluid mosaic model explains channels, carriers and receptors, and the experiment of Frye and Edidin (1970), in which mouse and human membrane proteins mixed within 40 minutes, showed the membrane is fluid.

MARKING SCHEME

✓ Singer and Nicolson; a fluid phospholipid bilayer, heads out and tails in.

✓ Peripheral and integral proteins scattered as a mosaic, channels and carriers.

✓ Sugar chains on the outer face, cholesterol, lateral movement.

✓ Sandwich model: continuous protein layers on a fixed bilayer; can't explain transport.

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

b. ANSWER A · 4

In the **nucleus**, the enzyme's gene is transcribed into **mRNA**, which leaves through the **nuclear pores**; the ribosomes themselves were made in the **nucleolus**.
On ribosomes bound to the **rough ER**, the mRNA is translated, and the protein passes into the **lumen of the RER**; vesicles carry it to the **cis face** of the **Golgi complex**.
As it moves through the **cisternae** it is modified (for example sugars added) and concentrated, and at the **trans face** it is packed into **secretory vesicles**.
The vesicles move to the **plasma membrane**, fuse with it and empty the enzyme outside (**exocytosis**). ATP from the **mitochondria** powers the steps.

MARKING SCHEME

- ✓ Gene transcribed in the nucleus; mRNA out through the pores.
- ✓ Made on ribosomes of the rough ER, into its lumen, vesicles to the Golgi.
- ✓ Modified and packed in the Golgi cisternae into secretory vesicles.
- ✓ Exocytosis at the plasma membrane.

8 Think

ANSWER HA · 3

Any three: they have **double membranes**; they divide by **fission**, on their own; they have their own **circular DNA without histones**, like a bacterium's; they have **70S ribosomes**, the bacterial kind; their genes are most like those of living bacteria.
They can't live alone because their DNA is small: a human mitochondrion's has only **13 protein genes**, and most of their proteins (over 1,000) are coded by the **nucleus**, made in the cytoplasm and imported. So they are **semi-autonomous**.

MARKING SCHEME

- ✓ Two pieces of evidence (double membrane, fission, circular naked DNA, 70S ribosomes).
- ✓ A third piece of evidence.
- ✓ Most of their proteins are coded by the nucleus: semi-autonomous, not independent.

9 Activity: Watch the cytoplasm stream

(not marked)

WHAT STUDENTS SHOULD FIND

Each cell is a long box with a wall; the green **chloroplasts** move slowly round its edge, all one way, just inside the wall, faster when warm. This is **cyclosis** (cytoplasmic streaming), driven by myosin moving along actin threads; it stops if the cell is killed.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	14	11	3	**39**

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking