

Cell: The Building Block of Life

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FREE SAMPLE CHAPTER

Section A — Multiple Choice Questions

Q1. Robert Hooke first observed cells in 1665 while examining a thin slice of which material? [1 mark]

- A. Onion peel
- B. Cork
- C. Potato
- D. Rhoeo leaf

Difficulty: easy

Q2. Which of the following correctly describes the fluid-mosaic model of the cell membrane? [1 mark]

- A. A single lipid layer with proteins only on the outer surface
- B. A rigid lipid bilayer with no proteins embedded in it
- C. A lipid bilayer with proteins embedded in it, where molecules can move sideways
- D. A protein bilayer with lipids embedded and fixed in position

Difficulty: medium

Q3. A plant cell is placed in a solution where the solute concentration of the extracellular medium is GREATER than the solute concentration inside the cell. The solution is termed: [1 mark]

- A. Isotonic
- B. Hypotonic
- C. Hypertonic
- D. Dilute

Difficulty: medium

Q4. Which organelle is responsible for modifying, sorting, and packaging proteins and/or lipids into vesicles for transport or secretion? [1 mark]

- A. Lysosome
- B. Mitochondrion
- C. Golgi apparatus
- D. Smooth Endoplasmic Reticulum

Difficulty: easy

Q5. Mature Red Blood Cells (RBCs) in humans lack a nucleus. What is the primary advantage of this adaptation? [1 mark]

- A. It allows RBCs to divide faster
- B. It provides more space for haemoglobin to transport more oxygen
- C. It enables RBCs to synthesise proteins efficiently
- D. It protects RBCs from osmotic damage

Difficulty: medium

Q6. The inner membrane of a mitochondrion is folded into finger-like projections. What are these projections called and what is their functional significance? [1 mark]

- A. Stroma; they store starch for energy
- B. Cristae; they increase surface area for chemical reactions and facilitate energy production
- C. Nucleoid; they store mitochondrial DNA
- D. Vesicles; they transport proteins within the mitochondrion

Difficulty: medium

Q7. Which type of cell division produces four daughter cells, each with half the number of chromosomes compared to the parent cell? [1 mark]

- A. Mitosis

- B. Binary fission
- C. Meiosis
- D. Cell culture

Difficulty: easy

Q8. In Activity 2.1, if the diameter of the visible field under a microscope is 4 mm and 20 cells are counted along that diameter, what is the estimated size of one cell? [1 mark]

- A. 100 μm
- B. 200 μm
- C. 400 μm
- D. 500 μm

Difficulty: hard

Section B — Fill in the Blanks

Q9. The movement of water through a selectively permeable membrane from a region of higher water concentration to a region of lower water concentration is called _____. [1 mark]

Difficulty: easy

Q10. The functional segments of DNA that carry genetic information are called _____. [1 mark]

Difficulty: easy

Q11. Plastids that store food materials such as starch, oils, or proteins and are colourless are called _____. [1 mark]

Difficulty: medium

Q12. Ribosomes are synthesised in a dense round body present inside the nucleus called the _____. [1 mark]

Difficulty: medium

Section C — True or False

Q13. Prokaryotic cells have membrane-bound organelles and a well-defined nucleus enclosed by a nuclear membrane. [1 mark]

- True
- False

Difficulty: easy

Q14. Both mitochondria and chloroplasts have their own DNA and ribosomes, suggesting an evolutionary history shared with bacteria. [1 mark]

- True
- False

Difficulty: medium

Q15. The cell wall of plant cells is impermeable, preventing all water and dissolved minerals from passing through it. [1 mark]

- True
- False

Difficulty: medium

Q16. In meiosis, the parent cell divides only once, producing two daughter cells with half the number of chromosomes. [1 mark]

True

False

Difficulty: medium

Section D — Match the Following

Q17. Match the cell organelles in Column A with their correct functions/descriptions in Column B.

Column A:

(i) Lysosome

(ii) Smooth Endoplasmic Reticulum (SER)

(iii) Mitochondrion

(iv) Ribosome

Column B:

P. Site of protein synthesis

Q. Breaks down unwanted proteins, carbohydrates, fats and damaged organelles

R. Stores energy as ATP through cellular respiration

S. Involved in synthesis and storage of fats and hormones [4 marks]

Difficulty: medium

Q18. Match the terms in Column A with their correct descriptions/examples in Column B.

Column A:

(i) Chromoplast

(ii) Nucleoid

(iii) Osmosis

(iv) Cytoskeleton

Column B:

P. Network of fine fibres in eukaryotic cells providing structural support and enabling cell movement

Q. Region in prokaryotic cells containing a single circular DNA molecule

R. Plastid containing yellow, orange or red pigments found in flower petals and fruits

S. Diffusion of water across a selectively permeable membrane [4 marks]

Difficulty: hard

Section E — Assertion and Reasoning

Q19. Assertion (A): When a plant cell is placed in a concentrated sugar solution, the inner content of the cell shrinks but the cell does not change its overall size.

Reason (R): The rigid cell wall of a plant cell maintains its shape even when the cell loses water by osmosis.

Options:

A. Both A and R are true and R is the correct explanation of A.

- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true. [1 mark]

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true.

Difficulty: hard

Q20. Assertion (A): The Rough Endoplasmic Reticulum (RER) appears rough under an electron microscope.

Reason (R): Ribosomes are attached to the surface of the RER, and ribosomes are the sites of protein synthesis.

Options:

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true. [1 mark]

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true.

Difficulty: medium

Q21. Assertion (A): Mitosis produces two daughter cells that are genetically identical to the parent cell.

Reason (R): During mitosis, the number of chromosomes in daughter cells is reduced to half the number present in the parent cell.

Options:

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true. [1 mark]

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.
- C. A is true but R is false.
- D. A is false but R is true.

Difficulty: hard

Q22. Assertion (A): Unicellular organisms like bacteria or yeast exchange materials and respond to their environment through the cell membrane.

Reason (R): The cell membrane is selectively permeable, allowing some substances to pass through while blocking others.

Options:

- A. Both A and R are true and R is the correct explanation of A.
- B. Both A and R are true but R is NOT the correct explanation of A.

C. A is true but R is false.

D. A is false but R is true. [1 mark]

A. Both A and R are true and R is the correct explanation of A.

B. Both A and R are true but R is NOT the correct explanation of A.

C. A is true but R is false.

D. A is false but R is true.

Difficulty: medium

Section F — Very Short Answer (2 marks)

Q23. Define osmosis as described in the context of cell membrane activity. [2 marks]

Difficulty: easy

Q24. What is the limit of resolution of the human eye, and what does it mean? [2 marks]

Difficulty: easy

Q25. State TWO structural differences between Rough Endoplasmic Reticulum (RER) and Smooth Endoplasmic Reticulum (SER). [2 marks]

Difficulty: easy

Q26. Name the two types of cell division and state ONE key difference between them. [2 marks]

Difficulty: medium

Q27. What are chromoplasts and leucoplasts? Give one example of where each is found in plants. [2 marks]

Difficulty: medium

Q28. What is the nucleoid in a prokaryotic cell? [2 marks]

Difficulty: easy

Section G — Short Answer (3 marks)

Q29. With the help of Activity 2.2 (potato experiment), explain what happens to a potato piece placed in plain water versus one placed in 20% salt solution. Name the process responsible and explain the role of the cell membrane in it. [3 marks]

Difficulty: medium

Q30. Describe the fluid-mosaic model of the cell membrane. Why is it called 'fluid' and why is it called 'mosaic'? [3 marks]

Difficulty: medium

Q31. Explain the role of the Golgi apparatus in a cell. How is it functionally linked to the endoplasmic reticulum? [3 marks]

Difficulty: medium

Q32. Compare prokaryotic and eukaryotic cells on the basis of: (i) presence of membrane-bound nucleus, (ii) size, and (iii) presence of membrane-bound organelles. [3 marks]

Difficulty: easy

Q33. Why are mature Red Blood Cells (RBCs) in humans said to be specialised? What advantage does the absence of a nucleus provide, and what is its disadvantage? [3 marks]

Difficulty: medium

Section H — Long Answer (5 marks)

Q34. Describe the structure and functions of the following cell organelles: (i) Mitochondria, (ii) Chloroplast, (iii) Vacuole. How do mitochondria and chloroplasts differ from other cell organelles in terms of their evolutionary significance? [5 marks]

Difficulty: hard

Q35. (a) What is cell division? Why is it essential for living organisms? (b) Distinguish between mitosis and meiosis on the basis of: (i) number of daughter cells produced, (ii) chromosome number in daughter cells, (iii) where it occurs, and (iv) its significance. (c) What could happen if mitosis or meiosis does not occur properly? [5 marks]

Difficulty: hard

Q36. Explain how scientists study cells that are too small to be seen with the naked eye. Describe the structure of a light microscope and how Activity 2.1 can be used to estimate the size of an onion peel cell. How has the electron microscope advanced our understanding of cell structure? [5 marks]

Difficulty: medium

Section I — Case-Based Questions

Q37. Read the following passage and answer the questions that follow:

During a science practical session, a teacher asked students to prepare two sets of slides of Rhoeo leaf peel cells. In Set 1, the cells were mounted in plain water, while in Set 2, the cells were treated with 20% sugar solution for 30 minutes before observation. When observed under a microscope, the students noticed that in Set 1 the cells appeared normal and turgid. However, in Set 2, the inner content of the cells had shrunk away from the cell wall, creating a visible gap between the cell membrane and the cell wall. The outer boundary (cell wall) of the cells in Set 2 remained unchanged. In a parallel experiment, cheek cells treated with the same 20% sugar solution showed complete shrinkage of the entire cell.

- (i) Name the phenomenon that caused the inner content of the Rhoeo cells to shrink in Set 2. What term is used specifically for this condition in plant cells?
- (ii) Why did the outer boundary of the Rhoeo cells remain unchanged in Set 2, while the inner content shrank? What does this tell us about the cell wall?
- (iii) Why did cheek cells shrink entirely when placed in 20% sugar solution, unlike Rhoeo cells where only the inner content shrank? [4 marks]

Difficulty: hard

Q38. Read the following passage and answer the questions that follow:

In 2010, scientist J. Craig Venter and his team conducted a landmark experiment in synthetic biology. They studied the complete DNA sequence of a simple bacterium called *Mycoplasma mycoides* using computer programming. They then chemically synthesised an exact copy of this DNA in the laboratory. Next, they took a closely related bacterium, removed its DNA but kept the rest of the cell - including the cytoplasm and cell membrane - intact. They then inserted the synthetic DNA into this 'empty' cell. After the insertion, the cell started to grow and divide, following the instructions from the newly inserted synthetic DNA. The

scientists noted that this experiment demonstrated the central role of DNA in controlling cell structure and activities. However, they also clarified that they had NOT created a completely new cell from scratch, because the cytoplasm and cell membrane were taken from an already existing living cell.

- (i) What does J. Craig Venter's experiment demonstrate about the role of DNA in a cell?
- (ii) The bacterium *Mycoplasma mycoides* is a prokaryote. Based on your knowledge of prokaryotic cells, where would its DNA normally be located, and what would be its structure?
- (iii) Why did the scientists say they had NOT created a completely new cell from scratch? What does this suggest about the origin of cells? [4 marks]

Difficulty: hard

Answer Key with Explanations

Q1. B. Cork

Robert Hooke observed small box-like compartments using his self-designed microscope while examining a thin slice of cork, and named them 'cells'.

Source: Section 2.1 - How to Study Cells?

Q2. C. A lipid bilayer with proteins embedded in it, where molecules can move sideways

The fluid-mosaic model describes the cell membrane as a lipid bilayer with embedded proteins. The molecules can move sideways, flip and rotate within the membrane (hence 'fluid'), and proteins are arranged like tiles in a mosaic (hence 'mosaic').

Source: Section 2.2.1 - Cell membrane

Q3. C. Hypertonic

When solute concentration of extracellular medium > solute concentration of intracellular medium, the solution is called hypertonic. The cell will lose water by osmosis and shrink.

Source: Section 2.2.1 - Fig 2.6, Effect of solutions of different concentrations on a cell

Q4. C. Golgi apparatus

The Golgi apparatus acts like the cell's post office - it modifies, sorts, and packages proteins and/or lipids into vesicles for transport, secretion, or lysosome formation.

Source: Section 2.3.1 - Golgi apparatus

Q5. B. It provides more space for haemoglobin to transport more oxygen

The absence of a nucleus in mature RBCs provides more space for haemoglobin, allowing it to transport a larger amount of oxygen to all cells of the body. However, this means they cannot repair or divide, resulting in a lifespan of approximately 120 days.

Source: Section 2.3.1 - Threads of Curiosity on RBCs

Q6. B. Cristae; they increase surface area for chemical reactions and facilitate energy production

The inner membrane of mitochondria is folded into finger-like projections called cristae, which increase the surface area for chemical reactions and facilitate energy production in the form of ATP.

Source: Section 2.3.1 - Mitochondria

Q7. C. Meiosis

In meiosis, the parent cell divides twice to form four daughter cells. During the first division, chromosome number is halved; the second division is similar to mitosis. The resulting gametes each have half the number of chromosomes of the parent cell.

Source: Section 2.4.1 - Meiosis

Q8. B. 200 μm

Diameter = 4 mm = 4 x 1000 = 4000 μm . Estimated size = 4000 μm ÷ 20 cells = 200 μm per cell.

Source: Section 2.1 - Activity 2.1

Q9. Osmosis

Osmosis is defined as the diffusion of water across a selectively permeable membrane, from a dilute solution (more water, less solute) to a concentrated solution (less water, more solute).

Source: Section 2.2.1 - Cell membrane and osmosis

Q10. Genes

According to the textbook, the functional segments of DNA are called genes. DNA molecules contain the genetic information and chromosomes are composed of DNA and specific proteins.

Source: Section 2.3.1 - Nucleus

Q11. Leucoplasts

Leucoplasts (from Greek leukos meaning white) are colourless plastids that store food material such as starch, oils, or

proteins. For example, they are found in potato and taro (*Colocasia*) cells.

Source: Section 2.3.1 - Plastids

Q12. Nucleolus

The nucleolus is the dense round body present inside the nucleus where synthesis of ribosomal subunits takes place. These subunits then exit to the cytoplasm where they assemble to form ribosomes.

Source: Section 2.3.1 - Nucleus

Q13. False

This statement is FALSE. Prokaryotic cells LACK membrane-bound organelles and a well-defined nucleus. Their DNA is present as a single circular molecule in a region called the nucleoid. It is eukaryotic cells that have a membrane-bound nucleus and membrane-bound organelles.

Source: Section 2.3 - Table 2.2: Comparison between prokaryotic and eukaryotic cells

Q14. True

This statement is TRUE. The textbook explicitly states that mitochondria and plastids both have their own DNA and ribosomes and can make some of their own proteins. These characteristics suggest that both share an evolutionary history with single-celled bacteria.

Source: Section 2.3.1 - Plastids (Chloroplasts)

Q15. False

This statement is FALSE. Although the plant cell wall is rigid, it is PERMEABLE, meaning water and some dissolved minerals CAN pass through it. This permeability, along with the selective permeability of the cell membrane, helps plant roots absorb water and nutrients from the soil.

Source: Section 2.2.2 - Cell wall

Q16. False

This statement is FALSE. In meiosis, the parent cell divides TWICE - one after the other. The first division reduces chromosome number to half, and the second division (similar to mitosis) produces four daughter cells in total, each with half the number of chromosomes.

Source: Section 2.4.1 - Meiosis

Q17. (i) - Q, (ii) - S, (iii) - R, (iv) - P

Lysosomes are single membrane-bound sacs filled with enzymes that break down cellular waste (Q). SER lacks ribosomes and is involved in synthesis and storage of fats and hormones (S). Mitochondria are the powerhouses where cellular respiration produces ATP (R). Ribosomes are the sites of protein synthesis (P).

Source: Section 2.3.1 - Cell organelles

Q18. (i) - R, (ii) - Q, (iii) - S, (iv) - P

Chromoplasts contain pigments like yellow, orange or red found in flowers and fruits (R). Nucleoid is the region in prokaryotic cells containing genetic material without a membrane (Q). Osmosis is the diffusion of water across a selectively permeable membrane (S). Cytoskeleton is the network of fine fibres providing structural support in eukaryotic cells (P).

Source: Sections 2.2.1, 2.3, 2.3.1

Q19. A. Both A and R are true and R is the correct explanation of A.

Both statements are true. When a plant cell is placed in a concentrated solution, it loses water by osmosis causing the cell membrane to pull away from the cell wall (plasmolysis), but the rigid cell wall maintains the cell's overall shape. The reason correctly explains the assertion.

Source: Section 2.2.2 - Cell wall

Q20. A. Both A and R are true and R is the correct explanation of A.

The RER appears rough because ribosomes are attached to its surface - this is the direct reason for its rough appearance. Ribosomes are indeed the sites of protein synthesis. The reason correctly explains the assertion.

Source: Section 2.3.1 - Endoplasmic Reticulum

Q21. C. A is true but R is false.

Assertion is TRUE - mitosis does produce two genetically identical daughter cells with the same DNA and same number of chromosomes as the parent cell. However, the Reason is FALSE - it is MEIOSIS (not mitosis) that reduces the chromosome number to half. In mitosis, each new cell gets the same number of chromosomes as the parent cell.

Source: Section 2.4.1 - Mitosis and Meiosis

Q22. A. Both A and R are true and R is the correct explanation of A.

Both statements are true. The textbook states that even single-celled organisms exchange materials and respond to their environment through the cell membrane. The selective permeability of the cell membrane is the property that enables this controlled exchange of materials, making R the correct explanation of A.

Source: Section 2.2 - Structure of a Cell and Section 2.2.1 - Cell membrane

Q23. Osmosis is the diffusion of water across a selectively permeable membrane, from an area of higher water concentration (dilute solution) to an area of lower water concentration (concentrated solution) until concentrations become equal.

Award 1 mark for mentioning 'movement of water through a selectively permeable membrane' and 1 mark for mentioning 'from dilute to concentrated solution'. Full definition: Osmosis is the movement of water through a selectively permeable membrane from a region of lower solute concentration to a region of higher solute concentration.

Source: Section 2.2.1 - Cell membrane and osmosis activity

Q24. The limit of resolution of the human eye is 0.1 mm. It means that when viewed from about 25 cm, two points separated by less than 0.1 mm cannot be seen as distinct and appear as a single point.

Award 1 mark for stating 0.1 mm as the limit of resolution, and 1 mark for correctly explaining that it is the minimum distance at which two points can be seen as distinct (at 25 cm - the near point of the human eye).

Source: Section 2.1 - How to Study Cells

Q25. RER has ribosomes attached to its surface, making it look rough under an electron microscope, and is mainly involved in protein synthesis. SER lacks ribosomes on its surface (looks smooth) and is involved in synthesis and storage of fats and hormones.

Award 1 mark for stating RER has ribosomes attached (looks rough) and 1 mark for stating SER lacks ribosomes (looks smooth). Functions may be mentioned for full clarity but the structural difference is key.

Source: Section 2.3.1 - Endoplasmic Reticulum

Q26. The two types of cell division are mitosis and meiosis. Mitosis produces two genetically identical daughter cells with the same chromosome number as the parent cell, whereas meiosis produces four daughter cells each with half the chromosome number of the parent cell.

Award 1 mark for correctly naming both types (mitosis and meiosis), and 1 mark for a valid key difference (e.g., number of daughter cells, chromosome number, or genetic identity). Both marks required for full credit.

Source: Section 2.4.1 - Cell division: Mitosis and Meiosis

Q27. Chromoplasts are plastids containing pigments other than chlorophyll (yellow, orange, or red), found in flower petals and fruits. Leucoplasts are colourless plastids that store food materials like starch, found in potato and taro (Colocasia) cells.

Award 1 mark for correctly defining chromoplasts with an example (flower petals/fruits) and 1 mark for correctly defining leucoplasts with an example (potato/taro). Partial credit: 0.5 mark each if only definition or only example is given.

Source: Section 2.3.1 - Plastids: chromoplasts and leucoplasts

Q28. The nucleoid is the region in a prokaryotic cell that contains its genetic material (a single circular DNA molecule associated with specific proteins). It is not enclosed by a membrane.

Award 1 mark for stating it is the region containing genetic material (DNA) in prokaryotic cells, and 1 mark for noting it lacks a membrane enclosure (not membrane-bound). The term 'single circular DNA' adds precision.

Source: Section 2.3 and 2.3.1 - Prokaryotic cells and nucleoid

Q29. The potato piece in plain water (Beaker A) swells and gains weight because water moves into the cells by osmosis - the external solution is hypotonic (less solute) so water enters the cells. The potato piece in 20%

salt solution (Beaker B) shrinks and loses weight because water moves out of the cells - the external solution is hypertonic (more solute) so water exits the cells. The process responsible is osmosis. The cell membrane is selectively permeable - it allows water molecules to pass through but blocks larger solute molecules (salt/sugar), thereby controlling the direction of water movement.

Award 1 mark for correctly describing what happens in each beaker (swelling in plain water, shrinking in salt solution).

Award 1 mark for correctly naming osmosis and defining it as movement of water through a selectively permeable membrane. Award 1 mark for explaining the role of the selectively permeable cell membrane (allows water, blocks solutes).

Source: Section 2.2.1 - Cell membrane, osmosis, Activity 2.2

Q30. The fluid-mosaic model describes the structure of the cell membrane as follows: It has a lipid bilayer - two layers of special fat molecules with water-attracting (hydrophilic) heads facing outwards and water-repelling (hydrophobic) tails facing inwards. Proteins are embedded in this lipid bilayer and act as gatekeepers, helping substances pass through. It is called 'fluid' because the lipid and protein molecules can move sideways, flip, and rotate within the membrane. It is called 'mosaic' because the proteins are arranged within the lipid bilayer like tiles in a mosaic pattern.

Award 1 mark for correctly describing the lipid bilayer structure (heads outwards, tails inwards, with embedded proteins). Award 1 mark for explaining 'fluid' - molecules can move sideways/flip/rotate. Award 1 mark for explaining 'mosaic' - proteins arranged like tiles in a mosaic.

Source: Section 2.2.1 - Fluid-mosaic model of the cell membrane

Q31. The Golgi apparatus consists of stacks of flattened, sac-like structures. It acts like the cell's post office - it modifies, sorts, and packages proteins and/or lipids into vesicles for transport, secretion, or lysosome formation. It is functionally linked to the endoplasmic reticulum (ER) because proteins and lipids synthesised in the ER are transported to the Golgi apparatus in vesicles. The Golgi apparatus then processes and packages these materials and dispatches them to their destinations (such as the cell membrane, outside the cell, or to form lysosomes).

Award 1 mark for describing the Golgi apparatus as the packaging and sorting centre (modifies, sorts, packages proteins/lipids into vesicles). Award 1 mark for its link to the ER (receives materials synthesised by ER). Award 1 mark for mentioning its role in secretion, transport, or lysosome formation.

Source: Section 2.3.1 - Golgi apparatus

Q32. (i) Membrane-bound nucleus: Prokaryotic cells do NOT have a membrane-bound nucleus; their genetic material is present in a region called the nucleoid. Eukaryotic cells HAVE a well-defined nucleus enclosed by a nuclear membrane. (ii) Size: Prokaryotic cells are smaller, typically 1 to 10 μm in diameter. Eukaryotic cells are larger, typically 10 to 100 μm in diameter. (iii) Membrane-bound organelles: Prokaryotic cells do NOT have membrane-bound organelles; most cellular activities occur in the cytoplasm. Eukaryotic cells HAVE several membrane-bound organelles such as mitochondria, chloroplasts, and lysosomes.

Award 1 mark each for correctly comparing on all three parameters. Each comparison must clearly state the feature in both prokaryotic and eukaryotic cells for full credit.

Source: Table 2.2 - Comparison between prokaryotic and eukaryotic cells

Q33. Mature Red Blood Cells (RBCs) in humans are specialised because they do not have a nucleus (they are enucleate). Advantage: The absence of a nucleus provides more space for haemoglobin, allowing RBCs to transport a larger amount of oxygen to all cells of the body. Disadvantage: Since they lack a nucleus, they cannot repair or divide themselves. As a result, their lifespan is short - they survive approximately 120 days only.

Award 1 mark for stating that mature RBCs lack a nucleus (enucleate). Award 1 mark for the advantage - more space for haemoglobin/more oxygen transport. Award 1 mark for the disadvantage - cannot repair/divide themselves, short lifespan (~120 days).

Source: Section 2.3.1 - Threads of Curiosity on RBCs

Q34. (i) Mitochondria: Called the 'powerhouse of the cell'. Each mitochondrion is surrounded by two membranes - the outer membrane is smooth and porous, and the inner membrane is folded into finger-like

projections called cristae, which increase the surface area for chemical reactions. Mitochondria break down glucose and other molecules to release energy through cellular respiration. The energy is stored as ATP (Adenosine Triphosphate), which acts as the energy currency of the cell. (ii) Chloroplast: Chloroplasts are double-membrane-bound organelles found in plant cells. Inside is a semi-fluid substance called the stroma, which contains disc-shaped membrane structures bearing chlorophyll. Chlorophyll absorbs sunlight for photosynthesis, producing sugars which are stored in the stroma along with starch granules. Chloroplasts are the sites of food synthesis in plants. (iii) Vacuole: In a mature plant cell, there is usually one large central vacuole surrounded by a single selectively permeable membrane. It is filled with cell sap containing water, minerals, sugars, and waste materials. By storing large amounts of water, the vacuole maintains pressure (turgor pressure) inside the cell, keeping the plant firm. In animal cells, vacuoles are smaller and help in temporary storage of materials. Without sufficient water, vacuoles lose water, cells become less firm, and the plant wilts. Evolutionary significance of mitochondria and chloroplasts: Both mitochondria and plastids have their own DNA and ribosomes, and can synthesise some of their own proteins. These characteristics are similar to certain bacteria, suggesting that both organelles share an evolutionary history with single-celled organisms (endosymbiotic theory).

Award 1 mark each for correctly describing mitochondria (structure: double membrane, cristae; function: cellular respiration, ATP production). Award 1 mark each for chloroplast (structure: double membrane, stroma, chlorophyll-bearing disc membranes; function: photosynthesis). Award 1 mark for vacuole (central vacuole in plants, cell sap, maintains turgor pressure; smaller in animal cells). Award 1 mark for evolutionary significance - own DNA and ribosomes suggesting evolutionary link with bacteria. Award final 1 mark for overall accuracy, labelled diagram if drawn, and coherent explanation.

Source: Section 2.3.1 - Mitochondria, Plastids (Chloroplasts), and Vacuoles

Q35. (a) Cell division is the process by which new cells are formed from pre-existing cells. It is essential for: growth of the organism (cells increase in number), repair of damaged tissues (replacement of dead or damaged cells), reproduction (both asexual and sexual), and replacement of cells lost regularly (e.g., skin cells). (b) Distinction between mitosis and meiosis: (i) Number of daughter cells: Mitosis produces 2 daughter cells; Meiosis produces 4 daughter cells. (ii) Chromosome number: In mitosis, each daughter cell has the same chromosome number as the parent cell (no reduction). In meiosis, each daughter cell has half the chromosome number of the parent cell (reduction division). (iii) Where it occurs: Mitosis occurs in all body (somatic) cells for growth and repair. Meiosis occurs only in cells of reproductive organs - testes (to produce sperm) and ovaries (to produce eggs) in animals; anthers and ovaries in plants. (iv) Significance: Mitosis is important for normal growth, repair, maintenance, and asexual reproduction; it maintains genetic identity. Meiosis is important for sexual reproduction and creation of genetic diversity; it also restores the original chromosome number after fertilisation when gametes combine. (c) If mitosis does not occur properly, errors can lead to uncontrolled cell division (potentially leading to cancer) or insufficient cell replacement, causing organ malfunction. If meiosis does not occur properly, gametes may have incorrect chromosome numbers, leading to genetic disorders in offspring.

Award 1 mark for definition of cell division and its importance. Award 2 marks for the comparison table (0.5 mark each for all four points in both mitosis and meiosis). Award 1 mark for significance of each type (0.5 each). Award 1 mark for the consequences of errors in mitosis and meiosis.

Source: Section 2.4 and 2.4.1 - Cell division, Mitosis, Meiosis

Q36. Cells are too small to be seen by the unaided eye because the limit of resolution of the human eye is 0.1 mm (at 25 cm). Scientists use microscopes to study cells. Robert Hooke was the first person to observe a cell in 1665 using a self-designed microscope (200-300X magnification), observing box-like compartments in cork slices which he named 'cells'. Light microscope structure: A light microscope uses visible light and a combination of lenses - the objective lens and the eyepiece. Key parts include the eyepiece, body tube, objective lens, stage (where the slide is placed), mirror (reflects light), coarse adjustment knob (for rough focusing), fine adjustment knob (for fine focusing), handle, and base. The total magnification = magnifying power of eyepiece x magnifying power of objective lens (e.g., 10X x 10X = 100X). Activity 2.1 to estimate cell size: (1) Place a transparent ruler on the microscope stage and measure the diameter of the circular field of view in mm, then convert to μm (1 mm = 1000 μm). (2) Place the onion peel slide and count the number of cells

along the diameter. (3) Estimated cell size = Diameter of field in $\mu\text{m} \div$ Number of cells along diameter.

Example: If diameter = 5 mm = 5000 μm and 25 cells fit along the diameter, then estimated size = $5000/25 = 200 \mu\text{m}$. **Role of electron microscope:** Electron microscopes use a beam of electrons instead of visible light to produce highly magnified images at the nanometre scale. They provide much greater resolution and magnification than light microscopes, allowing scientists to see fine details of cell structure such as ribosomes, the double membrane of mitochondria, cristae, and the internal structure of the Golgi apparatus - details invisible under a light microscope. Scientists have improved microscopes by improving resolution, contrast, and magnification.

Award 1 mark for explaining the limit of resolution of the human eye and need for microscopes (mentioning Hooke's discovery). Award 1 mark for labelled description of the parts of a light microscope. Award 1 mark for step-by-step explanation of Activity 2.1 and the formula. Award 1 mark for a worked example of cell size estimation. Award 1 mark for explaining the advantage of electron microscopes (electron beam, nanometre scale, greater resolution, reveals fine cell structures).

Source: Section 2.1 - How to Study Cells, Activity 2.1, Ready to Go Beyond (electron microscope)

Q37. (i) The phenomenon is osmosis - water moves out of the plant cell into the concentrated sugar solution (hypertonic solution) due to osmosis through the selectively permeable cell membrane. The specific term for the shrinkage of the cell's inner content away from the cell wall in plant cells is plasmolysis.

(ii) The outer boundary (cell wall) remained unchanged because the cell wall is rigid and permeable - it does not shrink. The cell wall maintains the shape of the plant cell even when the inner content (cytoplasm + cell membrane) loses water and pulls away. This shows that the cell wall provides rigidity and structural support to the plant cell, maintaining its original shape even under stress.

(iii) Cheek cells are animal cells and do NOT have a cell wall. Therefore, when they lose water by osmosis into the hypertonic sugar solution, there is no rigid outer structure to maintain their shape, so the entire cell shrinks. In Rhoecococcus cells, the rigid cell wall prevents the outer boundary from shrinking even though the inner content loses water.

Sub-question (i): Award 1 mark for osmosis and 0.5 mark for plasmolysis. Sub-question (ii): Award 1 mark for explaining that the cell wall is rigid and permeable, maintaining shape. Sub-question (iii): Award 1.5 marks for correctly explaining the absence of a cell wall in animal (cheek) cells as the reason for complete shrinkage, contrasted with plant cells that have a rigid cell wall.

Source: Section 2.2.1 and 2.2.2 - Osmosis, Cell wall, Activity 2.3

Q38. (i) The experiment demonstrates that DNA controls the structure and activities of a cell. The inserted synthetic DNA directed the 'empty' cell to grow and divide according to the instructions encoded in the new DNA, showing that DNA carries all the genetic information needed to direct cellular activities.

(ii) Since Mycoplasma mycoides is a prokaryote, its DNA would normally be located in the nucleoid region of the cell (not enclosed by a membrane). The DNA in prokaryotic cells is a single circular molecule associated with specific proteins, and there is no well-defined, membrane-bound nucleus.

(iii) The scientists said they had not created a completely new cell from scratch because the cytoplasm and cell membrane of the recipient cell were taken from an already existing living cell - only the DNA was synthetic. This suggests that cells can only arise from pre-existing cells (the cell theory principle), and that the non-DNA components of a cell (cytoplasm, membrane) are essential for life and cannot yet be fully synthesised artificially.

Sub-question (i): Award 1 mark for clearly stating that DNA controls cell structure and activities (directing growth and division). Sub-question (ii): Award 1.5 marks - 0.5 for nucleoid location, 0.5 for single circular DNA, 0.5 for absence of membrane-bound nucleus. Sub-question (iii): Award 1.5 marks - 1 mark for explaining that cytoplasm and membrane were from an existing cell (not synthetic), 0.5 mark for linking to the principle that cells arise from pre-existing cells.

Source: Section 2.3 - Threads of Curiosity: J. Craig Venter experiment; prokaryotic cell nucleoid

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