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SECONDARY 3 · SCIENCE (BIOLOGY) · CELL STRUCTURE AND ORGANISATION

Cell Structure and Organisation

Theory and worked examples

Cells: the basic unit of life

All living things are made of cells, the basic structural and functional unit of life. Some organisms, such as an amoeba, are made of just one cell; most plants and animals are multicellular, built from many cells working together. Cells are very small, but a typical plant or animal cell can be seen under a light microscope, and some of its smaller parts can be seen only with a more powerful electron microscope.

KEY IDEA

Every living thing is made of one or more cells, each enclosed by a cell membrane.

- Unicellular organisms (e.g. an amoeba) consist of a single cell that carries out every life process.
- Multicellular organisms (e.g. humans, flowering plants) are built from many cells, often of different kinds.

WORDS TO KNOW

cell	the basic structural and functional unit of life, too small to see with the unaided eye
organelle	a structure inside a cell that carries out a particular job

TRY THIS

Name the basic structural and functional unit of life.

Answer: The cell.

Looking at cells under the microscope

Cells can be examined under a light microscope using prepared slides, or fresh material that the student has prepared. Many cell structures are almost colourless, so a temporary stain is often added to fresh material to make them easier to see. A thin piece of onion epidermis (peeled from the inside of an onion scale leaf) is commonly stained with iodine solution, which colours the cell wall and nucleus so that the cell's outline shows up clearly. Cells scraped gently from the inside of the cheek are commonly stained with methylene blue, which colours the nucleus blue so that it stands out against the pale cytoplasm. A light microscope can show the cell wall, cell membrane, cytoplasm, nucleus, vacuole and chloroplasts. Mitochondria and ribosomes are far too small to be

seen with a light microscope; they can be seen only in photographs taken with an electron microscope, called electron micrographs.

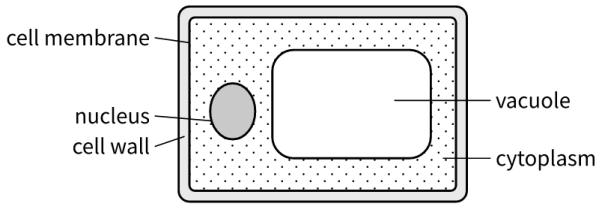
KEY IDEA

A temporary stain adds colour contrast to a cell's structures without permanently colouring or harming the material.

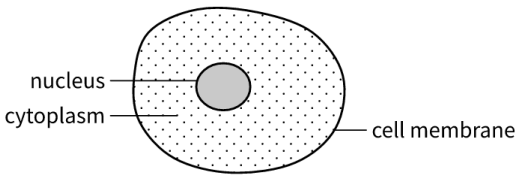
- Onion epidermis + iodine solution: stains the cell wall and nucleus, so the outline of each cell shows up clearly.
- Cheek cells + methylene blue: stains the nucleus blue, so it is easy to find against the paler cytoplasm.
- Without a stain, many cell structures are nearly transparent and hard to tell apart under a light microscope.

WORDS TO KNOW

light microscope	an instrument that uses light and lenses to magnify small objects so that they can be seen
temporary stain	a dye added just before a specimen is viewed, to make certain cell structures easier to see; it is not permanent
electron micrograph	a photograph taken using an electron microscope, showing much smaller detail than a light microscope can show



onion epidermis cell



cheek cell

WORKED EXAMPLE

A student peels a thin piece of epidermis from the inside of an onion scale leaf, places it on a microscope slide, and adds a drop of iodine solution before lowering the cover slip. Explain why she adds the iodine solution.

1. What is given: fresh onion epidermis, about to be viewed under a light microscope.
2. Biology idea: most cell structures are almost colourless, so they are hard to see and tell apart without added colour.
3. Iodine solution is a temporary stain that colours the cell wall and nucleus, giving the structures contrast against the rest of the cell.

Iodine solution is a temporary stain. It colours the cell wall and nucleus, making the outline of each cell and its nucleus easier to see under the light microscope, because these structures would otherwise be almost colourless.

TRY THIS

Name a stain that could be used to make the nucleus of a cheek cell easier to see.

Answer: Methylene blue.

Calculating magnification

The image of a cell seen under a microscope, or drawn from it, is much larger than the actual (real) size of the cell. Magnification tells us how many times larger the image is than the actual object: magnification = size of the image ÷ actual size of the object. Image size is usually measured in millimetres (mm), with a ruler on a printed photograph or a drawing; the actual size of a cell is usually given in micrometres (µm), because cells are so small. Remember that 1 mm = 1000 µm, and always convert both sizes to the same unit before dividing.

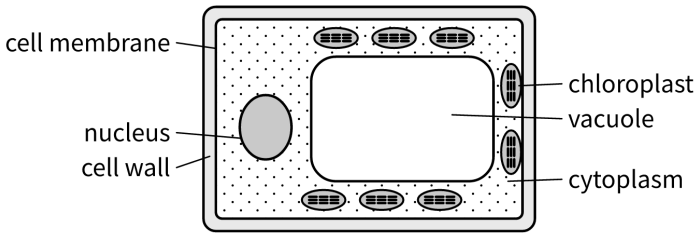
KEY IDEA

Magnification = image size ÷ actual size, with both sizes in the same unit.

- Magnification = image size ÷ actual size.
- Actual size = image size ÷ magnification.
- Image size = actual size × magnification.
- Always convert the image size and the actual size to the same unit before dividing.

WORDS TO KNOW

magnification	how many times larger an image is than the actual object: image size ÷ actual size (both in the same unit)
micrometre (µm)	a unit of length equal to one-thousandth of a millimetre (1 mm = 1000 µm); used for the actual size of a cell



WORKED EXAMPLE

A plant cell has an actual length of 125 µm. Its magnification under the microscope is ×400. (a) Calculate the length of the image of this cell, in mm. A second drawing of a similar cell, made at the same magnification, has an image length of 64 mm. (b) Calculate the actual length of this second cell, in µm.

1. (a) Image size = actual size × magnification = 125 × 400 = 50 000 µm.
2. Convert to mm: 50 000 ÷ 1000 = 50 mm.
3. (b) Actual size = image size ÷ magnification. Convert image size first: 64 mm = 64 × 1000 = 64 000 µm.
4. Actual size = 64 000 ÷ 400 = 160 µm.

(a) Image length = 125 × 400 = 50 000 µm = 50 mm. (b) Actual length = 64 000 ÷ 400 = 160 µm.

TRY THIS

A drawing of a cell is 36 mm long. The actual length of the cell is 90 µm. Calculate the magnification of the drawing.

Answer: 36 mm = 36 000 µm. Magnification = 36 000 ÷ 90 = ×400.

Structures found in both plant and animal cells

Every plant and animal cell has a cell membrane and cytoplasm, and most have a nucleus. The cell membrane surrounds the cytoplasm and is partially permeable: it controls which substances can move into and out of the cell. The cytoplasm is a jelly-like substance that fills most of the cell; it is where many of the cell's chemical reactions happen, and the organelles are suspended within it. The nucleus controls the activities of the cell and contains the genetic material (DNA), which is passed on when the cell divides.

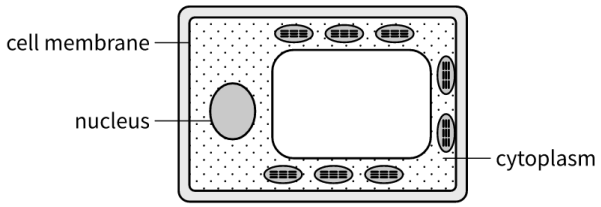
KEY IDEA

Cell membrane, cytoplasm and (in most cells) a nucleus are found in both plant and animal cells.

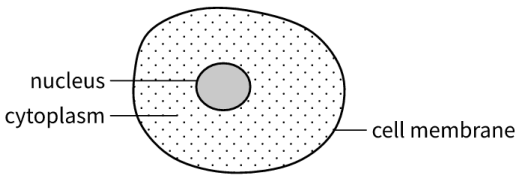
- A red blood cell is unusual: it loses its nucleus as it matures (covered later in this chapter).
- The nucleus is usually the largest, most easily seen structure under a light microscope.

WORDS TO KNOW

cell membrane	a thin, partially permeable structure that surrounds the cytoplasm and controls the movement of substances into and out of the cell
cytoplasm	the jelly-like material filling the cell, in which the organelles are suspended and many chemical reactions take place
nucleus	the structure that controls the activities of the cell and contains the genetic material (DNA)



plant cell



animal cell

WORKED EXAMPLE

A student looks at an unlabelled cell under a light microscope. The sample is damaged, so a cell wall, a vacuole and chloroplasts cannot be seen clearly in it. Suggest two structures the student should still be able to identify in the cell.

1. What is given: a cell with its plant-only structures not visible.
2. Biology idea: the cell membrane, cytoplasm and nucleus are present in (almost) every plant and animal cell, so they do not depend on the damaged structures.
3. Name two of these three structures.

The cell membrane (or its outline) and the nucleus (any two of cell membrane, cytoplasm and nucleus).

TRY THIS

State one structure found in both a typical plant cell and a typical animal cell, other than the cytoplasm.

Answer: Cell membrane (or nucleus).

CHAPTER 1

Practice Questions

Part 2: Cell Structure and Organisation



In the practice questions

23 questions, 73 marks. For each multiple-choice question, write the letter of the correct option (A, B, C or D) in the brackets. Write your other answers on the lines given. The answers are on page 268.

- Section A: Multiple-Choice Questions: 15 questions, 15 marks
- Section B: Structured Questions: 6 questions, 38 marks
- Section C: Free-Response Questions: 2 questions, 20 marks

Name: _____ Class: _____ Date: _____

SECONDARY 3 · SCIENCE (BIOLOGY) · CELL STRUCTURE AND ORGANISATION

Cell Structure and Organisation

INSTRUCTIONS

- 23 questions, 73 marks in total.
- Answer all questions in the spaces provided.
- For MCQs, write the letter (A, B, C or D) in the brackets.
- Write your other answers on the lines given, in full sentences.

Section A: Multiple-Choice Questions

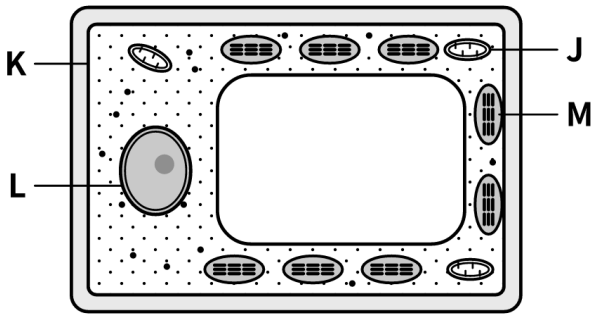
1 Which structure controls the activities of a cell and contains its genetic material? ( ) [1]

(A) cytoplasm (B) nucleus (C) cell membrane (D) vacuole

2 A structure surrounding the cytoplasm lets water pass through easily but holds back larger dissolved molecules. What is this structure, and what word describes this property? ( ) [1]

(A) cell wall; rigid
(B) nucleus; permeable
(C) cell membrane; partially permeable
(D) vacuole; selective

3 The figure shows a plant cell as seen under an electron microscope. Which letter labels a structure that cannot be seen using a light microscope? ( ) [1]



(A) J (B) K (C) L (D) M

4 The actual length of a cell is 25 μm. Its image, drawn from a microscope slide, is 10 mm long. What is the magnification of the drawing? ( ) [1]

Ⓐ ×4 Ⓑ ×40 Ⓒ ×4000 Ⓓ ×400

5 Which temporary stain is commonly used to make the nucleus of a cheek cell easier to see under a light microscope? ( ) [1]

Ⓐ iodine solution
Ⓑ methylene blue
Ⓒ Benedict's solution
Ⓓ biuret solution

6 Four students each wrote down whether a feature is present or absent in a typical plant cell and a typical animal cell. Only one student wrote both parts correctly. Which one? ( ) [1]

Row	Feature	Plant cell	Animal cell
A	Cell wall	Present	Present
B	Large permanent vacuole	Absent	Present
C	Chloroplast	Absent	Present
D	Cell wall	Present	Absent

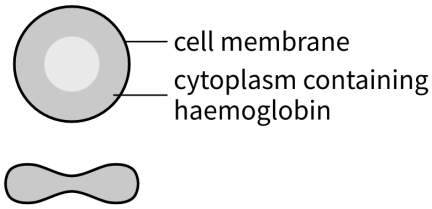
7 Which statements about the cell membrane are correct?
1 controls the movement of substances into and out of the cell
2 contains the genetic material
3 is partially permeable ( ) [1]

Ⓐ 1 and 3 only Ⓑ 1 and 2 only Ⓒ 2 and 3 only Ⓓ 1, 2 and 3

8 A root hair cell is well adapted for absorbing water and mineral salts because it has ( ) [1]

Ⓐ many chloroplasts
Ⓑ a thick cell wall
Ⓒ a long, narrow extension of the cell
Ⓓ no nucleus

9 The figure shows a red blood cell. Why does this cell have no nucleus? ( ) [1]



red blood cell

(A) to make it rounder

(B) to leave more space for haemoglobin, so it can carry more oxygen

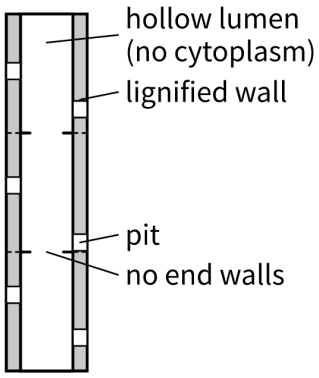
(C) to allow it to produce more mitochondria

(D) to make it more rigid

10 Which specialised cell is adapted with many mitochondria to supply more energy? ( ) [1]

(A) red blood cell (B) xylem vessel (C) root hair cell (D) muscle cell

11 The figure shows a xylem vessel. Which feature allows it to transport water efficiently? ( ) [1]



xylem vessel

(A) a large nucleus (B) many chloroplasts

(C) a hollow lumen with no cytoplasm (D) a thin cell wall