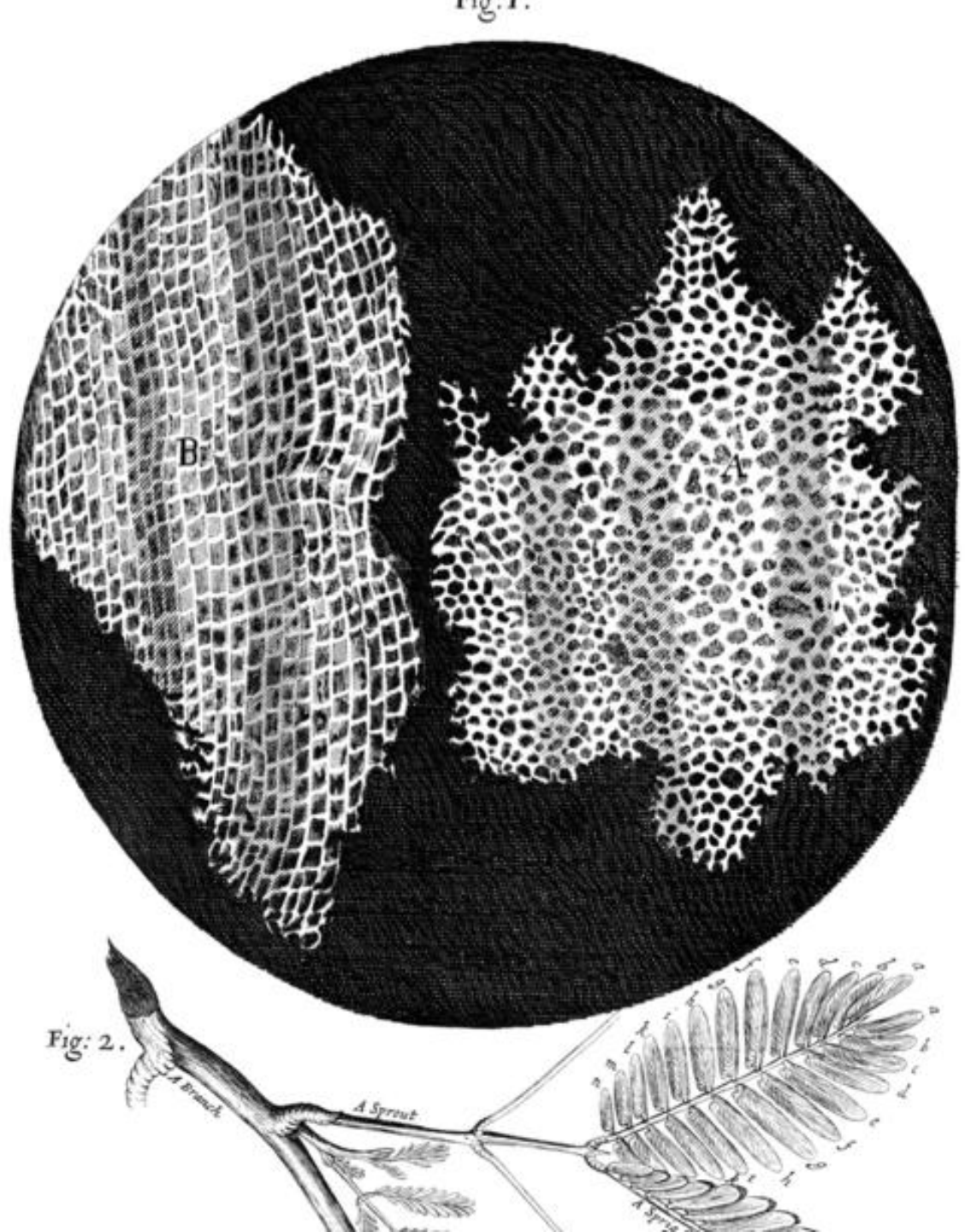
DP Biology – A2.2

Cell structure

- What do all cells share, and how do they differ?
- How do we use microscopes to study cell structure?

SL statements A2.2.1–11. Textbook pp. 49–81.
Image: cork cells, as drawn by Robert Hooke in 1665. Public domain.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	A2.2.1–3	Explain cell theory, calculate magnification and actual size, and compare types of microscopy
2	A2.2.4–6	Identify structures common to all cells, and compare prokaryotic and eukaryotic cells
3	A2.2.7–11	Explain life in a single cell, compare eukaryotes and atypical cells, and read and draw micrographs

Overview of this chapter

Part	Statements	What it covers
Cells and microscopes	A2.2.1–3	Cell theory, magnification and new techniques
All cells	A2.2.4	What every cell has
Two types of cell	A2.2.5–6	Prokaryotes and eukaryotes
Life and variety	A2.2.7–9	Functions of life, animals, fungi, plants, and atypical cells
Skills	A2.2.10–11	Reading and drawing micrographs

Cells: the basic unit of life

- All organisms are built from **cells**, the basic unit of structure
- Every organism consists of one or more cells
- Cells are the smallest units of life, and new cells come from existing cells

Deductive reasoning

Cell theory lets us make predictions. If all living organisms consist of cells, then we can predict that a newly discovered organism will consist of one or more cells.

Discussion

A theory can be tested with its predictions. Could one newly found organism with no cells overturn the theory? What would you want to check first? Think also about giant fungal hyphae and muscle fibres, which you will meet later.

Using a light microscope

A2.2.2



A compound microscope. Acagastya, CC0.

Skill	What to do
Temporary mounts	Thin specimen in a drop of water, with a coverslip lowered at an angle
Staining	Add a stain, such as methylene blue, to show structures
Focusing	Coarse adjustment at low power, then fine adjustment
Measuring	Use an eyepiece graticule, calibrated with a stage micrometer
Recording	Take photographs, and add a scale bar

Activity

Make a temporary mount of onion epidermis. Calibrate your graticule, measure one cell, and calculate its size in micrometres.

Calculating magnification and actual size

Magnification = image size / actual size

Unit	Conversion
Millimetre	1 mm = 1000 µm
Micrometre	1 µm = 1000 nm

Worked example 1

A red blood cell is 8 µm wide, and it is drawn 40 mm wide. Convert: 40 mm = 40 000 µm. Magnification = 40 000 / 8 = × 5000.

Worked example 2

A micrograph at × 2000 shows a cell 50 mm long. Convert: 50 mm = 50 000 µm. Actual size = 50 000 / 2000 = 25 µm.

Using scale bars

A2.2.2



This bar measures 20 mm

- A scale bar shows what a length on the image represents
- Measure the bar, and convert into the same units
- Then apply the same formula

Worked example

A scale bar labelled 100 µm measures 20 mm on the image. 20 mm = 20 000 µm. Magnification = 20 000 / 100 = × 200. An insect on the same image measures 60 mm, so its actual length = 60 000 / 200 = 300 µm.

Common mistake

Always convert units first. The most common error is to divide millimetres by micrometres. Also, check that your answer is sensible: a cell should be measured in micrometres, and a virus in nanometres.

Light and electron microscopes

A2.2.3

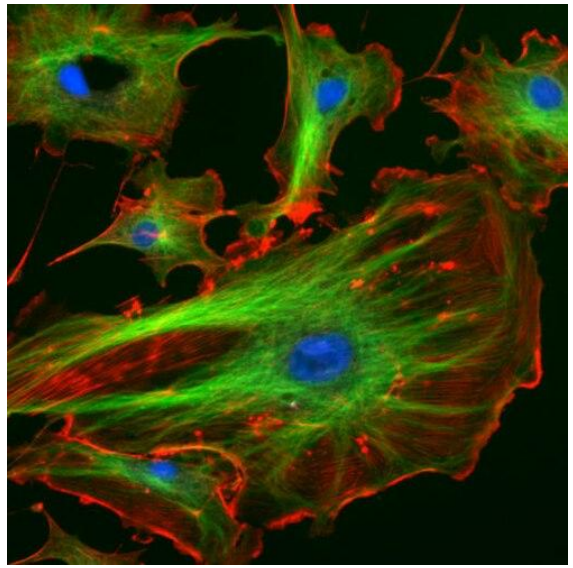
	Light	Electron
Uses	Light	Beams of electrons
Resolution	About 200 nm	About 2 nm or better
Useful magnification	Up to about × 1000	Up to about × 1 000 000
Living specimens?	Yes	No: must be in a vacuum
Colour	Natural or from stains	Black and white; colour is added later

Key idea

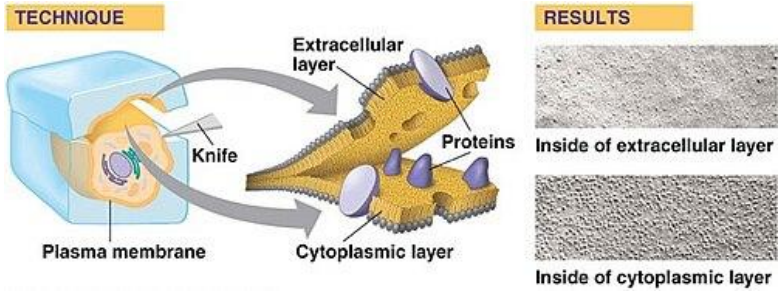
Resolution, not magnification, limits what you can see. Electrons have a much shorter wavelength than light, so they can separate points that are much closer together.

New techniques in microscopy

A2.2.3



Cells with fluorescent stains. Public domain.



Freeze-fracture images. Charles Mallery, public domain.

- **Cryogenic electron microscopy**: rapid freezing preserves molecules in their natural shape
- Many images together give a 3D model of a protein

Technique	How it helps
Fluorescent stains	Dyes glow under certain light, showing chosen structures in colour
Immunofluorescence	Antibodies carry a fluorescent dye to a specific target
Freeze fracture	Frozen cells split along the middle of membranes, revealing surfaces

Structures in all cells

A2.2.4

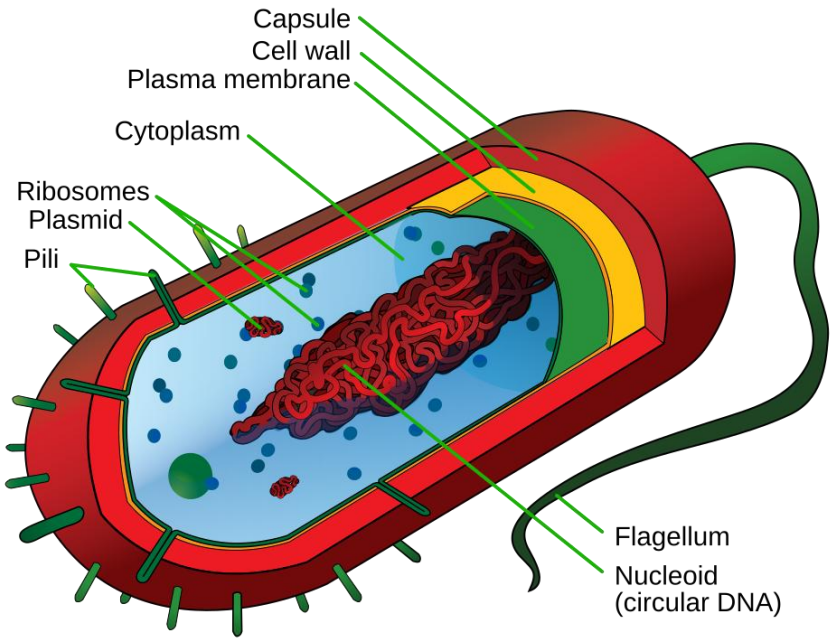
Structure	Made of	Why every cell needs it
Genetic material	DNA	Carries the instructions, and can be copied
Cytoplasm	Mainly water	Reactions take place here, in solution
Plasma membrane	Lipids	Separates inside from outside, and controls what crosses

Key idea

Bacteria and humans differ in a great many ways, but all of their cells have these three. Why is this what you would expect if they all share a common ancestor?

Prokaryotic cells

A2.2.5



A generalized prokaryote. LadyofHats, public domain.

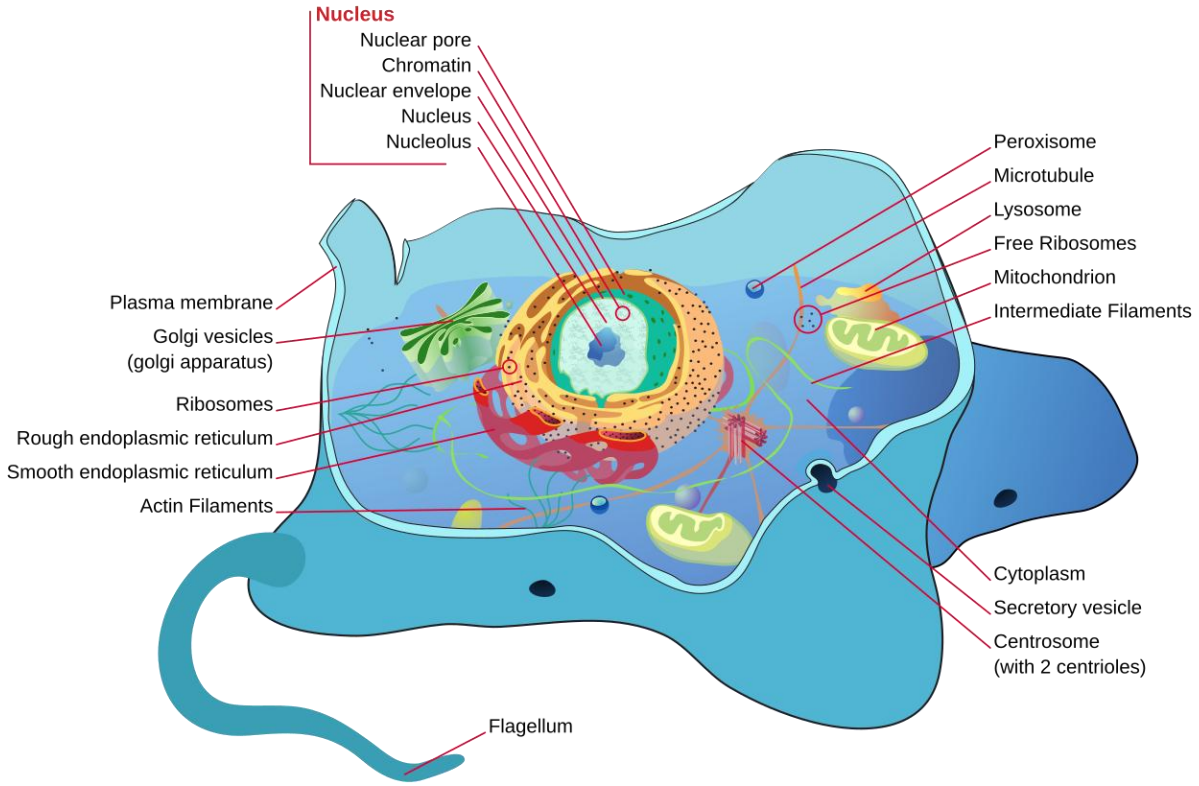
Structure	Detail
Cell wall	Outside the membrane
Plasma membrane	Lipid bilayer
Cytoplasm	No compartments
Naked DNA	A loop, in the nucleoid
Ribosomes	70S

Exam note

The required example is a Gram-positive eubacterium, such as Bacillus or Staphylococcus. Prokaryote structure does vary, but you do not need details of the variations. Be ready to draw one from an electron micrograph.

Eukaryotic cells

A2.2.6



An animal cell. LadyofHats, public domain.

- A plasma membrane encloses a **compartmentalized** cytoplasm
- **80S** ribosomes
- A **nucleus** with a double membrane and pores
- Chromosomes of DNA bound to histones
- Membrane-bound organelles
- A **cytoskeleton** of microtubules and microfilaments

Key idea

Compartments keep enzymes and substrates together at high concentration, and they keep harmful enzymes away from the rest of the cell.

Organelles and their functions

A2.2.6

Organelle	Structure	Function
Nucleus	Double membrane, pores	Stores DNA, and is where transcription occurs
Mitochondrion	Double membrane, cristae	Aerobic respiration, making ATP
Rough ER	Membranes with ribosomes	Makes proteins for secretion or for membranes
Smooth ER	Membranes, no ribosomes	Makes lipids
Golgi apparatus	Stacks of flattened sacs	Modifies and packages proteins
Lysosome	Single membrane, enzymes	Digests food and old organelles
Ribosome	Two subunits, no membrane	Translation: makes polypeptides

Life in a single cell

A2.2.7



Paramecium. Barfooz, CC BY-SA 3.0.

Function	In Paramecium
Homeostasis	Contractile vacuoles expel excess water
Metabolism	Enzymes catalyse reactions in the cytoplasm
Nutrition	Food vacuoles digest what it takes in
Movement	Cilia beat
Excretion	Wastes leave through the membrane
Growth	Takes in material, and gets larger
Response	Changes direction, away from harm
Reproduction	Divides in two

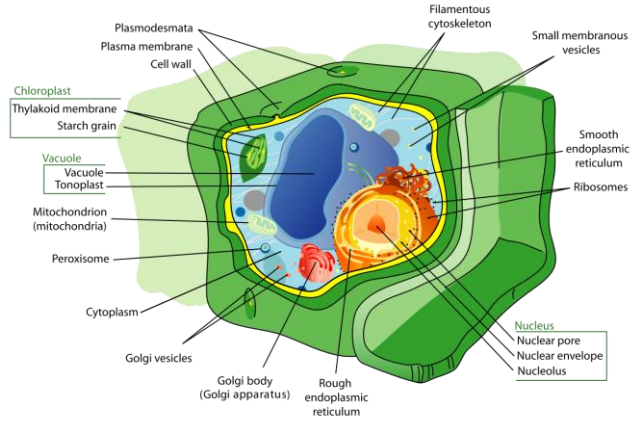
Activity

Chlamydomonas is a single-celled alga. How would its nutrition differ?

Animals, fungi and plants

A2.2.8

	Animals	Fungi	Plants
Cell wall	None	Chitin	Cellulose
Vacuole	Small, temporary	Large or small	Large, permanent sap vacuole
Chloroplasts	None	None	In many cells
Other plastids	None	None	Such as starch stores
Centrioles	Yes	Most: none	None
Cilia or flagella	Often	Most: none	Most: none



A plant cell. LadyofHats, public domain.



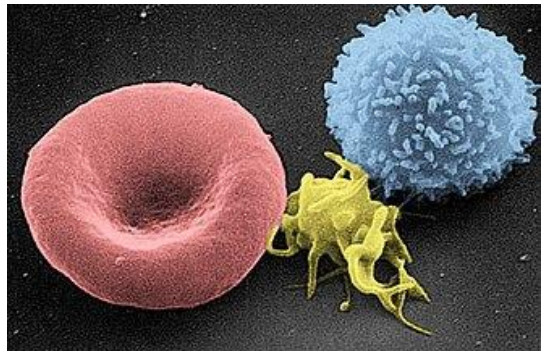
Yeast, a fungus. Murtey, Ramasamy, CC BY 3.0.

Atypical cell structure

A2.2.9

Cell	Nuclei	Why
Aseptate fungal hyphae	Many	Long, with no end walls, so nuclei share the cytoplasm
Skeletal muscle	Many	Cells fuse to form long fibres
Red blood cells	None	More room for haemoglobin, and more flexible
Phloem sieve tube elements	None	Companion cells support them, giving clear tubes for flow



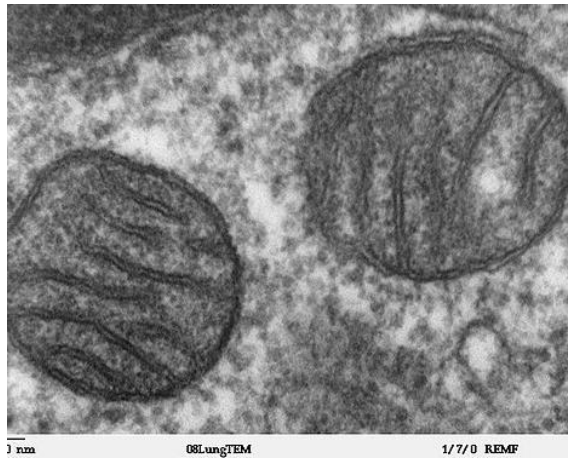




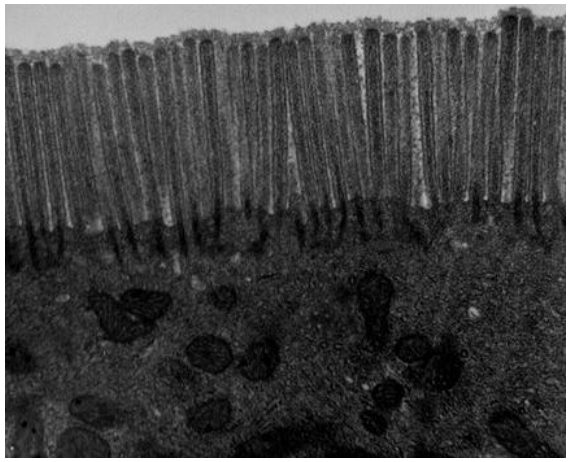
Skeletal muscle (CC BY-SA 3.0); red blood cells (public domain); hyphae (SCIdude, CC0). Atypical cells can challenge the idea that a cell has one nucleus.

Identifying structures in micrographs

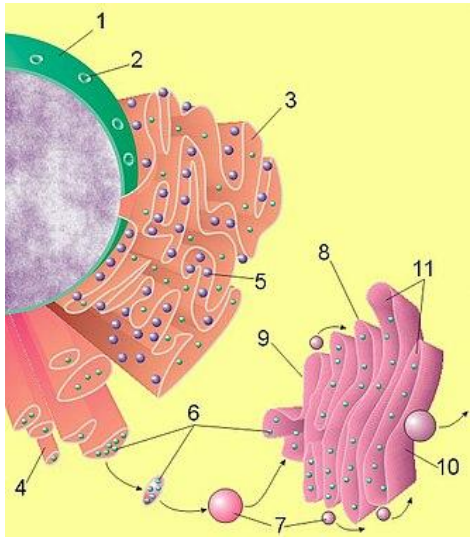
A2.2.10



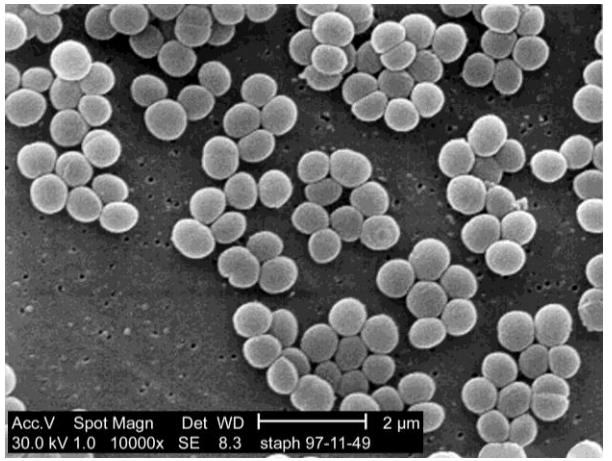
Mitochondria. Louisa Howard, public domain.



Microvilli. Louisa Howard, public domain.



Nucleus, ER, Golgi. Public domain.



Staphylococci. Janice Carr, public domain.

Cell type	Clues in a micrograph
Prokaryote	Small; nucleoid with no membrane; cell wall; no large organelles
Plant	Cell wall, chloroplasts and a large vacuole
Animal	Nucleus, mitochondria and no cell wall

Drawing and annotating from micrographs

A2.2.11

- Use a sharp pencil, and clear, continuous lines
- Do not shade, and keep to the proportions of the micrograph
- Draw only what you can see, and label with straight lines
- **Annotate** with a function, as well as naming each structure
- Add a scale bar or the magnification, where you can

Structures to practise	Example of an annotation
Nucleus, chromosomes	Double membrane with pores, allowing mRNA to leave
Mitochondrion, chloroplast	Folded inner membrane gives a large area for respiration
Golgi, ER, secretory vesicles	Vesicles carry proteins from the Golgi to the membrane
Sap vacuole, cell wall, microvilli	Microvilli increase the surface area for absorption

Prokaryotes and eukaryotes compared

A2.2.6

	Prokaryotes	Eukaryotes
Size	Small: about 1 to 5 μm	Larger: about 10 to 100 μm
DNA	Naked, in a loop	Bound to histones, in a nucleus
Ribosomes	70S	80S
Compartments	None	Many, with membranes
Cell wall	Yes, in the required example	Plants and fungi only

Both have DNA, cytoplasm, a plasma membrane, and ribosomes.

Check that you can explain

1. Cell theory, and its predictions
2. How to calculate magnification and size
3. Light and electron microscopes
4. Fluorescence, freeze fracture and cryo-EM
5. Structures that all cells have
6. Prokaryotes and eukaryotes
7. The functions of life in a single cell
8. Differences between animals, fungi and plants
9. Atypical cells and their nuclei
10. How to read and draw micrographs

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. A cell is 20 μm long, and it is 40 mm long in an image. Calculate the magnification.

2. State three structures found in all cells.

3. Give one difference between the DNA of a prokaryote and that of a eukaryote.

Image credits

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FreezefractureMU.jpg – Dr. Charles H. Mallery, Department of Biology, University of – Public domain

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