Cell structure

Learning outcomes

When you have finished this unit, you should be able to:

- ☐ compare the structure of animal and plant cells as seen through a light microscope
- ☐ measure cells using an eyepiece graticule and stage micrometer scale
- ☐ use the units of length needed in cell studies (millimetre, micrometre and nanometre)
- ☐ calculate the magnifications of drawings and micrographs
- ☐ calculate the sizes of specimens from drawings and micrographs
- ☐ understand the difference between magnification and resolution
- ☐ interpret electron micrographs of animal and plant cells
- ☐ recognise these cell structures and know their functions:
  - cell surface membrane
  - nucleus, nuclear envelope and nucleolus
  - rough endoplasmic reticulum
  - smooth endoplasmic reticulum
  - Golgi body
  - mitochondria
  - ribosomes
  - lysosomes
  - microtubules
  - centrioles
  - chloroplasts
  - cell wall
  - plasmodesmata
  - large permanent vacuole and tonoplast of plant cells
- ☐ outline the role of ATP in cells
- ☐ compare the structure of a bacterial cell with that of animal and plant cells
- ☐ outline the main features of viruses.

The **cell** is the basic 'unit' of living organisms. There are thousands of different types of cell. Each type is adapted for a different function, but they are all recognisable as cells by the structures they contain.

1.01 The structure of animal and plant cells

You should have the opportunity to make temporary slides of suitable animal and plant cells, such as human cheek cells or cells from the leaf of a plant. Stains such as iodine solution or methylene blue are often used to show the cell contents more clearly. For example, iodine stains starch in plant cells blue-black, and colours the nuclei, cytoplasm and cell walls pale yellow. Using a light microscope only enables you to see the larger structures present in cells. From slides you can make drawings of the cells. Alternatively, a photograph of a cell as seen through a light microscope can be taken. A photograph of an image seen through a light microscope is called a light micrograph.

Using a school microscope, you can identify the structures shown in Figure 1.01.

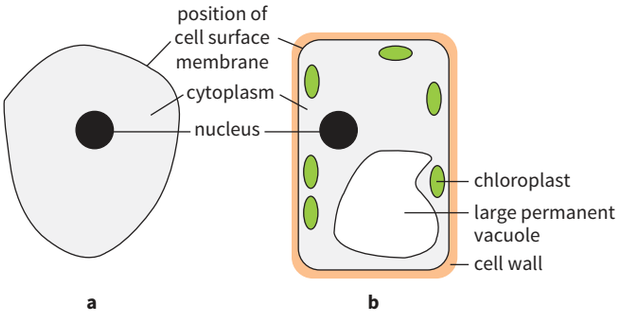

Figure 1.01 The main structures of typical animal and plant cells visible with a school microscope: **a** animal cell and **b** plant cell.

TIP

The cell surface membrane is very thin – too thin to actually be visible through a light microscope. It is better to label its location, such as 'position of cell surface membrane'.

It is possible to see one or two other cell structures through a light microscope, such as **mitochondria** and **Golgi bodies**. However, this needs a very high quality microscope and often involves special staining procedures.

Progress check 1.01

1 What structures can you see in *both* an animal cell *and* a plant cell through a light microscope?

2 What structures are visible in a plant cell but not in an animal cell?

3 Explain why stains are used when making microscope slides of cells.

1.02 Measuring cells

Ideally, to measure a cell you would place a scale or ruler on the slide alongside the specimen. This is not physically possible, but you can use a separate slide with a 'ruler' called a stage micrometer. This has a scale a millimetre in length, divided into 100 divisions (each division = 0.01 mm or 10 μm). The stage micrometer is used together with a scale in the eyepiece lens, called an eyepiece graticule. The eyepiece graticule has no measureable units such as millimetres, because the divisions will represent different lengths depending on the magnification you are using. We say that the eyepiece scale is in arbitrary units. This means that the divisions on the scale are all the same size and can be used for comparison, but if you want to know the actual length of an image, you have to calibrate the eyepiece graticule divisions using the stage micrometer.

Worked example 1.01

Question

A student placed a stage micrometer slide on the stage of his microscope and observed it using a medium power objective lens. He lined up the micrometer scale with the eyepiece graticule and noted that 100 divisions on the graticule scale measured 25 divisions on the stage micrometer (Figure 1.02).

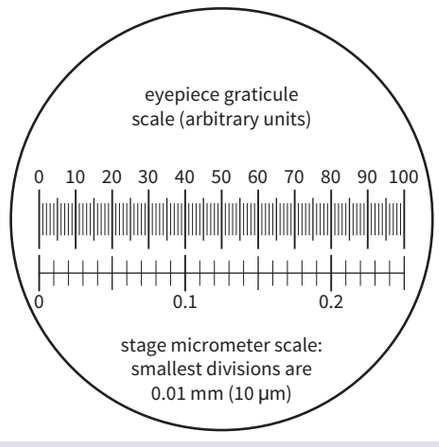

Figure 1.02 Image of a stage micrometer scale aligned alongside an eyepiece graticule scale.

The student removed the stage micrometer from the microscope and replaced it with a slide of some plant tissue. He focused on a cell using the same medium power objective lens. He noted that the cell measured 48 divisions on the eyepiece scale.

Calculate the length of the plant cell in micrometres (μm).

Answer

Step 1:

The length of 25 divisions on the stage micrometer = 25 × 10 μm = 250 μm

Therefore each eyepiece division is equivalent to:

$$\frac{250\ \mu m}{100} = 2.5\ \mu m$$

Step 2:

Using the *same magnification*, 48 divisions on the eyepiece scale are equivalent to:

48 × 2.5 μm = 120 μm

Therefore the length of the plant cell is 120 μm.

TIP

You must use the microscope on the *same magnification* when calibrating the eyepiece graticule and when using it to measure the specimen. If you need to use another objective lens, such as a high power one, you will need to re-calibrate the graticule for use with this lens.

Units of length used in cell studies

- 1 millimetre (mm) = 1/1000 of a metre, or 10^{-3} m
- 1 micrometre (μm) = 1/1000 of a mm, or 10^{-6} m
- 1 nanometre (nm) = 1/1000 of a μm, or 10^{-9} m.

Cells vary a great deal in size, but on average they are a fraction of a millimetre in diameter or length, with plant cells tending to be larger than animal ones. The plant cell in Worked example 1.01 was 120 μm in length. There are 1000 μm in a millimetre; so 120 μm is equal to 0.12 mm.

The structures within a cell are called organelles. Large organelles such as the nucleus and mitochondria are normally measured in micrometres. A typical nucleus is about 5–10 μm in diameter, while a mitochondrion is about 1 μm in diameter and up to 10 μm in length. Smaller organelles are measured in nanometres. For example, a **ribosome** is about 25 nm in diameter, while the cell surface membrane has a thickness of around 7 nm.

Progress check 1.02

1 The student in Worked example 1.01 measured the size of the nucleus of the plant cell and found it to be three divisions on his eyepiece scale, using the same medium power objective lens. What is the diameter of the nucleus in micrometres?

2 A chloroplast is 7 μm in length. What is this length in:

a millimetres

b nanometres?

1.03 Magnification

The **magnification** of a drawing or photomicrograph is the number of times larger the drawing or photomicrograph is, when compared with the actual size of the specimen. For example, the formula for the magnification of a drawing is:

$$\text{magnification} = \frac{\text{size of drawing}}{\text{size of specimen}}$$

The measurement of the drawing and that of the specimen must be in the *same units* in the formula.

A magnification is written like this: ×200 (meaning 'times 200').

Worked example 1.02

Question

A student looked at a plant cell through a microscope and measured its diameter. She found it to be 38 μm. She made a drawing of this cell and measured the diameter of the drawing with a ruler (Figure 1.03). What is the magnification of her drawing?

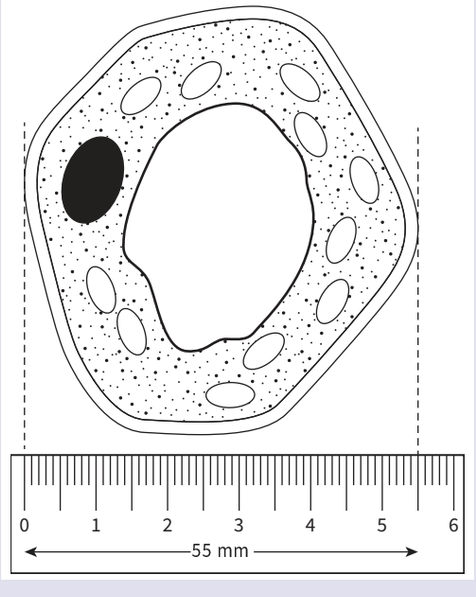

Figure 1.03 A student's drawing of a cell, with a ruler marked in millimetres alongside the drawing.

Answer

Step 1:

The width of the drawing measures 55 mm on the ruler. The drawing and the specimen must be measured in the same units. The specimen is 38 µm and the drawing is 55 mm. It is easiest to convert 55 mm into µm:

size of drawing in µm = (55 mm × 1000 µm/mm) = 55 000 µm

Step 2:

Actual size of specimen = 38 µm

$$\text{magnification} = \frac{\text{size of drawing}}{\text{size of specimen}}$$

$$= \frac{55\,000\ \mu\text{m}}{38\ \mu\text{m}}$$

$$= \times 1447$$

$$= \times 1400 \text{ (to two significant figures)}$$

(i.e. the student's drawing is 1400 times larger than the actual cell on the slide.)

The magnification of a microscope can be found by multiplying the power of the eyepiece by the power of the objective lens. For example, a ×10 eyepiece and a ×40 objective gives the microscope an overall magnification of 10 × 40 = ×400.

TIP

When putting a magnification on a drawing, do not be tempted to use the microscope magnification. This only tells you how much bigger the image seen through the microscope is in comparison with the specimen. The magnification of a drawing will depend on how big you make your drawing!

Drawings or photomicrographs should always show the magnification of the specimen. This can be as a number (e.g. ×800) or by using a scale bar. A scale bar is a line drawn alongside the specimen, with the length of the line labelled (Figure 1.04).

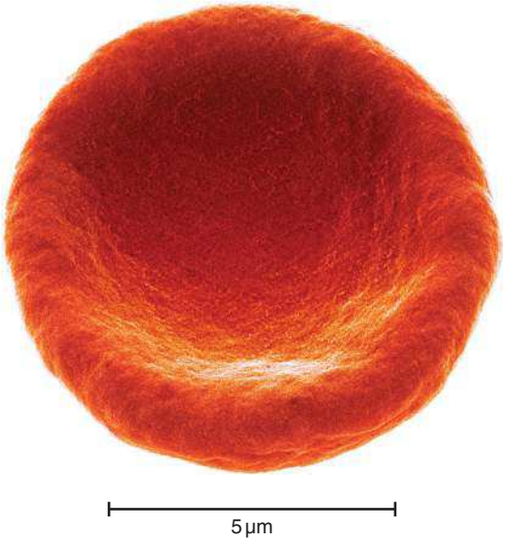

Figure 1.04 Photomicrograph of red blood cell, with a scale bar.

The scale bar can be used to find the magnification. In Figure 1.04 the scale bar is 40 mm in length, which is 40 000 µm, so:

$$\text{magnification of the scale bar (and the specimen)} = \frac{\text{size of scale bar on the photomicrograph}}{\text{real size of scale bar}}$$

$$= \frac{40\,000\ \mu\text{m}}{5\ \mu\text{m}}$$

$$= \times 8000$$

Magnification and resolution

A good quality light microscope can magnify objects about 2000 times (×2000), allowing us to view structures down to about 1 µm in length. However, at this magnification the 'detail' that is visible is very limited. The amount of detail is called the **resolution**. It is defined as the shortest distance between two points that can be distinguished as being separate. In a light microscope this is about 0.2 µm (200 nm). Through this microscope, two points that are closer than 200 nm will appeared blurred together and not visible as separate points.

We could take a photomicrograph and increase its magnification, 'blowing it up' so that it was the size of a poster, but this would not improve its resolution. To increase the magnification and improve the resolution of an image we have to use an electron microscope. The wavelength of a beam of electrons is much less than that

of visible light, so an electron microscope can achieve a much better magnification and resolution than a light microscope. The useful limit of a modern **transmission electron microscope (TEM)** is over a million times magnification, with a resolution of less than 1 nm.

1.04 Electron micrographs of cells

A photograph of a specimen seen through an electron microscope is called an electron micrograph. Whereas a light microscope is normally used to look at cells at a magnification of a few hundred times, most electron micrographs are taken in the approximate range ×10 000 to ×200 000. Using higher magnifications and the improved resolution, much more can be seen of the structure within a cell and within the individual organelles. This fine detail is called the ultrastructure of the cell. Figure 1.05 shows a diagram of a typical plant cell from a leaf, as seen through the electron microscope.

Much of the mass of a cell consists of membranes. As well as the cell surface membrane, the cytoplasm contains an extensive membrane system called **rough endoplasmic reticulum** (rough ER) covered with tiny organelles called **ribosomes**. There is also **smooth endoplasmic reticulum** (smooth ER), which lacks ribosomes. Other organelles such as the **nucleus, mitochondria** and **chloroplasts** are also surrounded by their own membranes. Membranes serve to isolate the processes and chemical reactions going on within the organelles. This is called **compartmentalisation**. All the membranes in a cell have a similar structure (see Unit 4). Table 1.01 shows a summary of the main organelles found in cells.

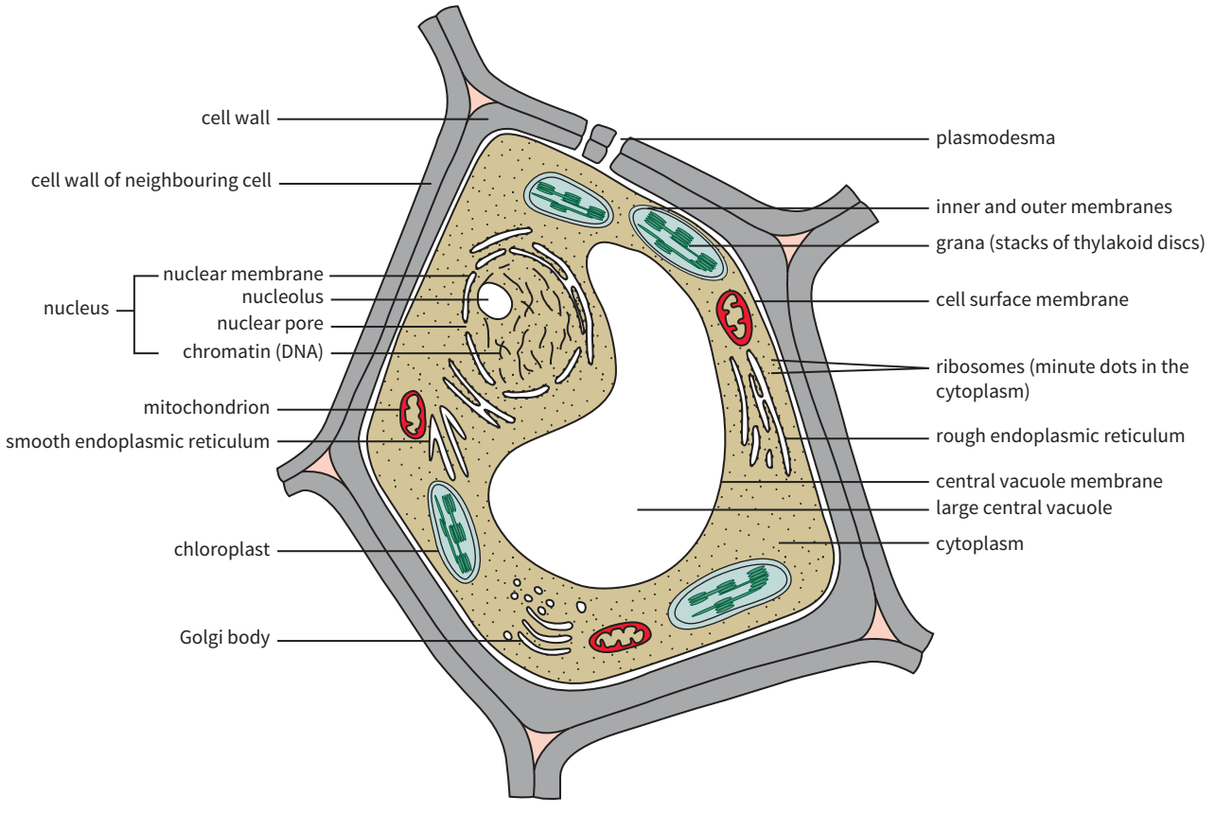

Figure 1.05 The ultrastructure of a typical plant cell from a leaf.

Organelle	Location and size	Structure and function(s)
cell surface membrane	surrounds cell (about 7 nm thick)	composed of phospholipids and protein (see Unit 4); partially permeable and controls the movement of substances into and out of the cell; allows cells to interact with each other and to respond to signals from outside the cell
nucleus	in cytoplasm, usually one per cell (about 5–10 µm in diameter)	contains the hereditary material (**deoxyribonucleic acid (DNA)**) coding for the synthesis of proteins in the cytoplasm. Surrounded by a double membrane called the **nuclear envelope**
nucleolus	one to several in nucleus (1–2 µm in diameter)	synthesises ribosomal RNA and makes ribosomes
rough ER	throughout cytoplasm (membranes about 4 nm thick)	'rough' because covered with ribosomes; membranes enclose compartments (sacs) that transport proteins synthesised on the ribosomes
smooth ER	in cytoplasm; extent depends on type of cell (membranes about 4 nm thick)	similar to rough ER but no ribosomes; synthesises and transports lipid molecules
Golgi body	in cytoplasm (variable in size and number)	synthesises glycoproteins (proteins with carbohydrate groups attached); packages proteins for export from the cell
mitochondria (singular = mitochondrion)	in cytoplasm; can be many thousands in some cells (around 1 µm diameter, up to 10 µm in length)	produce **adenosine triphosphate (ATP)** by aerobic respiration (see below and Unit 12)
ribosomes	attached to rough ER or free in cytoplasm (20–25 nm in size)	site of protein synthesis
lysosomes	in cytoplasm; variable in number (0.1–0.5 µm in diameter)	digests unwanted materials and worn-out organelles
microtubules	throughout cytoplasm (long hollow protein tubes 25 nm in diameter)	along with thinner protein filaments form the **cytoskeleton**; involved in movement of organelles
centrioles	two hollow cylinders about 0.5 µm long, present in animal cells; lie next to the nucleus in a region called the centrosome	made of protein microtubules; the centrosome is a microtubule organising centre (MTOC) and is involved with the formation of the spindle during nuclear division (see Unit 5), but the exact function of the centrioles is unknown; plant cells do not have a centrosome or centrioles, but can still form a spindle
chloroplasts	in cytoplasm of some plant cells (up to 10 µm in length)	contain **chlorophyll** and are the site of photosynthesis (see Unit 13)
cell wall	layer surrounding plant cells, variable thickness	made of the carbohydrate **cellulose** (see Unit 2); supports the plant cell and maintains its shape
plasmodesmata (singular = plasmodesma)	pores in plant cell wall (about 50 nm in diameter)	contain fine strands of cytoplasm linking a plant cell with its neighbouring cells and allowing movement of materials between cells
vacuole	large central space in plant cells (variable in size)	contains various solutes such as sugars, mineral salts and pigments; surrounded by a membrane called the **tonoplast**, which controls exchange of materials between the vacuole and the cytoplasm (note that animal cells have vacuoles, but these are small temporary structures)

Table 1.01 Summary of the main organelles present in cells.

Many of the structures in Table 1.01 will be described in more detail in later units of this book (see references in Table 1.01). For now all you need to be able to do is recognise the organelles and give an *outline* of their functions.

Figure 1.06 is a diagram of the structure of a typical animal cell, as seen through an electron microscope.

With reference to Figures 1.05 and 1.06, note these extra points:

- The nucleus is surrounded by a double membrane called the nuclear envelope. The outer membrane of the nuclear envelope is continuous with the endoplasmic reticulum.
- The nuclear envelope contains 'holes' called **nuclear pores**. These allow movement of materials between the nucleus and the cytoplasm. For example, messenger RNA (mRNA) made in the nucleus can exit to the cytoplasm, carrying the instructions for protein synthesis encoded in the DNA (see Unit 6). Substances made in the cytoplasm can enter the nucleus through the pores (e.g. ATP).
- The nucleus contains the hereditary material (DNA) within structures called **chromosomes**. These are only visible when the nucleus divides (see Unit 5). Between cell divisions the chromosomes form a loosely coiled material called **chromatin**.
- The endoplasmic reticulum forms a complex three-dimensional system of sheet-like membranes and tubes enclosing fluid-filled sacs. Rough ER is 'studded' with ribosomes. Smooth ER lacks ribosomes, and is more tubular in appearance than rough ER. Ribosomes are also found 'loose' in the cytoplasm, where they are known as free ribosomes.
- Ribosomes are the site of protein synthesis. They are composed of protein and RNA. The 'instructions' for protein synthesis are encoded in the DNA and carried out to the ribosomes by mRNA.
- Ribosomes in the cytoplasm are large (known as 80S ribosomes). There are also smaller ribosomes (70S) in mitochondria and chloroplasts.
- The Golgi body (also known as the Golgi apparatus) consists of a stack of flattened membranes enclosing hollow sacs, called **cisternae**. Small spherical membrane vesicles containing protein are continually 'pinched off' the rough ER and fuse together to

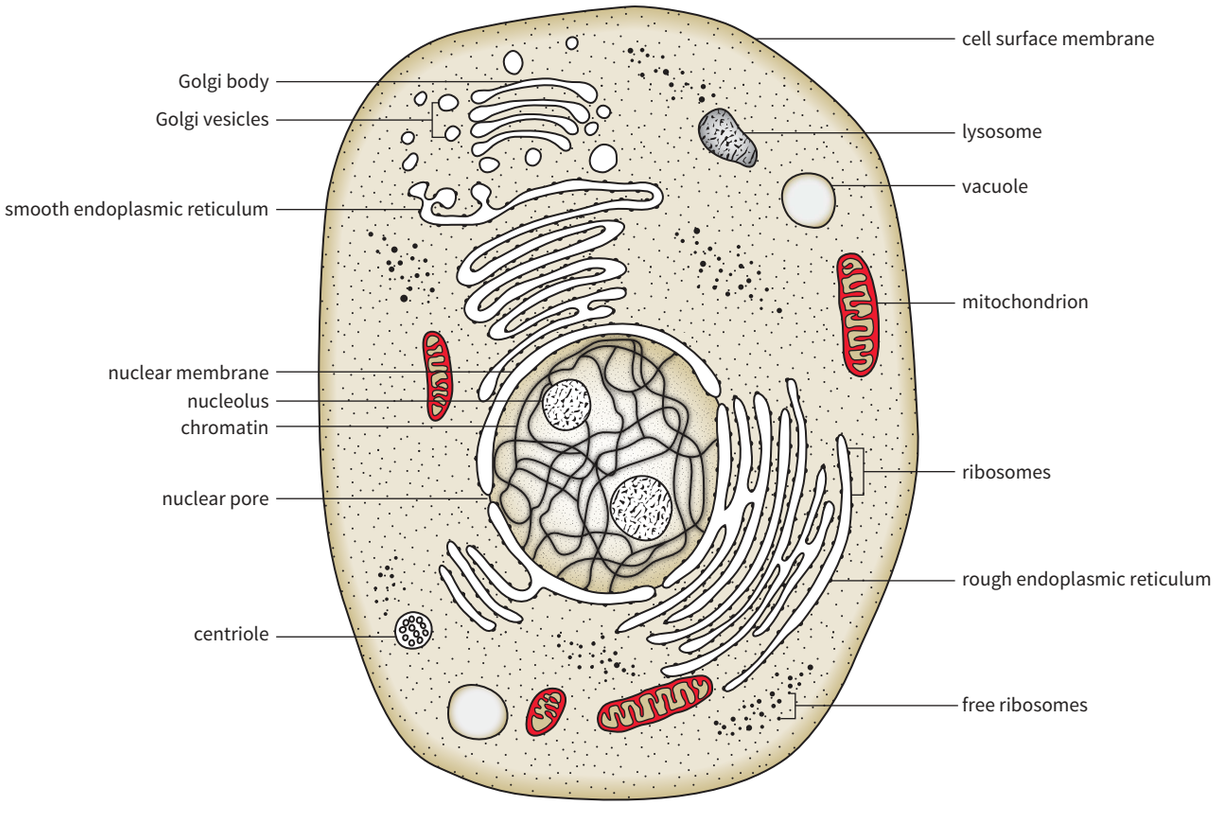

Figure 1.06 The ultrastructure of a typical animal cell.

form the Golgi body, on its side closest to the nucleus. Inside the cisternae the protein is chemically modified, such as by addition of carbohydrate to form **glycoproteins**. At the side furthest from the nucleus, vesicles containing the modified protein bud off from the cisternae and are transported to other parts of the cell. Some vesicles may fuse with the cell membrane, releasing their contents out of the cell. This secretion process is called **exocytosis** (see Unit 4). The Golgi body is also involved in making lysosomes.

- Lysosomes are found in most animal and plant cells. They are membrane-bound sacs formed when digestive enzymes are incorporated into vesicles from the Golgi body. The single membrane surrounding the lysosome keeps the digestive enzymes separate from the rest of the cell. Lysosomes can fuse with vacuoles containing unwanted structures such as old organelles. The enzymes in the lysosome then break down (digest) the unwanted material. Lysosomes are especially common in animal cells that carry out a process called phagocytosis, such as some white blood cells (see Unit 8), where they are used to digest pathogenic organisms such as bacteria.
- Chloroplasts are found in cells from the green parts of plants such as leaves and green stems. They are surrounded by a membrane and contain a complex internal system of membranes called **thylakoids**, arranged in stacks called **grana**. The membranes contain photosynthetic pigments such as chlorophyll, which absorb light energy and use it to make organic molecules such as glucose and starch (see Unit 13).

Progress check 1.03

1 Explain the difference between the magnification and the resolution of a microscope.

2 Briefly describe the location of these organelles and their functions:
   - **a** nucleolus
   - **b** lysosomes
   - **c** plasmodesmata.

3 Arrange theses organelles in increasing order of size: nucleus, chloroplast, ribosome, centriole.

1.05 Mitochondria and the role of ATP

Mitochondria are present in nearly all animal and plant cells. The number of mitochondria in a cell is directly related to its energy demands. Cells that require a lot of energy, such as a muscle cell, contain many thousands of mitochondria, whereas less active cells have fewer of these organelles. Aerobic respiration takes place inside mitochondria. This releases energy, which is used to make a substance called adenosine triphosphate (ATP). ATP is the universal energy 'currency' in cells.

During respiration, energy-rich molecules such as glucose are broken down in a series of reactions. The chemical energy contained within these molecules is used to make ATP, which is in turn used to drive all the energy-requiring processes in a cell. To extract the energy from ATP, the molecule is broken down by a hydrolysis reaction, to form adenosine diphosphate (ADP) and phosphate. A simplified equation for this is:

ATP + water → ADP + phosphate + energy

The details of the formation of ATP during respiration are described in full in Unit 12, but at this stage all you need to know is that most ATP is formed during the last stages of respiration, which take place in the mitochondria. To carry out these stages a cell needs oxygen, which is why this is called ***aerobic*** respiration.

Figure 1.07 shows the internal structure of a mitochondrion. It has a smooth outer membrane and an inner membrane that is folded into a number of shelf-like **cristae**, which increases the surface area of the inner membrane. The last two stages of aerobic respiration are called the **Krebs cycle** and **oxidative phosphorylation**. The Krebs cycle takes place in the fluid-filled **matrix** of the mitochondrion and oxidative phosphorylation (where most ATP is produced) occurs on the inner membrane.

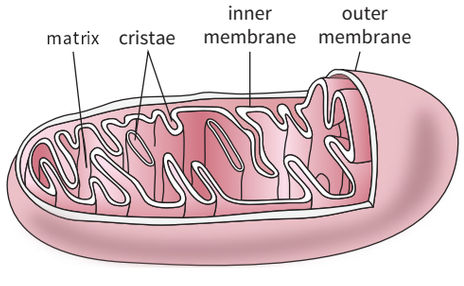

Figure 1.07 The internal structure of a mitochondrion.

Sample question 1.01

Explain the involvement of the nucleus, rough endoplasmic reticulum and Golgi body in the synthesis of glycoproteins in a cell. [10 marks]

[Mark points are shown in square brackets – to a maximum of 10 marks]

The nucleus contains the genetic material within the chromosomes, in the form of deoxyribonucleic acid (DNA) **[1]**. DNA carries the instructions (genetic code) needed for the synthesis of proteins **[1]** in the cytoplasm. These instructions are carried out to the cytoplasm by messenger RNA (mRNA) **[1]** through pores in the nuclear envelope **[1]**, and enter the sacs of the rough endoplasmic reticulum (rough ER) **[1]**, which are continuous with the nuclear envelope **[1]**. The rough ER is covered in small organelles called ribosomes **[1]**, where proteins are synthesised **[1]**. Small vesicles containing protein are pinched off the rough ER **[1]** and fuse together to form the cisternae of the Golgi body **[1]**, on its side closest to the nucleus. Inside the cisternae the protein is chemically modified by addition of carbohydrate to form glycoproteins **[1]**. At the side furthest from the nucleus, vesicles containing the modified protein bud off from the cisternae **[1]** and are transported to other parts of the cell.

This question requires you to know the location, structure and function of each of the three named organelles, and to put this information together as an account of the sequence of events taking place that result in production of glycoproteins in the cytoplasm.

The sample answer is laid out in the correct sequence and summarises the steps clearly, without including any irrelevant information.

Note that it is best to give the full names of biological terms when they are first used, such as deoxyribonucleic acid (DNA). The abbreviations can then be used in the rest of the answer.

1.06 Prokaryotic cells

The cells described so far in this unit are examples of **eukaryotic** cells. Eukaryotic means 'having a true nucleus'. Bacteria are also composed of cells, but they are much smaller than eukaryotic cells and simpler in structure. They are called **prokaryotic** cells (meaning 'before nucleus'). Bacterial cells have no nucleus or nuclear membrane. Their DNA is loose in the cytoplasm, forming a single circular loop, which is sometimes called a **bacterial chromosome**. Some bacteria also have smaller loops of DNA in the cytoplasm, called **plasmids**. Their cells lack endoplasmic reticulum and membrane-bound organelles such as mitochondria and chloroplasts.

The structure of a generalised bacterial cell is shown in Figure 1.08.

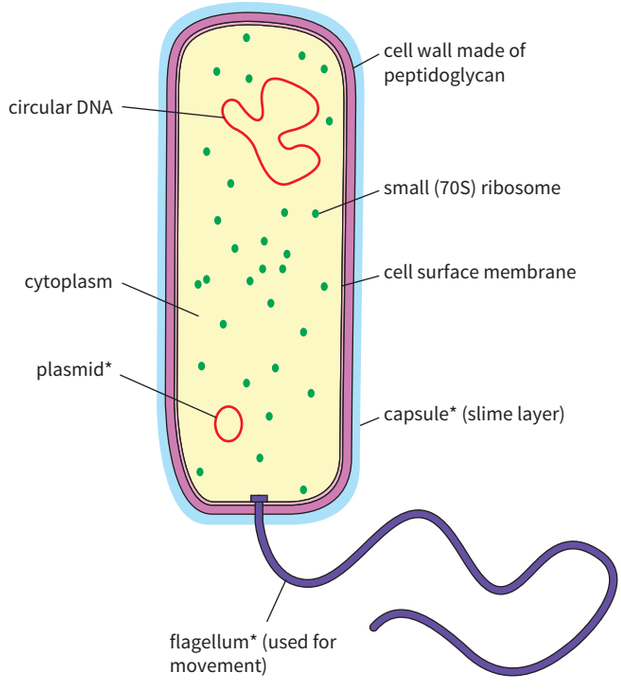

Figure 1.08 Diagram of a generalised bacterial cell. The structures marked with an asterisk are not found in all bacteria.

Eukaryotic cells	Prokaryotic cells
large (typically 10–100 µm in diameter)	small (typically 0.5–3 µm in diameter); volume as little as 1/10 000 of a eukaryotic cell
true nucleus surrounded by a nuclear membrane	no nucleus
linear DNA associated with protein, forming true chromosomes	circular DNA, not associated with proteins; may contain separate loops of DNA called plasmids
if present, cell wall made of cellulose (in plants) or chitin (in fungi)	cell wall made of **peptidoglycan** (a polysaccharide with some amino acid groups)
endoplasmic reticulum present	no endoplasmic reticulum or associated organelles such as the Golgi body
membrane-bound organelles such as mitochondria and chloroplasts present	no membrane-bound organelles (infolds of the cell surface membrane may be involved in photosynthesis and other processes)
large (80S) ribosomes attached to the rough ER and free in the cytoplasm	small (70S) ribosomes free in the cytoplasm
flagella present in some cells; they have a complex structure containing several microtubules	if present, flagella are made of a single microtubule

Table 1.02 Differences between eukaryotic and prokaryotic cells.

A comparison of the structure of eukaryotic and prokaryotic cells is given in Table 1.02.

1.07 Viruses

Viruses are tiny particles that are much smaller than bacteria. They do not consist of cells, and in many ways can be thought of as being intermediate between a chemical and a living organism. Viruses are not free-living and can only reproduce inside a host cell (i.e. they are parasites).

Viruses cause many diseases in plants and animals. For example, the tobacco mosaic virus produces brown blotches on the leaves of tobacco plants and the human influenza virus causes the symptoms we know as 'flu'. The **human immunodeficiency virus (HIV)** is the virus responsible for causing acquired immune deficiency syndrome (AIDS).

A virus particle is very simple in structure. It has no nucleus or cytoplasm, and consists of genetic material contained within a protein coat (Figure 1.09). The protein coat or **capsid** is made up of many individual protein molecules called **capsomeres**. The genetic material can be either DNA or RNA and makes up just a few genes. The genetic material, along with one or two enzymes, is all that the virus needs in order to reproduce within the host cell. The virus takes over the host cell, instructing it to make more virus particles. This normally causes the death of the host cell. Some viruses are surrounded by a membrane called an envelope. This is not part of the virus itself – it is derived from the host cell. During the life cycle of the virus, the virus particles burst out of the host cell, taking part of the surface membrane of the host cell with them.

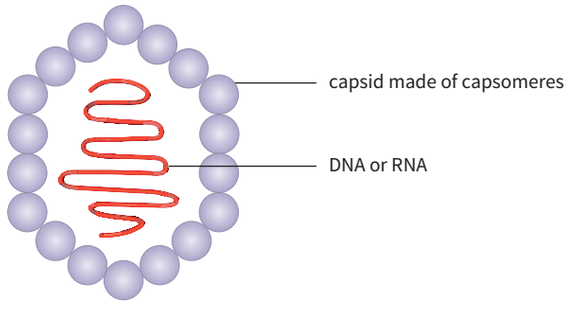

Figure 1.09 The structure of HIV.

Progress check 1.04

1 Briefly describe (in one paragraph) the main differences between a eukaryotic and a prokaryotic cell.

2 Explain why some biologists do not regard viruses as living organisms.

Revision checklist

Check that you know:

- ☐ the similarities and differences between an animal and a plant cell as seen through the light microscope
- ☐ the units of length used in cell studies (millimetre, micrometre and nanometre)
- ☐ how to calculate the magnifications of drawings, photomicrographs or electron micrographs
- ☐ how to calculate the sizes of specimens from drawings, photomicrographs or electron micrographs
- ☐ the difference between magnification and resolution
- ☐ how to describe and interpret electron micrographs of animal and plant cells
- ☐ how to recognise the following cell structures and knowing their functions:
  - cell surface membrane
  - nucleus, nuclear envelope and nucleolus
  - rough endoplasmic reticulum
  - smooth endoplasmic reticulum
  - Golgi body
  - mitochondria
  - ribosomes
  - lysosomes
  - microtubules
  - centrioles
  - chloroplasts
  - cell wall
  - plasmodesmata
  - large permanent vacuole and tonoplast of plant cells
- ☐ an outline of the role of ATP in cells
- ☐ how to compare the structure of a bacterial cell with the structure of animal and plant cells
- ☐ an outline of the main features of viruses.

Exam-style questions

1 Figure 1.10 is a drawing made from an electron micrograph of an animal cell.

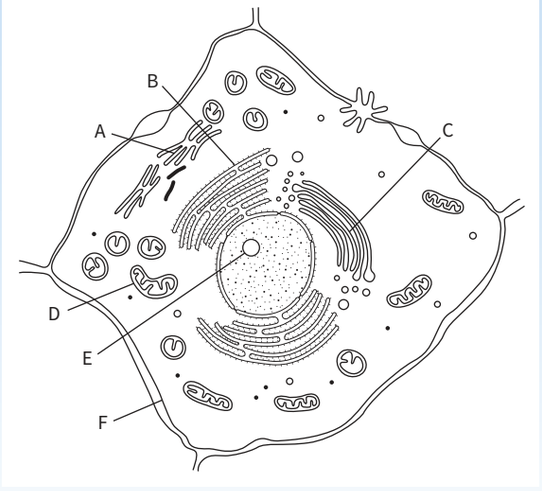

Figure 1.10 A drawing made from an electron micrograph of an animal cell.

a Copy and complete Table 1.03, name the organelles A to F and state one function of each. [6]

b Explain why an electron micrograph of this cell shows more detail than a light micrograph taken at the same magnification. [2]

c Name three other structures, not visible in Figure 1.10, which could be seen in an electron micrograph of a plant leaf cell. [3]

2 Table 1.04 lists some features of animal, plant and bacterial (prokaryotic) cells. Copy and complete Table 1.04, placing a tick (✓) in the appropriate box if the statement is correct and a cross (✗) if it is not. [8]

3 a Briefly describe the structure of a virus particle. [3]

b 'All viruses are parasitic'. Explain this statement. [2]

→

	Name of organelle	Function
A		
B		
C		
D		
E		
F		

Table 1.03

Feature	Animal cell	Plant cell	Bacterial cell
cell wall made of cellulose			
cell surface membrane			
rough endoplasmic reticulum			
ribosomes			
cytoskeleton			
Golgi apparatus			
chloroplasts			
mitochondria			

Table 1.04