

This unit should fill approximately **29 periods** of teaching time.

Learning competencies for Unit 4

By the end of this unit students should be able to:

- Tell the history of cell biology.
- Describe cell theory and investigate the size, structure and shape of cells.
- State the basic functions of cells.
- Appreciate that all life on Earth originates from cells.
- Appreciate that there are just two basic types of cells: prokaryotic and eukaryotic cells.
- Give examples and describe the basic structure of each type.
- Explain the difference between prokaryotic and eukaryotic cells.
- Discuss the importance of a cell membrane.
- Describe the composition and arrangement of lipids and proteins in the membrane.
- Compare the Davson–Danielli and fluid mosaic models.
- Construct and show the arrangement of the phospholipids and proteins in the fluid mosaic model.
- Explain the role of glycoprotein and other components in the cell membrane.
- Name the different parts of the cell and explain their functions.
- State and explain the mechanisms of substance transport across a cell membrane.
- Conduct an experiment to show movement of solvent through a semi-permeable membrane.
- Demonstrate osmosis at a semi-permeable membrane.
- Explain that the size of a cell changes by osmosis because of the inflow and outflow of water.
- Appreciate that osmosis is responsible for everyday life phenomena.

This section should fill approximately **8 periods** of teaching time.

4.1 Cell theory

Learning competencies

By the end of this section students should be able to:

- Tell the history of cell biology.
- Describe cell theory and investigate the size, structure and shape of cells.
- State the basic functions of cells.
- Appreciate that all life on Earth originates from cells.



Starting off

Introduce the unit by asking students to name as many different types of cells as they can think of. Inevitably, this will start with them naming human cells, but with a little prompting, they can easily widen this to include cells from all kinds of other organisms.

It could even be worth making a display, which could highlight:

- features that cells have in common
- the range of size of the different cells
- the range of functions of different cells
- the way in which some different cells are adapted to their functions

Students should appreciate that any serious study of cells, even their discovery, had to wait for the invention of reliable microscopy.

Teaching notes

The Students' Book provides a description of the major events in the history of the development of the modern cell theory and a slightly more inclusive one in tabular form. These could form the basis for students to construct a time line of their own using the diagram below as a format.

They could add more detail to the timeline, such as:

- photographs/drawings of the scientists involved
- illustrations of what they found (where relevant)
- descriptions of any theories they put forward
- any limitations of their work

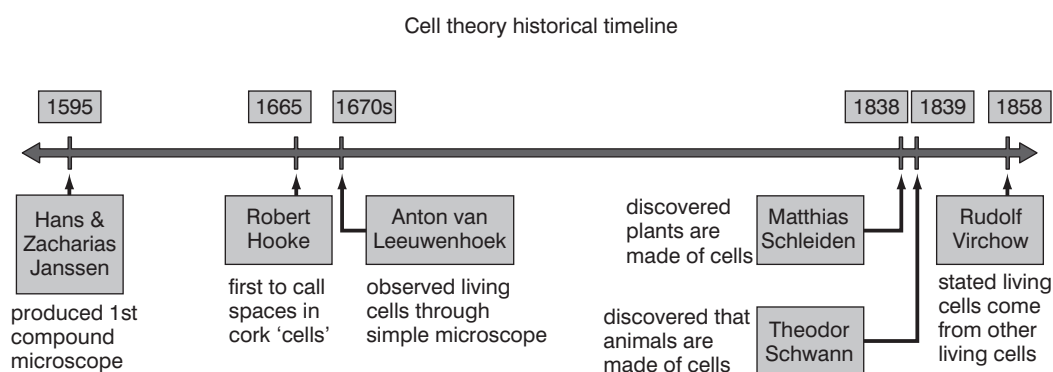


Figure 4.1

Ask students how big cells are and you will likely get the answer 'microscopic'. Whereas this is a true statement for most cells, it does not really answer the question, and, often, students do not really have an idea as to the size of cells. Nor do they really understand what units cell size is measured in.



Introduce students to the problems of measuring very small objects in everyday units – the number of decimal places involved is bewildering and not easily comprehensible. Introduce them to:

- micrometres (μm , 0.000 001 m) and
- nanometres (nm, 0.000 000 001 m)

and the way to convert them to everyday units such as millimetres.

To measure the size of cells accurately, a stage micrometer and eyepiece graticule are essential. Students find the theory behind using these a little confusing and so it must be presented in bite-sized chunks!

You could try the following approach.

- If there was a 'built-in' ruler on the slide of the cells we were looking at, we could measure the cells against that.
- However, it is not practical to try to have a scale on the slide and cells at the same time – there just isn't room.
- We could place a 'ruler' inside the eyepiece and as we look at the cells we could see this ruler at the same time.
- But when we changed magnification the ruler in the eyepiece would not take account of this and measure the same part of the field of view as the same size!
- So we place a ruler on the slide (the stage micrometer) without cells and in the eyepiece (the graticule) at the same time.
- For each magnification, we work out how the scale on the graticule relates to the scale in the eyepiece – this is called calibrating the eyepiece graticule.
- Now we can just use the eyepiece graticule, because we know (from the calibration exercise) exactly what the divisions on the graticule are measuring.

A practical exercise in calibrating an eyepiece graticule and using it to measure onion epidermis cells can be found at:

http://www.cambridge.org/uk/education/secondary/science/alevel/coas/downloads/biology_practical.pdf

If it is not possible to use a graticule and a stage micrometer, an alternative method is described that will give much less accurate results, but results that are, none-the-less, of the right order of magnitude. All that is needed is a transparent ruler with millimetre divisions.

From the concept of linear dimensions of a cell, we move on to surface area and volume and the relationship between the two in different sized cells. If students carry out the exercise in the Students' Book, they will see that as the linear dimensions increase, then the surface-area-to-volume ratio decreases.

The consequences of this are best explained in terms of 'supply' (of oxygen is the easiest to understand) and 'demand'. If they appreciate that the volume creates the demand (the more cell there actually is, the more oxygen it will require) and that the cell surface (and so the surface area) determines the supply, then if the volume increases faster than the surface area, demand will outstrip supply.

The section ends with a question about the consequences of the change in surface-area-to-volume ratio. If the supply of oxygen is inadequate, the cell will not be able to respire effectively and release the energy needed.

Explain to the students that all the same arguments just applied to cells can also be applied to organisms. During evolution, further increase in size of organisms has occurred because either:

- organisms developed gas exchange surfaces with large surface areas to restore the surface-area-to-volume ratio
- organisms evolved shapes with a high surface-area-to-volume ratio.

SA = starter activity MA = main activity CA = concluding activity	
The origins of modern cell theory (1)	
SA	Students discuss the nature of cells and the idea of cell theory.
MA	Students write down as many types of cells as they can think of - note they should not all be human cells. Students then put their lists together and discuss.
CA	Students read and review the timeline of discoveries described in the textbook - they can continue as homework if necessary.
The origins of modern cell theory (2)	
SA	Students create tables to summarise what they have learnt about the development of cell theory.
MA	Students split into groups and begin to research their presentations for activity 4.1, using libraries, the Internet, and other sources of information where possible.
CA	Students continue their presentation planning.
Presentations: cell theory	
SA	Students make final preparations in their groups for their presentations.
MA	Students make their presentations for activity 4.1 to the rest of the class.
CA	Students discuss and rate the presentations.
Measuring the size of cells (1)	
SA	Students discuss the range of sizes of cells, giving examples.
MA	Students describe the metre as the SI unit of length and relate derived units to the metre, explaining how conversion between derived units can be calculated and working in groups on example calculations.
CA	Students prepare for activity 4.2 by reading through the text and assembling the equipment required.
Measuring the size of cells (2)	
SA	Students complete activity 4.2. Guidance on this and similar activities is given in the teaching notes section.
MA	Students discuss results of activity 4.2 and complete the 'How you make a rough estimate of cell size' activity from page 117.
CA	Students write up their practicals and calculate cell size.
Size and surface-area-to-volume ratio (1)	
SA	Students discuss what is meant by: • linear dimensions • surface area • volume in relation to a cube.
MA	Students carry out activity 4.3. Help students design a table for their results and refresh their understanding of how to plot a graph before letting them begin.
CA	Students plot graph of results of activity 4.3.

Size and surface-area-to-volume ratio (2)	
SA	Students review and discuss the graphs they made in the previous lesson.
MA	Students explain how different surface-area-to-volume ratios of a cell wall affect how well exchange occurs at a cell surface.
CA	Students divide into three groups ready for preparing activity 4.4 in the next lesson, and familiarise themselves with the idea and structure of the debate.
Size and surface-area-to-volume ratio (3)	
SA	Students break into their groups, assign roles within the groups and discuss their approach to the activity 4.4 debate
MA	Students complete the debate in activity 4.4.
CA	Students vote on the outcome of the debate and write up the results.

Answers to review questions

1. C 6. B
2. B 7. D
3. D 8. B
4. B 9. C
5. D 10. C

This section should fill approximately **4 periods** of teaching time.

4.2 Types of cells

Learning competencies

By the end of this section students should be able to:

- Appreciate that there are just two basic types of cells: prokaryotic and eukaryotic cells.
- Give examples and describe the basic structure of each type.
- Explain the difference between prokaryotic and eukaryotic cells.

Starting off

If you ask the students for the two main types of cells, they will almost certainly answer plant and animal cells. It must be explained that, although there are differences between these two types of cells, they are essentially built to the same basic plan; there are a distinct nucleus, membrane-bound organelles and a plasma membrane to control entry and exit. Plant cells have some extra structures, but the core divisions are the same. Explain that these are called eukaryotic cells, they have a true, membrane-bound nucleus. Introduce the prokaryotic cells that do not contain a membrane-bound nucleus.

Teaching notes

The nature of prokaryotic and eukaryotic cells is dealt with in sufficient detail in the Students' Book, with a summative table at the end of the section.

Further information on the structure of prokaryotic and eukaryotic cells can be found at the websites listed in the Further Resources section.

SA = starter activity MA = main activity CA = concluding activity	
Prokaryotic and eukaryotic cells	
SA	Students examine that, although there are many hundreds of different cells, they can all be classified into just two main types called prokaryotic and eukaryotic.
MA	Students study the structure of a bacterial cell (prokaryotic), a 'typical' plant cell (eukaryotic) and a 'typical' animal cell. Students discuss the features that plant and animal cells (as eukaryotic cells) share and the differences between these cells and bacterial cells (prokaryotic cells).
CA	Students produce a table showing which structures are present in which cells.
The origin of eukaryotic cells (the endosymbiont theory)	
SA	Students study the features of mitochondria and chloroplasts that make them similar to some ancient bacteria.
MA	Students examine the way in which the eukaryotic cell is thought to have originated from prokaryotes, according to the endosymbiont theory.
CA	Students list the types of organisms that have eukaryotic cells and those that have prokaryotic cells. Figure 4.18 can be used as a basis.
The differences between eukaryotic cells and prokaryotic cells	
SA	Students revise the features found in the different types of cells.
MA	Students list the differences between eukaryotic and prokaryotic cells and discuss the consequences of these differences between the cells.
CA	Students copy table 4.2 into their notes.

Answers to review questions

1. D
2. C
3. B
4. C
5. A

This section should fill approximately **17 periods** of teaching time.

4.3 Parts of the cell and their functions

Learning competencies

By the end of this section students should be able to:

- Discuss the importance of a cell membrane.
- Describe the composition and arrangement of lipids and proteins in the membrane.
- Compare the Davson–Danielli and fluid mosaic models.
- Construct and show the arrangement of the phospholipids and proteins in the fluid mosaic model.
- Explain the role of glycoprotein and other components in the cell membrane.
- Name the different parts of the cell and explain their functions.
- State and explain the mechanisms of substance transport across a cell membrane.
- Conduct an experiment to show movement of solvent through a semi-permeable membrane.
- Demonstrate osmosis at a semi-permeable membrane.
- Explain that the size of a cell changes by osmosis because of the inflow and outflow of water.
- Appreciate that osmosis is responsible for everyday life phenomena.

Starting off

Recap the structure of a eukaryotic cell, mentioning the major organelles once more. Direct the students' attention to the problem of controlling what enters and leaves the cell. Get them to realise that it must be the cell surface membrane (plasma membrane) that carries out this function (rather than the cell wall, which some believe also regulates movement into and out of cells) as animal cells have no cell wall.

Teaching notes

Introduce the topic of the cell membrane by discussing its various functions in:

- controlling what enters and leaves the cell
- cell signalling and cell recognition.

Then discuss with the students the history of the development of our understanding of the structure of the plasma membrane. A timeline of the important developments is provided in the Students' Book.

Another, slightly more detailed account of this timeline can be seen at:

<http://www.nature.com/nrm/journal/v4/n5/images/nrm1102-i1.jpg>

It is then necessary to focus on the Davson–Danielli model to show how it was initially thought to be a plausible model based on the available evidence. Students should realise that, although the model was developed without the aid of electron micrographs, as these became available they were initially taken as evidence confirming the Davson–Danielli model. The three layers apparent in the micrographs were taken as being the two outer protein layers and a middle lipid layer.

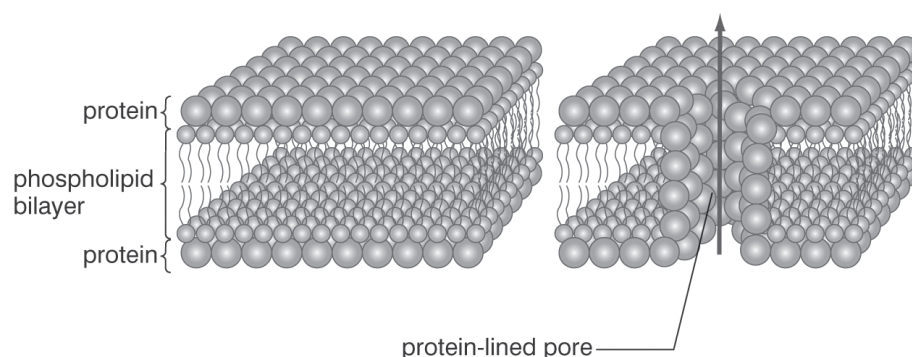


Figure 4.2

Discuss then with the students the evidence that began to accumulate that was incompatible with the Davson–Danielli model.

1. Biologists knew that membranes had some properties of fluids. The Davson–Danielli model did not make it clear how such fluidity could occur without tearing or breaking of bonds.
2. Microsurgical methods reinforced the idea that the membrane was a fluid. If a cell membrane is pushed with a probe, it bends like the surface of a balloon, and springs back when released. If it is penetrated, however, the membrane simply conforms around the probe. When the probe is withdrawn, the membrane reseals as if it were a liquid flowing into itself.
3. New chemical methods revealed that the proteins of membranes were highly variable in both quantity and type.
4. The new methods also showed that the proteins in membranes, rather than being hydrophilic (as the Davson–Danielli model required), were largely lipophilic and hydrophobic.
5. Using 'freeze-fracture' techniques, biologists were able to split cell membranes along the lipid layer. This revealed a smooth surface with bumps sticking out. The bumps turned out to be proteins – in the middle of the membrane. They could not merely be a layer coating the central lipids.

For these reasons the Davson–Danielli model was rejected in 1972 in favour of the fluid mosaic model devised by Singer and Nicholson.

Discuss with the students the structure of the membrane as shown in the fluid mosaic model shown in figure 4.22 in the Students' Book.

Students should understand that the structure of the membrane is highly complex, but need a diagram that they can reproduce, if necessary, that shows the essence of the membrane without showing every detail. Something like the diagram below would be appropriate.

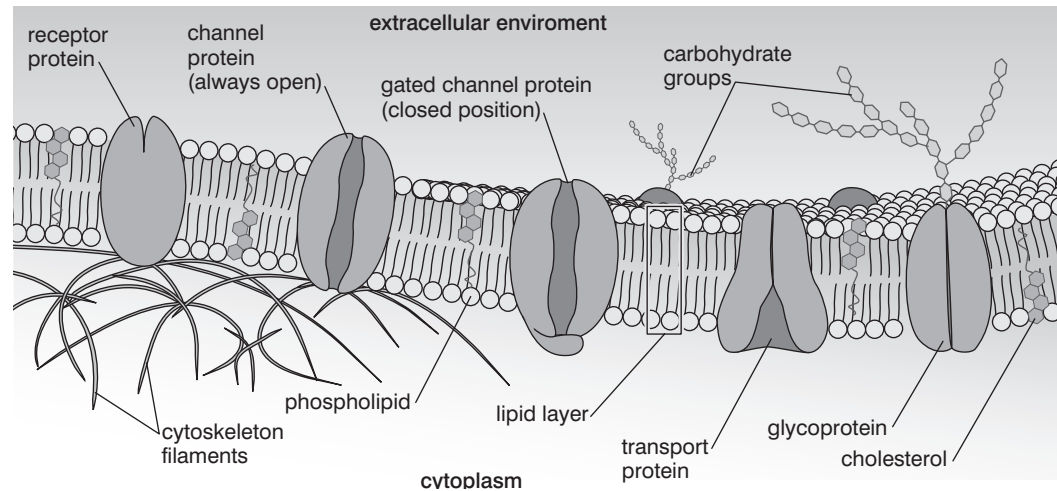


Figure 4.3

Discuss with the students the role of the various proteins in the membrane together with the role of cholesterol in maintaining membrane stability.

Next introduce the different ways in which substances cross the membrane. The students may well have heard of some of these before, but will not be aware of the way in which the process is related to cell membrane structure. Discuss the division of processes into passive processes that require no input of metabolic energy and active processes that require metabolic energy to take place. These are summarised in table 4.4 in the Students' Book.

After a general discussion, it is best to introduce simple diffusion as the first transport process. Ensure that students understand that the ability of particles to cross the membrane by simple diffusion depends on their ability to pass between adjacent phospholipid molecules. For particles to do this they must be:

- small
- lipid soluble
- non-polar

The only particle that can cross membranes by diffusion and does not quite conform to all of these criteria is the water molecule. It is able to pass the membrane because of its extremely small size. Following the discussion of the process itself, the factors affecting the rate of diffusion are discussed and summarised mathematically in Fick's law.

If it was established in the students' mind that only certain particles could pass the membrane by simple diffusion, the need for a process such as facilitated diffusion will be readily appreciated. Discuss with students the distinction between a protein pore and a carrier protein. This is illustrated in figure 4.26 in the Students' Book. Explain that the dependence of the process on carrier proteins or protein pores sets a finite limit on the rate of the process. When all the protein carriers/pores are occupied all the time, the process cannot proceed any faster, despite any changes in the concentration gradient.

We then come to the third passive process – osmosis. The concept of water potential, central to an understanding of osmosis, does not come naturally to the students. The idea of assigning a maximum value of zero and making all other values negative is counterintuitive and needs careful explaining. The explanation of water potential (in terms of hydration shells reducing the number of 'free water molecules' in a system) given in the Students' Book is reasonably accurate at this



level, where discussions of free energy are not really appropriate. The diagram below can be used to illustrate the process, showing:

- the partial permeability of the membrane
- the 'free' and 'attached' water molecules in the solution
- the concept of net movement of water molecules.

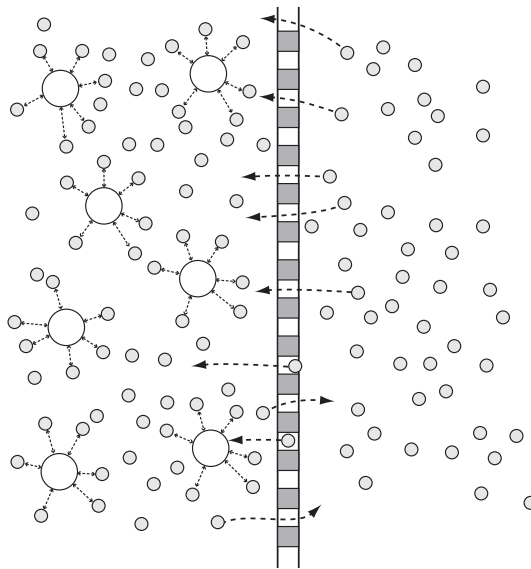


Figure 4.4

With the concept of water potential established, the definition of osmosis then resembles the definition of diffusion, except that, in the case of osmosis, the process can *only* take place across a membrane. The term partially permeable is now the Institute of Biology's preferred description of such membranes (rather than semi-permeable).

The influence of solutions with different water potentials on plant and animal cells is described and illustrated in the Students' Book. The importance of turgor in plant cells should be discussed with the students.

There are many different practical opportunities that are based on the process of osmosis. Two are described in the Students' Book. One is based on a non-living system and the other on living plasma membranes.

Next we encounter the first of the active processes – active transport. The need for an energy input to move substances against a concentration gradient can be likened to moving a boulder against a physical gradient. You have to push it uphill, whereas it will roll downhill (move down the gradient) freely.

The mechanism of the sodium–potassium pump is used to illustrate how ATP binds to the transport protein and is hydrolysed to ADP and P_i during the process, setting in motion the series of events that then move sodium ions and potassium ions in opposite directions across the membrane. The critical point for the students to appreciate is not particularly *how* ATP binds, but the fact that it does bind and release energy for the process to take place.

Endocytosis and exocytosis are readily appreciated as active processes by most students. Both processes are illustrated to an appropriate level of detail in the Students' Book.

Table 4.5 provides a useful summary of the main features of the processes that transport substances across plasma membranes.



The practical opportunity of investigating the effect of temperature on beetroot cell membranes is best carried out using a colorimeter, but qualitative or semi-quantitative data can be obtained without a colorimeter by:

- preparing in advance extracts from beetroot cells that have been in water of different temperatures for different lengths of time to give a range of coloration
- placing these in order from most intense to least intense and numbering them (1 is least intense)
- students carry out the practical and, at the end, match their extracts to one of the numbered reference tubes (or assign a value between two of the reference tubes).

The table below gives some data that can be used for analysis if it is not possible to carry out the practical. Note that these readings are for transmission, not absorbance, as described in the experiment; decreasing transmission will indicate more pigment escaping from the cells into the water during the experiment.

Temperature (°C)	Observation	Colorimeter reading (% transmission of light)			
		Sample A	Sample B	Sample C	Mean
0	clear	100	98.5	99.0	99.2
22	very pale pink	93.9	95.0	96.0	95.0
42	very pale pink	80.1	77.0	76.9	78.0
63.5	pink	26.3	29.9	31.0	29.1
87	dark pink	0.7	0.7	1.0	0.8
93	red	0.0	0.1	0.0	0.0

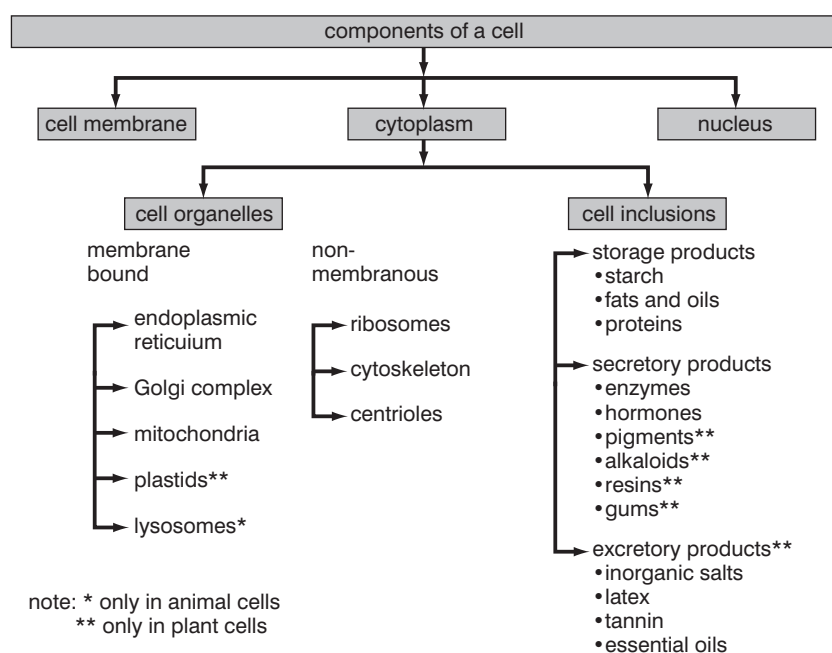
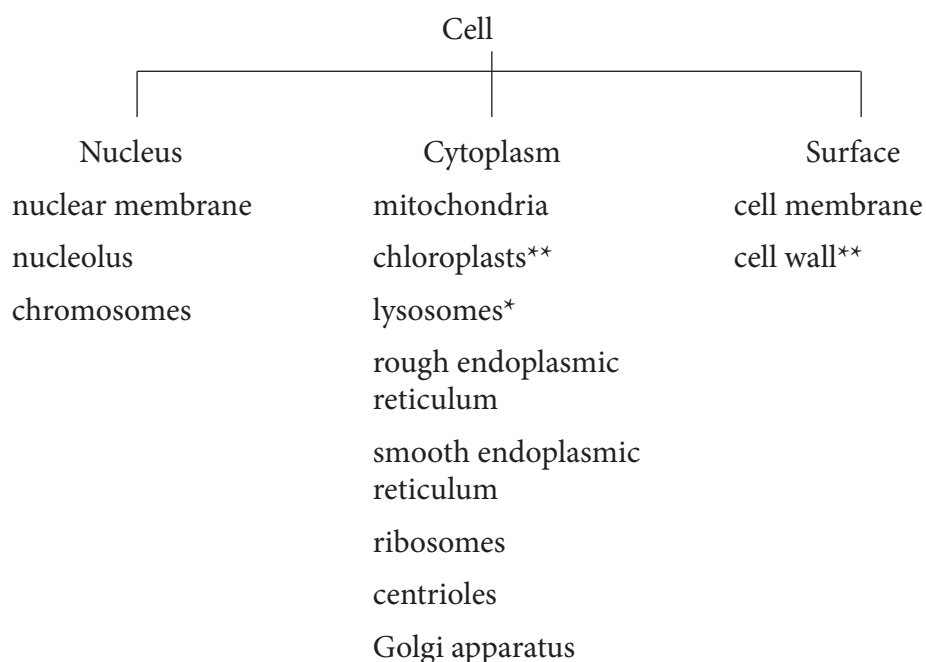
Students should be able to explain the changes using their knowledge of the fluid mosaic model and their knowledge of lipids and proteins. There are two influences on the permeability of the membrane:

- the increase in the fluidity of the membrane (causing temporary 'gaps' to appear and disappear) due to the increased mobility of the lipids as temperature increases
- the denaturing of the proteins causing large permanent gaps to appear.

The first is a gradual trend, whereas the second is more sudden. Students should be asked to deduce from these results when they think that this happened and how they could modify the experiment to give a more accurate answer.

Having discussed at some length the structure and properties of the cell membrane, we now address the other cell organelles. The descriptions in the Students' Book are accompanied by electron micrographs of the organelles to help students to visualise the nature of each.

Students often find the detailed structure of a cell a little bewildering as it seems to be just a list of various 'bits' with no obvious relation to each other. The classifications below of the structures in a cell may help in introducing some sort of order into the nature of the components of a cell.

Classification by nature of the component:**Classification of component by location:**

It is recommended that some method of grouping the organelles is adopted so that there is structure and focus to the lessons.

Finally, the technique of cell fractionation is discussed to explain to students how biologists have been able to isolate individual organelles so that they could carry out experiments with them to find out how they carry out their functions.

The principle of larger, heavier organelles settling out at lower centrifugation speeds is usually quite readily accepted by most.

One point worthy of stressing is that storing the sample in an isotonic solution is to protect the organelles from osmotic damage, not the cell. The cell will soon be processed in a blender!

SA = starter activity MA = main activity CA = concluding activity	
The importance of the cell membrane	
SA	Students examine the distinction between a cell membrane and a cell wall that may be present in some cells. Students examine that: • the cell wall is largely inert, provides support, but is freely permeable to all substances • the cell membrane is an active structure, provides no support, but is selectively permeable and therefore controls what enters and leaves the cell.
MA	Students discuss the different ways in which substances can enter and leave a cell and the membrane's role in cell signalling.
CA	Students make a table giving functions of the cell membrane with examples.
The structure of the cell membrane (1)	
SA	Students review with the teacher the evidence that eventually led to the development of the fluid mosaic model of the cell membrane.
MA	Students examine how advances in technology provided ever more information and allowed an increasingly sophisticated model of the structure of the membrane to develop. Students be aware of the following models of membrane structure: • Davson–Danielli 1935 • Davson–Danielli 1954 • Singer and Nicholson (fluid mosaic) 1972
CA	Students label photocopied diagrams of each model.
The structure of the cell membrane (2)	
SA	Students go back to their labelled diagrams and produce a table showing the similarities and differences between the models.
MA	Students list the key structures in the fluid-mosaic model and describe their functions. Make sure they include a description of the different types of proteins.
CA	Students make notes on why the fluid-mosaic model is so called.
Crossing the cell membrane	
SA	Students review the nature of the membrane and relate this to the molecules that could physically pass through the bilayer.
MA	Students examine the distinction between active and passive processes that are involved in moving particles across the membrane.
CA	Students write up notes on the substances that can cross the membrane unaided, explaining why.
Passive processes – simple diffusion	
SA	Students review the idea that although no energy from metabolism is required for these processes, the idea that they don't need energy is erroneous. The processes are dependent on the kinetic energy of the particles.
MA	Students discuss and revise their ideas on simple diffusion. Students discuss the concepts of: • concentration gradient • surface area • diffusion distance as they relate to the process of simple diffusion across a cell membrane and from them explain the derivation of Fick's law.
CA	Students make notes on the process of simple diffusion, stating and explaining Fick's law.



Passive processes - facilitated diffusion	
SA	Students recall the factors that affect simple diffusion and discuss that all of them also affect facilitated diffusion, plus one extra (the number of carrier pores or ion pores that are present in the membrane).
MA	Students study figure 4.26 and use it to help them make notes on facilitated diffusion. They can then make a table comparing simple and facilitated diffusion.
CA	Students discuss their tables in pairs and read the section on osmosis to prepare for the next lesson.
Passive processes – osmosis (1)	
SA	Students state the definition of osmosis that they know from earlier studies; this will probably involve some difference in 'concentration of solutions'. Students examine the idea that osmosis relies on a gradient in a similar way to diffusion, but this cannot be described as a concentration gradient as concentration is usually a measure of one substance dissolved in another.
MA	Students explain the concept of water potential as a measure of the free water particles in an aqueous system. Students must understand that all water potential values are relative values as the water potential of pure water is arbitrarily set at zero. From this, students copy and then explain a definition of osmosis based on water potential. Students then discuss the terms isotonic, hyponic and hypertonic and make notes on the same.
CA	Students set up activity 4.8. The experiment will be completed in the next lesson. Detailed guidance on facilitating students' understanding of osmosis is given in the teaching notes.
Passive processes – osmosis (2)	
SA	Students discuss the direction of water movement when cells are placed in each of the above solutions, and discuss why the consequences of being placed in such solutions are different for plant and animal cells.
MA	Students complete activity 4.8 with the equipment set up in the last lesson.
CA	Students draw their graphs and write up their results.
Passive processes – osmosis (3)	
SA	Students set up activity 4.9 and prepare the table for their results. Ensure they read the instructions carefully and understand the aim of the experiment before they begin. As before, split the students into pairs or groups according to how much equipment is available.
MA	Students complete activity 4.9.
CA	Students write up activity 4.9. Show them how to construct the graph, which will have to show both positive and negative percentage changes in mass. The concentration of the solution producing zero change in mass has a water potential equivalent to that of the potato cells.
Osmosis in an Egg	
SA	Students read through the instructions for activity 4.7 and collect the necessary equipment. Explain in detail the process and the aim of the experiment, using the steps in the textbook as a guide. Ensure that there is sufficient time and space in the room for students carry out the experiment and divide them into pairs or groups according to availability of space and equipment.
MA	Students complete activity 4.7.
CA	Students write up the results of their practical and discuss.



Active processes (1)		
SA	Students examine the concept by comparing this with movement of a rock up and down a slope. The stone will roll down the slope – comparable to movement down a concentration gradient, but energy must be put in to move it up the slope – comparable to moving against a concentration gradient.	
MA	Students use figures 4.32, 4.33 and 4.34 as a basis for discussion and understanding the idea of active processes. They then make notes on the different types of active processes.	
CA	Students discuss the role of ATP in active processes.	
Active processes (2)		
SA	Students brainstorm the differences between the active and passive processes they have studied.	
MA	Students design and complete a table similar to table 4.4 to record their comparison of active and passive processes.	
CA	Students define different active and passive processes without reference to notes in response to direct questions from you during a general discussion.	
The effect of temperature on the permeability of a cell membrane (1)		
SA	Students revise the structure of a membrane. Students suggest how heat may affect: • proteins in the membrane • the phospholipids in the membrane.	
MA	Students discuss the idea that any factor that disrupts membrane structure will affect permeability. Students work in pairs to discuss the likely effects of alcohol and changes in pH, and then come together for a class discussion on this.	
CA	Students design a table in which to record the results of activity 4.10, which they will complete in the next lesson.	
The effect of temperature on the permeability of a cell membrane (2)		
SA	Students set up activity 4.10. Ensure students are aware of safety issues when working with water baths and talk them through the set up by demonstrating at the front of the class. Again, divide students into pairs or groups according to availability of equipment.	
MA	Students complete activity 4.10: this will take until the end of the lesson, given the waiting times involved.	
CA	Students complete activity 4.10, noting their results in the tables they prepared in the last lesson.	
The other cell organelles (1)		
SA	Students discuss and list the organelles found in plant and animal cells.	
MA	Students discuss and make notes on the structure and function of the major organelles.	
CA	Students make a table to summarise the above. A suggested format is given below.	
	Organelle	Structure (include diagram and description)
		Functions
The other cell organelles (2)		
SA	Students review (and complete if necessary) the tables they made in the last lesson.	
MA	Students complete activity 4.11.	
CA	Students give their presentations to the rest of the class, briefly.	

How do biologists study the organelles?

SA	Students discuss the need to isolate organelles to be able to study individual functions. Get the students suggest the basis for a separation technique.
MA	Students study a centrifuge if possible and either an explanation of how it works or a demonstration of a separation of a suspension (e.g. chalk and water). Students examine the ultracentrifuge works on the same principle but spins at much higher speeds, creating much higher sedimentation forces. Students examine the importance of the preparation of the cell sample prior to centrifuging.
CA	Students answer multiple choice questions.

Answers to review questions

1. A 6. A
2. A 7. C
3. C 8. C
4. C 9. D
5. D 10. D

Answers to end of unit questions

1. a) i) The cell is the unit of structure, physiology, and organisation in living things.
The cell retains a dual existence as:
 - a distinct entity, and
 - a 'building block' in the formation of organisms.
 ii) Cells arise by spontaneous generation
iii) Virchow
- b) The cell is the unit of structure, physiology and organisation in living things.
Cells contains hereditary information that is passed from cell to cell during cell division.
All cells have basically the same chemical composition.
All energy flow (metabolism & biochemistry) occurs within cells.
2. a) Hooke developed one of the first microscopes and saw dead cells in cork.
b) van Leeuwenhoek saw living protocista and living bacteria.
c) Dutrochet proposed that all living things are made of cells and that growth occurs because of the addition of cells.

Feature	Prokaryotic cells	Eukaryotic cells
Size	1–10 μm	10–100 μm
Nucleus	absent	present
DNA	• in a continuous loop	• linear • associated with protein
Mitochondria	absent	present
Ribosomes	70S ribosomes	80S ribosomes

4. a) Increase surface area
more transport proteins
for facilitated diffusion
- b) Mitochondria
release energy/produce ATP
during respiration
needed for active transport
- c) A – facilitated diffusion as transport protein but no ATP
B – osmosis as water only moves by osmosis
C – active transport as transport protein and ATP
D – simple diffusion as no transport protein
5. a) i) $\frac{79 + 49 + 44 + 24}{18 + 51 + 52 + 76}$
= 1.005:1
- ii) *Two of:*
Transport protein
ion pore
glycoprotein/cell recognition
- iii) Formation of glycoproteins/antigens
- iv) Proteins usually associated with transport
cell D more actively involved in transport than A
- b) i) Move around more
temporary gaps appear
so increase permeability of membrane
- ii) 30–50 °C
- iii) Wider range
20–60 °C
- iv) Stabilise phospholipids
reduce fluidity of membrane
6. a)

Organelle	Function
Nucleus	Contains DNA, regulates cell metabolism
Ribosome	Protein synthesis
Mitochondrion	Site of aerobic respiration, produces most of the ATP in a cell
Golgi body	Modifies structure of protein molecules
Lysosome	Contains hydrolytic enzymes; digests worn-out organelles
Chloroplast	Photosynthesis
Plasma membrane	Controls entry and exit of substances from cell
Cell wall	Gives cell support and rigidity



- b) Cells stored in cool, isotonic and buffered solution
prevent damage to organelles
processed in blender
release organelles
spun at low speeds
nucleus settles out
spun at higher speeds
other organelles settle out according to density/mass
7. a) 1 – phospholipid bilayer
2 – glycoprotein
3 – cholesterol
4 – ion pore/channel
- b) Transport protein
moves ions across membrane
by facilitated diffusion
- c) Membrane has fluid properties
due to phospholipids/proteins moving around
proteins studded in phospholipids like a mosaic
8. Award marks in the following categories:

Category	Marks	Descriptors
Breadth	0–2	Student involves all the main aspects of the topic in reasonable detail
Relevance	0–2	Student does not bring in irrelevant material, although some extra, related biology is acceptable
Communication	0–2	Essay is well written and logically presented, making good use of scientific vocabulary
Biological accuracy	0–5	Biological content is not at the required level and may contain significant misconceptions
	6–10	Biological content is essentially correct and of an acceptable standard although there may be an occasional slight error
	11–15	Essay is of a high standard with no significant errors.



Answers to end of unit crossword puzzle

Across

- 1 Golgi body
- 6 active transport
- 9 osmosis
- 11 chloroplast
- 12 fluid mosaic
- 15 Schleiden and Schwann
- 18 micrometre
- 20 plasma membrane
- 21 mitochondrion
- 22 Robert Hooke
- 23 eukaryotic

Down

- 2 Davson and Danielli
- 3 nucleus
- 4 prokaryotic
- 5 simple diffusion
- 7 Rudolf Virchow
- 8 ribosome
- 10 water potential
- 11 cell fractionation
- 13 carrier protein
- 14 van Leeuwenhoek
- 16 amoeba
- 17 channel protein
- 19 membrane

Further resources

<http://www.biologyreference.com/Gr-Hi/History-of-Biology-Cell-Theory-and-Cell-Structure.html> – cell theory and cell structure

<http://kentsimmons.uwinnipeg.ca/cm1504/celltheory.htm> – cell theory

<http://www.bio.miami.edu/~cmallery/150/unity/cell.text.htm> – more cell theory

<http://library.thinkquest.org/12413/structures.html> – structure of prokaryotic and eukaryotic cells

<http://www.tvdsb.on.ca/westmin/science/Sbi3a1/cells/cellquiz.htm> – cell structure quiz

<http://library.thinkquest.org/12413/structures.html> – organelles

<http://learn.genetics.utah.edu/content/begin/cells/insideacell/> – interactive resource

<http://www.johnkyrk.com/> – cell biology animations

<http://www.cellsalive.com/index.htm> – cell biology activities and resources