7 Cell Structure and Function

Learning Outcomes

- **Investigate the structure of animal and plant cells.** **(BW 01)**
- **Relate the different parts of each type of cell to their function.** **(BW 01)**

Cells are the building blocks of all living organisms. All cells come from other cells. This is called the **continuity of life**. Some living things are made up of only one cell (unicellular), such as bacteria and yeast; other living things are made up of many cells (multicellular), such as a tree or a human being. Understanding the cell helps us to understand how living things work.

Fig. 1 A paramecium is a unicellular organism that lives in freshwater ponds.

Fig. 2 A dog is a multicellular organism.

Did You Know?

In 1663 Robert Hooke, an English scientist, was the first person to describe the appearance of cells. He made his observations using a microscope. The microscopes that were used at that time were very simple. In fact, scientists were only able to see the outside of cells. The microscopes in use today are much more powerful and scientists are able to observe the outside and the inside of cells in great detail.

7.1 Using a light microscope

Light microscope
A type of microscope that uses white light and a system of lenses to magnify small samples.

A **light microscope** shines light through a specimen and magnifies it using glass lenses. The light microscopes used in most school laboratories can magnify a specimen up to 400 times the actual size (x 400).

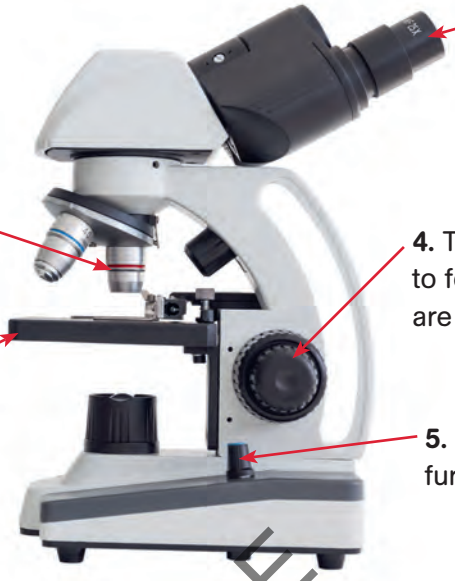


Fig. 3 A light microscope.

The eyepiece usually magnifies by 10 (×10).
The objective lenses magnify by four (×4), by ten (×10) and by forty (×40).
At high power the microscope will magnify the sample 10 x 40 = 400 times.

Activity
Using a light microscope

1. Plug in the light or adjust the mirror underneath so that light is seen when you look through the eyepiece lens.
2. Place the glass slide on the stage so that what you want to look at is over the centre of the hole on the stage.
3. With the low power objective lens in position, watch from the side and turn the coarse focus knob to lower the objective lens close to the slide, without touching it.
   Warning! Do not allow the lens to touch the slide – the objective lens is easily damaged!
4. Look through the eyepiece and very slowly turn the coarse focus knob. The object you are looking at should now become visible. You may need to move the slide very slightly on the stage in order to centre it perfectly. Use the fine focus knob to improve the visibility of the image.
5. When using the medium power (x10) objective lens or the high power (x40) lens, never use the coarse focus knob – only the fine focus knob.

Note
Using the microscope to get the best results takes practice! Try examining a hair, a speck of dust and a piece of newspaper under the microscope. You will first have to mount the object on a slide and cover it with a cover-slip, as described on page 37.

Research this

Investigate the different types of microscopes used in science today. Which ones are the most powerful and what do they display? Where are these microscopes used?

7.2 Cell structure

The cells in the following images all look very different. While cells can have different appearances and functions, they have the same basic structure.

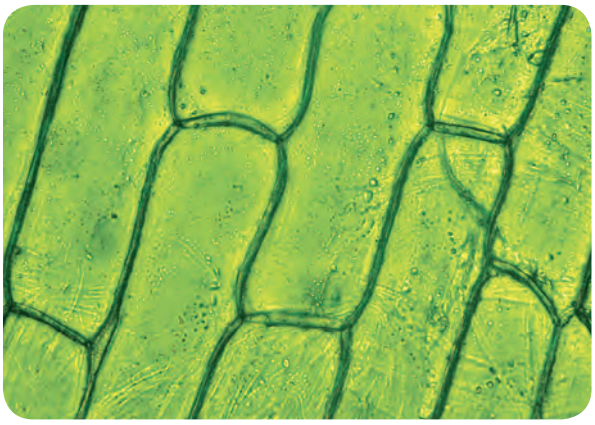


Fig. 4 Plant cells.

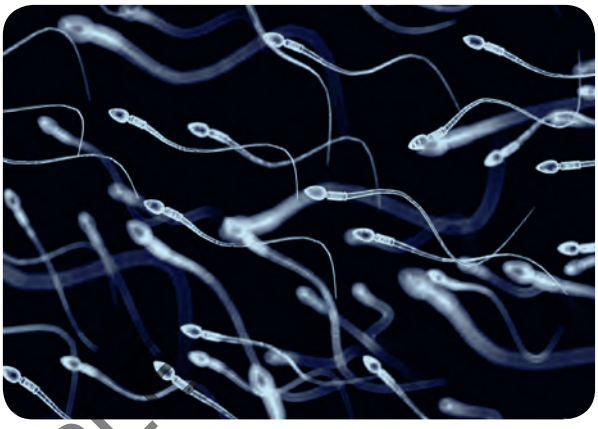


Fig. 5 Sperm cells.

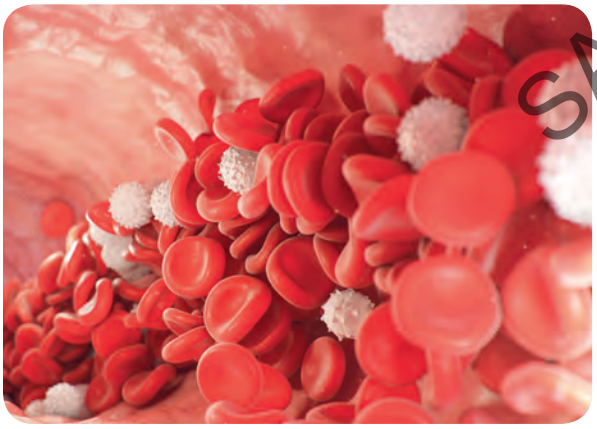


Fig. 6 Red and white blood cells.

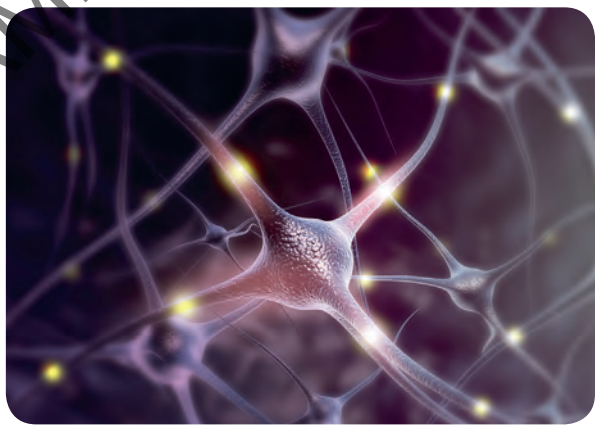


Fig. 7 Nerve cells.

Most cells have the following structures:

- **Cell membrane:** Holds the cell together. It controls what can enter and leave the cell.
- **Cytoplasm:** This is a watery, jelly-like fluid in which the other structures are suspended.
- **Nucleus:** Controls cell activities. It contains genetic information in the form of **DNA**. DNA is contained in structures called **chromosomes**.
- **Small vacuole:** Used for temporary storage of food and waste.
- **Mitochondrion:** Carries out a chemical reaction called **respiration** which releases energy from glucose for various cellular activities.

Chromosomes
Coiled threads of DNA and protein. Found in the nucleus of cells.

Respiration
Chemical reaction that occurs in a cell to release energy from glucose.

Plant cells

Photosynthesis Chemical reaction in plant cells that uses the sun's energy, carbon dioxide and water to produce glucose.

Plant cells also have extra structures that are not found in animal cells:

- **Chloroplasts:** Contain the green chemical called **chlorophyll** which allows plants to make their own food from water and carbon dioxide during **photosynthesis**.
- **Cell wall:** A tough structure made of **cellulose**, located outside the cell membrane. It gives the plant cell support and structure.
- **Large vacuole:** Stores water, sugar and waste and helps to give shape to the cell.

Cellulose Carbohydrate made up of long chains of sugar molecules.

Differences between animal and plant cells

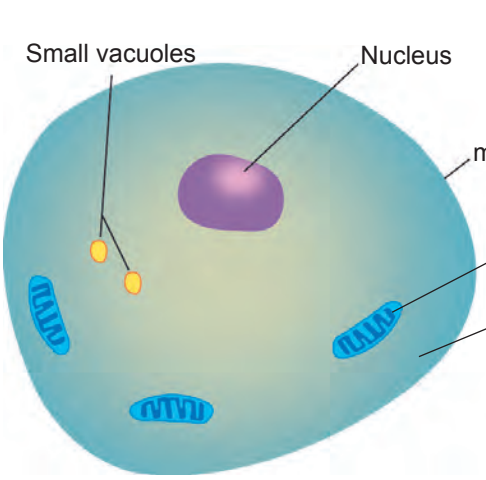


Fig. 8 Animal cell.

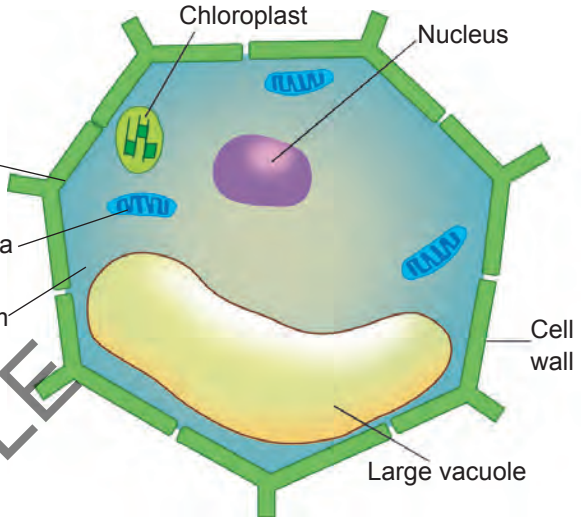


Fig. 9 Plant cell.

Animal cells	Plant cells
1. No cell wall. 2. No chloroplasts or chlorophyll. 3. Small vacuoles.	1. Have a cell wall. 2. Contain chloroplasts and chlorophyll. 3. Small and large vacuoles.

Activity
Model-making

Create a model of a plant or animal cell.

Method

Create a model of a plant or animal cell.
Include the structures found inside the cell.
Label each part and describe its function in the cell.
For each cell part, decide on the shape, size and texture.

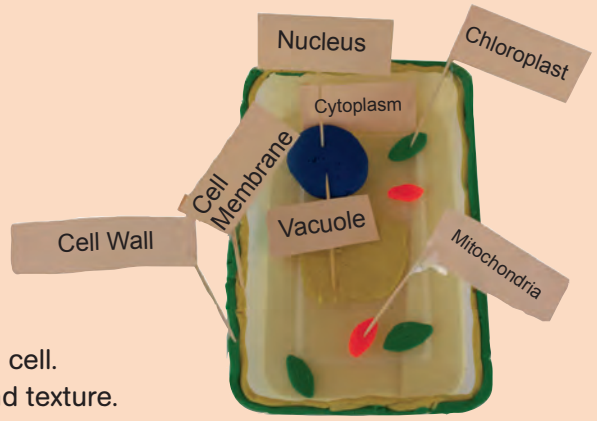


Fig. 10 An example of a model of a plant cell using a plastic container modelling clay, toothpaste and labels.

Preparing a slide

Before you can use the microscope, you will first need to mount a thin section of the object you want to look at on a glass slide, apply a drop of water or stain and cover with a cover-slip. Stains are used to make the cell structures easier to see.

Applying a cover slip

Using a mounted needle, hold a cover-slip at the edge of the sample at an angle of 45° and gently lower the cover-slip to avoid trapping air bubbles.

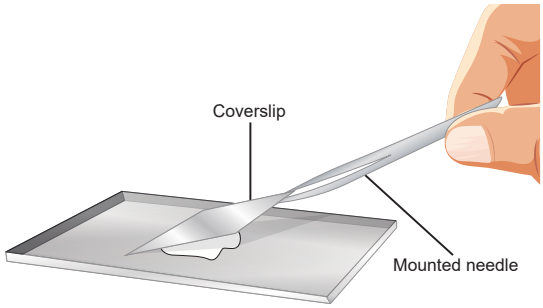


Fig. 11 Using a mounted needle and cover-slip to prepare an object for inspection.

Investigate this

Examine the structure of a plant cell and an animal cell

(a) Examine onion cells (plant cells)

Apparatus

Microscope, slide, cover-slip, needle, dropper, onion, iodine stain

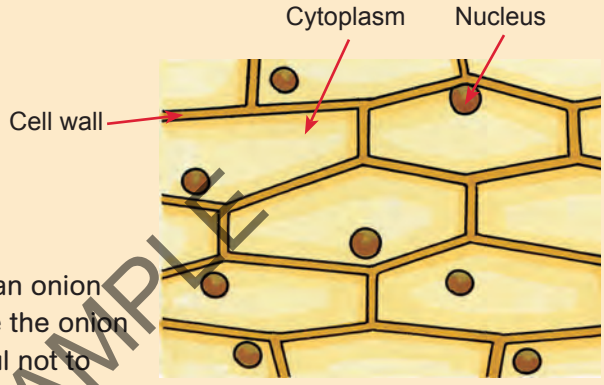


Fig. 12 Onion cells

Method

1. Peel the thin skin between the layers of an onion and carefully place on a slide. Make sure the onion skin is flat and not folded over. Be careful not to scrape the sample.
2. Apply a few drops of iodine stain to the sample and leave for one minute. Iodine will stain the cell wall and nucleus of the plant cell a darker colour.
3. Apply a cover-slip and then apply a drop of water and draw through the sample using some filter paper. This will remove any excess stain.
4. Examine the cells under low and high power.
5. Draw and label what you see.

(b) Examine human cheek cells (animal cells)

Apparatus

Microscope, slide, cover-slip, dropper, methylene blue stain, cotton bud

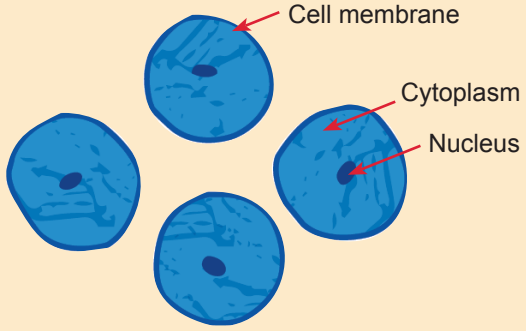


Fig. 13 Animal cells

Method

1. Rub a clean finger or cotton bud against the inside of your cheek to obtain some cells.
2. Smear the cells onto a clean slide.
3. Apply the methylene blue stain to the sample and leave for one minute. Methylene blue will stain the nucleus of an animal cell a darker blue colour.
4. Apply a cover-slip and then apply a drop of water and draw through the sample using some filter paper. This will remove any excess stain.

5. Examine the cells under the microscope using the low and high power.
6. Draw and label what you see.

Questions

1. Which specific parts of the onion cell were stained by the iodine?
2. What are the functions of these parts?
3. Which specific parts of a cheek cell were stained by methylene blue?
4. What are the functions of these parts?
5. What is the advantage of using stains when observing cells with a microscope?
6. Suggest a reason for using thin samples when preparing a slide for examination.
7. Why do you think it is necessary to rinse off the excess stain from the specimen before looking at it under the microscope?
8. The cover-slip should be applied at an angle. What is the reason for this?

7.3 Specialised cells

All cells have the same basic structure but different types of cells have special features that are suited to the functions they carry out.

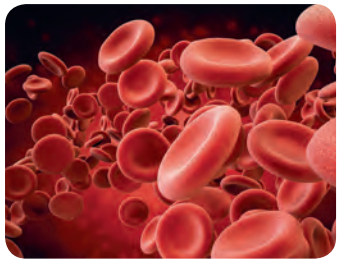
Examples:

Sperm cell

- Tail for swimming.
- Lots of mitochondria to give the sperm energy to swim to the egg.

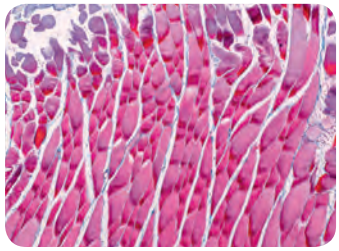
Haemoglobin
The chemical that allows red blood cells to carry oxygen to other cells in the body.

Red blood cells



- Contain a chemical called **haemoglobin** which can bond to oxygen. Red blood cells carry oxygen around the body.
- Their shape allows them to bend to fit through small blood vessels.

Muscle cells



- Lots of mitochondria for energy.
- Can contract and relax to enable movement.

Light-sensitive cells in the eye

- A layer at the back of the eye called the retina contains special cells that can detect white and coloured light. This allows us to see.

Nerve cells:

- Can carry electrical messages.
- Can pass the message to another nerve cell. This enables us to think, feel, move, taste, smell, see and hear.

Plant cells:

- Contain chloroplasts for photosynthesis.
- Have a cell wall to give support to the plant.
- Have a large vacuole to give shape to the cell.

Activity

Examine a variety of prepared cells under the microscope. Note the difference in their structure. Make simple drawings of what you see.

Investigation

Investigate movement across a selectively permeable membrane

The cell membrane is a structure that allows some but not all substances to move in and out of the cell. It is **selectively permeable.** This experiment will demonstrate how substances can move through a membrane. The membrane used in the experiment is called 'visking tubing'. Visking tubing allows the movement of small molecules, such as water and iodine, through it, but not large molecules, such as starch. In this way it models the cell membrane.

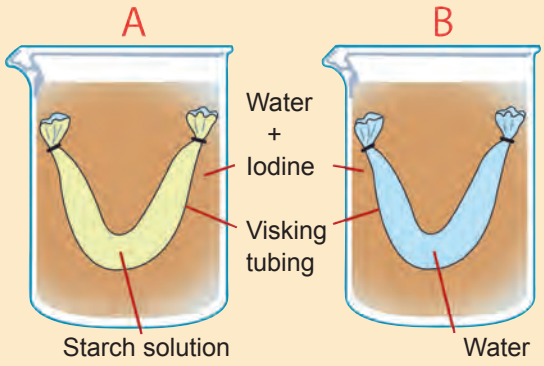
Apparatus

Two lengths of visking tubing, approximately 25 cm long each
Two beakers of water labelled A and B
Starch solution
Iodine solution
Two glass rods

Method

1. Soak the visking tubing in warm water for two minutes to soften.
2. Remove the visking tubing and tie one end of each tube.
3. Two-thirds fill one tube with starch solution.
4. Two-thirds fill another tube with water. This is a control.
5. Remove any air and make sure the tubes are not completely full before tying the ends.
6. Add a few drops of iodine solution to both beakers of water. Label A and B.
7. Place the visking tubing with starch solution into beaker A, and the visking tubing with water into beaker B. Leave for 20-30 minutes.
8. Remove and dry each tube and observe any changes in the tubes and in the water.
9. Copy the table on the next page into your Science copybook and record your observations.

Note: Iodine solution reacts chemically with starch to form a blue-black product.



	Tube A	Tube B
Initial colour inside tube		
Final colour inside tube		
Initial colour of liquid in beaker		
Final colour of liquid in beaker		

Questions

1. Why did the starch solution in the visking tubing in beaker A eventually turn a blue-black colour?
2. Why did the water in beaker A not turn blue-black?
3. What does this tell you about the **permeability** of visking tubing?
4. Was there any change inside or outside the visking tubing in beaker B?
5. Was there any difference in the fullness of the tubes? Can you explain this?
6. What does this experiment tell you about the structure and function of a cell membrane?

Permeability
The degree to which substances can pass through something.

Tissue
A group of cells working together is called a tissue.

Organ
Tissues working together form an organ.

System
Different organs work together to form a system.

Organism
Systems work together to make an organism, e.g. a person.

7.4 Cell organisation

A multicellular organism, such as a human, is made up of trillions of individual cells. Each cell is **organised** with other similar cells into more complex structures. They **work together** to carry out a function.

A group of similar cells working together to carry out a specific function is called a **tissue**, e.g. muscle tissue.

Tissues work together to form an **organ**, e.g. a stomach.

Different organs work together to form a **system**, e.g. the digestive system.

Systems work together to make an **organism**, e.g. a human.

In multicellular organisms, cells arrange into tissues, organs and systems to carry out **specialised functions**.

cells → tissue → organ → system → organism

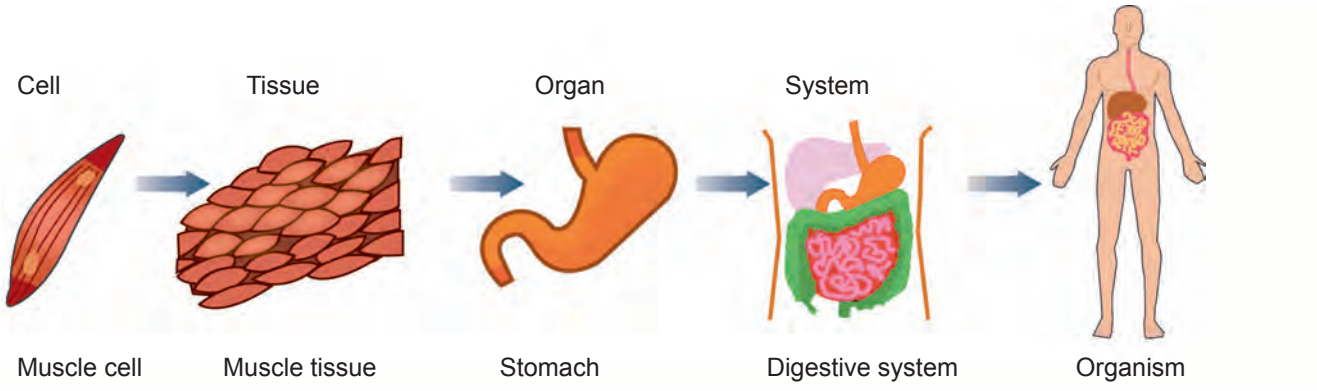


Fig. 14 Cell organisation

Activity

Mapping the organs: Predict the location, shape and size of organs in the human body.

Materials

Roll of paper. Marker.

Procedure

1. Work in pairs.
2. Obtain a large piece of paper from your teacher.
3. Trace the outline of your partner's body on the paper, excluding the legs and arms.
4. Brainstorm with your partner about the shape, size and location of any organs in the body.
5. Draw and label the organs on the traced outline of your partner's body.
6. Compare your diagram with another group.
7. Check with your teacher to find out how accurate you were.

Did You Know?

Stem cells are cells that have the ability to develop into many different types of cells. When a stem cell divides, it can become another stem cell or a different type of cell like a muscle cell, liver cell or brain cell.
Stem cells are found in embryos (embryonic stem cells), umbilical cords and in the bone marrow of adults (adult stem cells). Stem cells can be used for medical purposes. Adult stem cells are used to treat a type of cancer called leukaemia. Scientists are currently carrying out stem cell research in an effort to find cures and treatments for many illnesses that affect people, e.g. Parkinson's disease, strokes and spinal cord injuries.

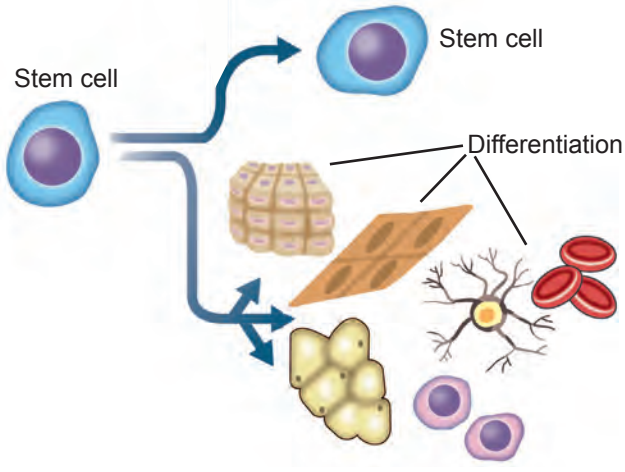


Fig. 15 Stem cells can develop into different types of cells.

Science in Society Investigation

Society: A question about the ethics of stem cell research.

7 End-of-chapter Assessment

Chapter Summary

1. Cells are the **building blocks** of all organisms.
2. A **unicellular organism** is made up of only one cell; a **multicellular organism** is made up of many cells.
3. A **light microscope** is a type of microscope that uses white light and a system of lenses to magnify images of small samples.
4. **Most cells** have the following **structures**: cell membrane, cytoplasm, nucleus, small vacuoles and mitochondria.
5. **Plant cells** have the following extra **structures**: cell wall, chloroplasts and a large vacuole.
6. A **cell's structure** is suited to the role(s) it carries out.
7. A **group of cells** working together is called a **tissue**, e.g. muscle tissue.
8. **Tissues** working together form an **organ**, e.g. stomach.
9. **Different organs** work together to form a **system**, e.g. digestive system.
10. **Systems work** together to form an **organism**.

End-of-chapter questions

Knowledge

Rewrite the following sentences in your copybook and fill in the blanks.

1. The basic unit of all living organisms is the _____.
2. A unicellular organism is made up of _____ cell.
3. A _____ organism is made up of many cells.
4. A light microscope shines light through a sample and uses _____ to magnify.
5. When viewing a specimen under the microscope you should always start with the _____ magnification.
6. A _____ is placed over the specimen to protect it.
7. The watery, jelly-like fluid in a cell is called the _____.
8. Plant cells have a _____ _____ but animal cells do not.
9. Specialised cells have _____ that make them suited to the functions they carry out.
10. The green pigment _____ enables a plant cell to make food by photosynthesis.
11. A sperm cell has a _____ for movement.
12. Muscle cells have a lot of _____ to give them energy.
13. In red blood cells the chemical _____ can bond with oxygen.
14. A group of similar cells working together is called a _____.
15. A group of tissues working together makes up an _____.
16. A group of organs working together makes a _____.
17. An example of an animal organ is the _____.
18. An example of an animal system is the _____.
19. Systems work together in an _____.

Understanding

20. In your copybook, write the names of the parts labelled A - E in the diagram below.

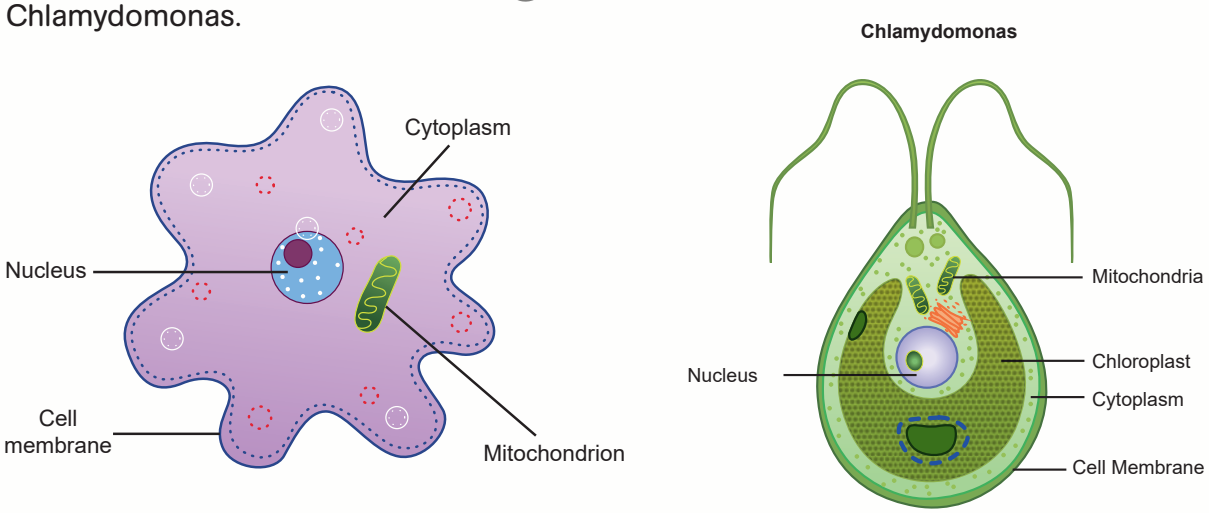
Thinking

21. Some cells have special features that enable them to carry out a specific function. Give two examples of cells that have special features to enable them to carry out their features and describe these features.

22. Plant and animal cells have some features in common. Name these features.

Exam-Style Questions

This image shows two single-celled organisms found in freshwater ponds: Amoeba and Chlamydomonas.



(a) Which one of these organisms is capable of photosynthesis? Justify your answer.
(b) Which structure controls the activity of each organism?
(c) Both cells produce energy from food in a process called respiration. Where does respiration take place in the cell?
(d) Both organisms can be found in ponds. Chlamydomonas have two whip-like structures called flagella. An amoeba does not have any flagella. Suggest one benefit that having flagella will give to Chlamydomonas.

Now go to page 20 of your *Nature of Science Workbook* to complete the questions on Cell Structure and Function. You will also find more Exam-Style Questions there.