1 Looking at life

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This chapter covers:

- the characteristics of life
- cell structure
- practical techniques for making slides
- levels of organization
- diffusion and osmosis.

Test your own knowledge

Before reading the material in this chapter test your current knowledge with the following questions:

1. How do we know something is alive?
2. What is a cell? What are the main components of an animal and a plant cell? Which components are shared by both plant and animal cells?
3. What is the function of each cell component?
4. How do substances get in and out of cells? Are there any rules for this?
5. What is the definition of a cell, an organelle, a tissue and an organism?

What is life?

Everything that is considered to be alive carries out the seven characteristics of life. These are known by the mnemonic MRS GREN (**M**ovement, **R**espiration, **S**ensitivity, **G**rowth, **R**eproduction, **E**xcretion and **N**utrition).

The following information can be used to construct a card sort for students to recap this topic from Key Stage 3:

- **Movement:** Organisms may move all or parts of their bodies towards or away from influences that are important to them. For example, a plant may move its leaves towards the sun.
- **Respiration:** The release of energy stored in food, such as glucose, to provide power for the cell to function. The energy currency of the cell is adenosine tri-phosphate, or ATP for short. Respiration takes place in the mitochondria of every cell.
- **Sensitivity:** Awareness of the organisms' surroundings. This may be complex, such as the passage of nerve impulses, or simpler, such as the growth of plant roots down into the soil.
- **Growth:** An increase in size, such as the division of one cell into two identical cells (mitosis).
- **Reproduction:** The formation of more individuals from one parent (asexually) or two parents (sexually).
- **Excretion:** Getting rid of the products of the chemical reactions that have taken place in the organism (metabolism). Metabolism occurs at a cellular level, and so excretion includes getting rid of water and carbon dioxide. (Not getting rid of solid waste!)
- **Nutrition:** Using a food source to release energy for cell function. This is either autotrophic, when plants make their own food by photosynthesis and then metabolise it, or heterotrophic, when ready-made food is taken into an organism.

The cell

What is a cell? A cell is a single unit that can function on its own and can divide to form other cells of the same type. It is a package that contains all the 'bits' needed to be alive. These component parts of cells are called organelles. The cell itself is the basic unit of life, and all multicellular organisms are derived originally from one cell. It should be noted that animal cells are generally smaller than plant cells and lack some of the cell contents of plant cells.

How science works

The cell was first discovered by Robert Hooke in 1665. He used a basic microscope to look at thin slices of cork (from a cork tree) and he saw boxes that reminded him of monks' rooms or cells. Hence the name – 'cell'.

A good way to get students to compare animal and plant cells is by using a Venn diagram. This helps assess prior learning and gives you the basis to discuss any misconceptions that the students may have.

Provide the students with a list of the cell components and ask them to categorize these as being present in animals only, plants only or in both animal and plant cells (a shared field in the centre). Students could be asked to extend this by underlining the components that cannot be seen by using an ordinary light microscope, such as the ones they may use in class.

The completed example is shown in Figure 1.1. The words underlined are those components that cannot be seen through a standard light microscope as used in schools.

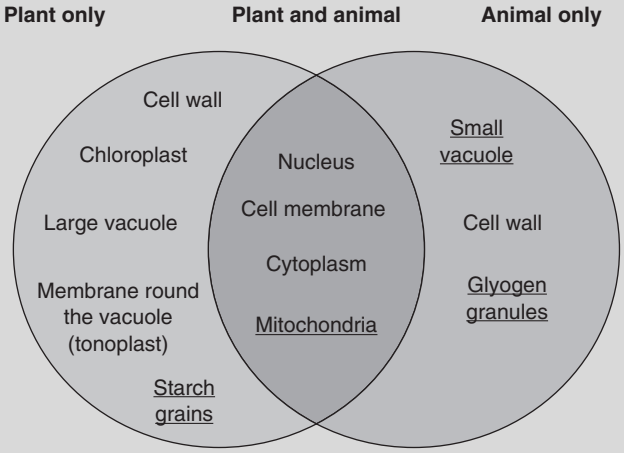

Figure 1.1 Venn diagram comparing plant and animal cells

The cell: card sort

The list of cell components, their description and function can be organized as a card sort. This can be seen in the card sort exercise shown in Figure 1.2, which can be easily differentiated by the removal of the more complex components. Simply cut these out in advance of the lesson.

Cell component	Description	Function
Nucleus	Largest cell organelle. Contains strands of DNA. Appears patchy and dark coloured when a stain is added.	Regulates cell activities. Stores information which it passes on by cell division (mitosis and meiosis).

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Cell component	Description	Function
Cell membrane	Exterior layer of the cell. Composed of protein and oil (lipid).	Keeps all cell contents together. Is selectively permeable as it regulates what enters and leaves the cell.
Cell wall	Made of strong cellulose. Permeable to water and other substances.	Gives shape and support to the plant cell. Resists water movement into the cell when the cell is turgid.
Cytoplasm	Jelly-like substance (consistency of raw egg white). Composed mainly of water.	Supports the organelles. Store of water and/or pigments.
Chloroplast	Large green-coloured organelles.	To carry out photosynthesis. This uses trapped light energy to combine carbon dioxide and water to form glucose and oxygen. The glucose stores energy in its bonds.
Vacuoles	Large permanent vacuoles are found in the centre of plant cells. Small non-permanent vacuoles are found scattered throughout the cytoplasm in animal cells.	Storage of materials such as food or pigments and water control. Transport of substances around the cell and secretion of substances outside the cell (e.g. mucus or hormones).
Starch grain	Grains found inside plant cells. Small glucose molecules are converted into starch so that they can be stored.	Storage of food until needed. Glucose cannot be stored as it moves by diffusion and is therefore not kept in one place.
Glycogen granules and fat droplets	Granules or droplets found within the cytoplasm of animal cells.	Storage of food until needed.
Mitochondria	Organelles (about 5 μm) found in the cytoplasm.	Carries out aerobic respiration in cells.
Ribosomes	Tiny organelles (20 nm) found in the cytoplasm.	Make proteins by assembling amino acids in chains.

Figure 1.2 Card sort activity: the cell

Common misconceptions include students using the terms 'cell wall' and 'cell membrane' interchangeably and thinking that mitochondria can be seen with a light microscope. It should be noted that the cell membrane and tonoplast are difficult to see in many plant cells. The position of these can be highlighted during a practical by using the purple epidermis layers between the fleshy leaves in red onions. The position of the cytoplasm can be located because the cell contents are suspended within it.

Levels of organization: card sort

Cells can be added together to make increasingly complex organisms and parts of organisms. This can be seen in the card sort exercise in Figure 1.3.

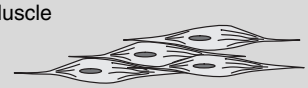
Level of organization	Description	Example
Atom	Fundamental unit of matter	Hydrogen 
Molecule	At least two atoms held together by chemical bonds	Water 
Organelle	Small units in cells that do one particular job	Mitochondrion 
Cell	The basic unit of life that can function independently	Sperm cell 
Tissue	Collection of similar cells that perform the same job	Muscle 
Organ	Collection of tissues that perform a specific or several functions	Liver 
Organ system	Collection of organs that work together to carry out a specific task	Digestive system 
Organism	A group of organ systems making up an individual	Mouse 

Figure 1.3 Card sort activity: levels of organization

Practical activity

Looking at animal cells

You can look at your own cells, but this requires you to take a sample of your own cheek cells (epithelial cells). The students quite like this as they are looking at their own cells – a rare opportunity.

Health and safety

You must check the health and safety regulations where you teach as rules vary from school to school and from county to county. Your senior technician or health and safety officer will be able to say if any practical is banned in your school. Alternatives are usually available if this is the case.

If you can go ahead and do this practical, you must make sure you use a clean scraper or cotton bud and dispose of it in accordance with the regulations in your school. Ideally the scrapers should have been dry sterilized before use and be disposed of in disinfectant afterwards.

Be careful not to focus direct sunlight through the microscope because this can damage your eyes.

Method

The method is as follows (see also Figure 1.4). Take a clean scraper and rub it on the inside of your cheek. Around ten scrapes are enough to get a decent

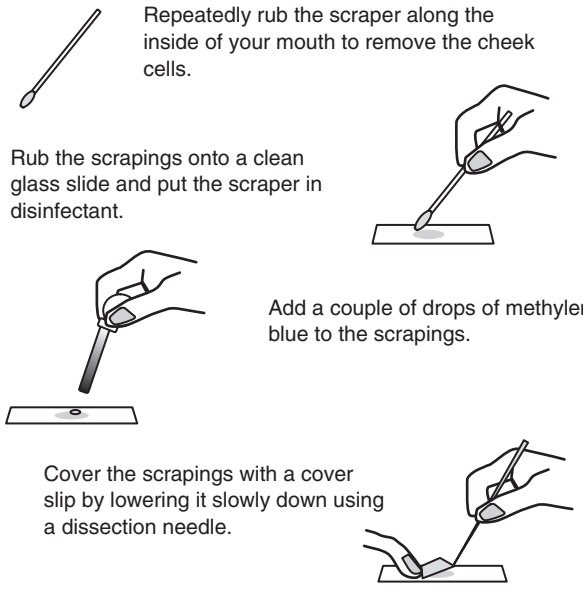


Figure 1.4 Preparing an animal cell slide

sample, but be careful to collect cheek cells and not saliva. Rub the scrapings on to a clean glass slide and put the scraper in disinfectant. Add a couple of drops of methylene blue, being careful not to stain your hands or clothes. Cover the scrapings with a cover slip by lowering it slowly down using a dissection needle. The stain will spread out under the cover slip. Examine using a microscope, low power first, and then switch to a higher magnification. The students should be able to see cell membranes, nuclei and the cytoplasm. They should recognize that the cells are broadly square shaped, because they would fit rather like paving flags forming the epithelial layer inside your cheek.

Practical activity

Looking at plant cells

You can look at the cells of the onion to see typical plant cells. The best results are found when you use red onions. You will be using the thin epidermis layers between the fleshy leaves as these are only a few cells thick.

Health and safety

Care should be taken if the students are using scalpals, and the appropriate warnings should be given prior to their use. Goggles should be worn when using the iodine solution and care should be taken to avoid contact with the skin. Be careful not to focus direct sunlight through the microscope because this can damage your eyes.

Method

The method is as follows (see also Figure 1.5). Take the epidermis layer from between the fleshy part of the onion. The darker-coloured cells are best as they contain the pigments in the cytoplasm and the vacuoles. Cut a piece approximately 1 cm^2, using a scalpel. Place this on to a slide and ensure that it is lying flat. It is easiest to do this using a pair of tweezers. Add one or two drops of dilute iodine solution, being careful not to stain your hands or clothes. Cover the epidermis layer with a cover slip by lowering it slowly down using a dissection needle. The stain will spread out under the cover slip. Examine using a microscope, low power first, and then switch to a higher magnification. You will be able to see elongate cells with distinct nuclei and the clear double cell walls of two adjoining cells.

Alternatively, you can place the epidermis cells in sucrose solution of varying concentrations – 1M, 0.8M, 0.6M, 0.4M, 0.2M and 0M (distilled water). If the

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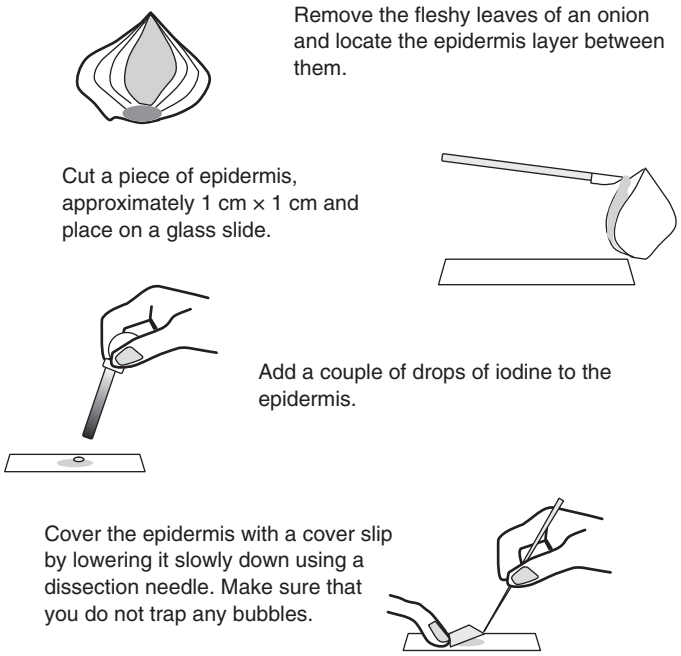

Figure 1.5 Preparing a plant cell slide

pigment is present then you should be able to see the cell membranes come away from the cell walls as the cells lose water. The cells are said to be plasmolysed if the membranes have detached from the cell wall. This is an alternative experiment to the 'osmosis in potato chips' option (see below).

Diffusion and osmosis

It would be wrong not to mention the processes of diffusion and osmosis when discussing cells. The movement of substances in and out of the cells is vital to the functioning of the cell. Oxygen, water, carbon dioxide, waste and nutrients have to cross the cell membranes to allow life to continue.

Diffusion is the passive movement of molecules or atoms from a high concentration to a low concentration, down what is said to be a concentration gradient. Passive means that no energy is expended by the cell to move that particular substance. Examples of substances that move in

and out of cells by diffusion are carbon dioxide, glucose and oxygen. These are generally substances that pass in and out of our blood. This happens quickly as there is no part of the body that is more than a few millimetres away from a blood vessel. This is called a short diffusion distance and is evident in the lungs.

Osmosis is the passive movement of water molecules from a high concentration to a low concentration, across a selectively permeable membrane. It is basically a special type of diffusion that describes how water moves in and out of cells. Students are required to answer exam questions in terms of solute molecules and water molecules. As the solute molecules are too large to pass across the cell membrane, these tend to stay where they are and the smaller water molecules move backwards and forwards. It is useful to tell the students that:

Solvent + Solute = Solution
(e.g. Water + Sugar = Sugar solution)

This makes it easier for the students to understand and then be able to explain the effect of solutes either inside or outside a cell.

Practical activity

Diffusion in jelly cubes

Diffusion and the effect of surface area can be studied by looking at gelatine blocks that contain cresol red – a pH indicator. This is red in alkali conditions and turns yellow when conditions become acidic.

The method is as follows. Start with a gelatine block and cut various cubes using a scalpel. (Care should be taken when using the scalpel.) The sizes should be progressively smaller, and a suitable suggestion is as follows:

- 10 mm × 10 mm × 10 mm
- 10 mm × 10 mm × 5 mm
- 10 mm × 5 mm × 5 mm
- 5 mm × 5 mm × 5 mm

Put the cubes into a test tube, fill the test tube with dilute hydrochloric acid and start a stop watch. Put in a rubber bung and lay the test tube horizontally. Record the time taken for the blocks to change from red to yellow. Use ideas about diffusion and surface-area-to-volume ratio to explain why the smallest cube changes colour first.

Practical activity

Osmosis in potato chips

Osmosis can be studied by cutting potato chips of roughly similar dimensions and then immersing them in varying concentrations of sucrose solution – 1M, 0.8M, 0.6M, 0.4M, 0.2M and 0M (distilled water). Measure the mass of each potato chip before placing it in a boiling tube filled with one of the concentrations suggested. Repeat with the other concentrations of sucrose. Leave for preferably 30 minutes, although reasonable results can be gained after around 20 minutes. Reweigh each chip and calculate the percentage change in mass using the following equation:

$$\frac{\text{Initial mass} - \text{Final mass}}{\text{Initial mass}} \times 100$$

Plotting the results on a graph will allow you to see exactly where the line crosses the origin. This is where the sucrose solution outside the potato cells is the same concentration as the solution inside the cell. This means you can estimate the concentration of the sap inside the potato. The closest value is around 0.4M although this will vary with different potatoes. Encourage the students to feel the chips when they are reweighed. Which chips have gone flaccid (floppy) and which are turgid (hard)?

Water moves out of the cells when the solute concentration outside of the cells is higher than inside. Putting it simply, the sugar concentration outside is higher than the concentration inside of the cell. This means that there is a large concentration gradient and the net movement of water is out of the cells. When there are more water molecules outside (less solute), then there is a net movement of water molecules into the cells.

Engaging activity

It is quite easy to make 3D models using a variety of model making substances, old boxes, string, cotton wool and the like. What makes a more interesting model is an edible model of a cell.

Making a 3D jelly model

Take a plastic container, the kind that you may use to carry sandwiches; this will represent the cell wall. In the box place a variety of different foodstuffs as follows: several grapes representing chloroplasts; several small sweets representing starch grains; one prune/plum or apricot represents a nucleus; several

rice crispies represents mitochondria. The actual amounts are not important, but the relative amounts are crucial. For example you only need one nucleus! Mix up some flavoured jelly and pour this into the box. This will need to be refrigerated until set, preferably overnight. The key thing about this is that it gets students to think about cells being three dimensional. They seem confused when they can't see all the contents of a cell under the microscope, without moving the fine focus up and down. Turning the jelly out on to a plate allows you to cut through it to reveal sections, the sort that you might see looking at plant cells using a microscope (see Figure 1.6). This explains why some cells look long and thin while others look equidimensional.

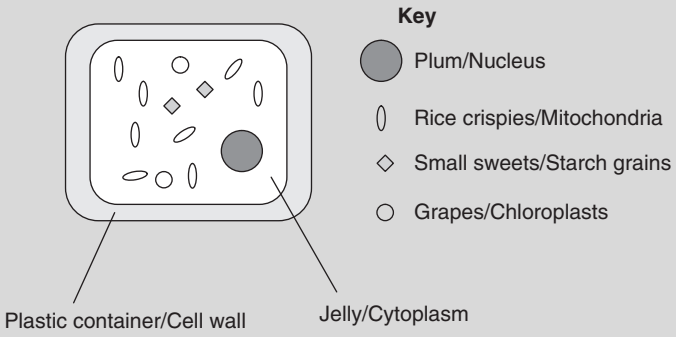

Figure 1.6 One slice through the 3D jelly model

Further reading

Kennedy, P. and Sochacki, F. (2008) *Biology AS for OCR*. Oxford: Heinemann Educational.
This has useful background information at AS level about cells and cell structure.

Parsons, R. (2003) *GCSE Biology: Complete Revision and Practice*. Kirkby-in-Furness: Co-ordination Group Publications.
This is a useful summary of the level of knowledge required for GCSE.

Parsons, R. (2006) *GCSE Biology, OCR Gateway: The Revision Guide, Higher Level*. Kirkby-in-Furness: Co-ordination Group Publications.
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