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Chapter 1
Nature of living organisms

1.1 Characteristics of living organisms

Living organisms share eight basic characteristics:

Nutrition

Living organisms need to obtain nutrients (e.g. carbohydrates, proteins and vitamins). The nutrients provide them with

- energy
- materials for growth
- substances that allow them to function properly and keep them healthy

Figure 1.1 Living organisms like plants can use sunlight to make their own food. Others need to obtain food, which they digest and absorb nutrients from.

Excretion

During metabolism (see Section 2.2), living organisms inevitably produce toxic wastes, like urea, carbon dioxide and oxygen. They are removed from the body by different ways during excretion.

Respiration

Food stores chemical energy, which is released in a process called respiration. The energy released is used for various functions, such as

- movement
- growth
- synthesis of new molecules

Homeostasis

In order to function properly, living organisms must maintain stable internal conditions. A failure in homeostasis is likely to cause survival problems for an organism.

Figure 1.2 Diabetes mellitus is a disease in which patients fail to maintain a constant blood glucose level. Patients need to monitor their blood glucose level and inject insulin when required.

What's more

Internal conditions that must be controlled in humans include blood glucose level, water content in blood and body temperature.

Sensitivity

Living organisms can detect and respond to stimuli in their surroundings. Higher organisms have sense organs, such as the nose and eyes, to detect smell and light. Plant roots and stems can detect and grow in certain directions in response to stimuli like light and gravity. This growth response is called tropism.

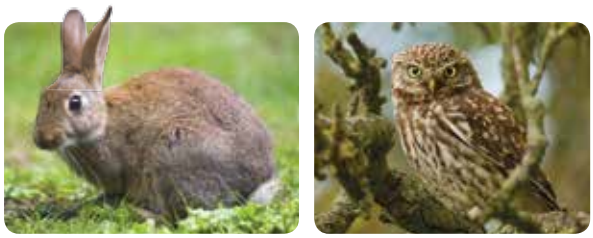


Figure 1.3 Rabbits (left) have a good hearing for detecting predators, while owls (right) have remarkable eyesight for catching prey.

What's more

A stimulus (plural: stimuli) is any detectable change in the environment.

Movement

Living organisms can move to various degrees. In mammals, movement is brought about by muscles and bones. Movement in plants is associated with directional growth in response to stimuli, which is generally much slower.

Reproduction

Reproduction results in an increase in the size of a population. In some living organisms that carry out sexual reproduction, offspring show variations from their parents and from each other. A varied population has a better chance to survive in a changing environment (see Chapter 10).

Figure 1.4 Flowering plants produce seeds (left), which grow into new plants. A human foetus grows and develops in the mother's womb before being born as a baby (right).

What's more

Sexual reproduction is one of the reasons for variations in a population.

Growth and development

Living organisms grow and develop by increasing in size, or in the number of cells. In this way, they become better at dealing with their survival needs, such as fighting for food.

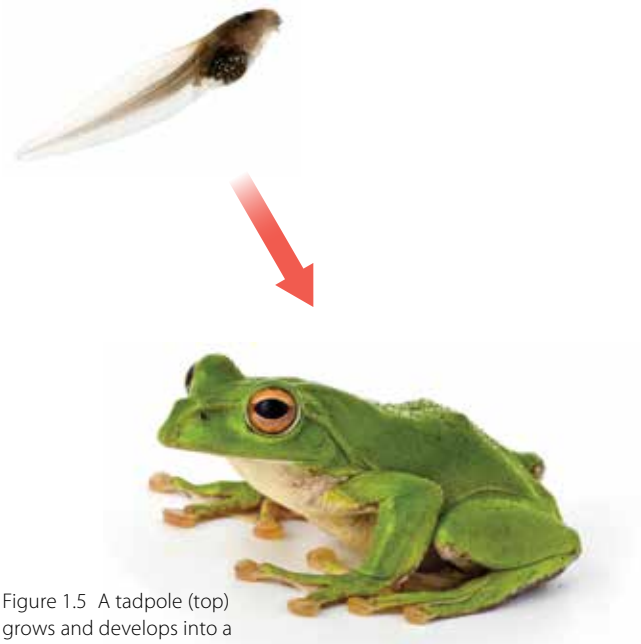


Figure 1.5 A tadpole (top) grows and develops into a frog (bottom).

1.2 Common characteristics of cells

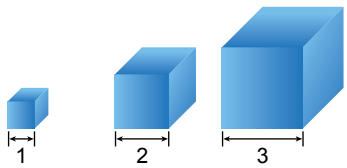
Cells, rather than biological molecules, are considered the basic units of living organisms. This is because a cell is the smallest unit that can perform all the characteristics of life. Some common characteristics of cells will be discussed in the following section.

All cells have cell membranes

The cell membrane is a barrier that separates the cell content from the surroundings. It is selectively permeable, only allowing small molecules to pass through. Therefore, it controls the movement of substances into and out of the cell (see Section 2.4).

Cells are microscopic

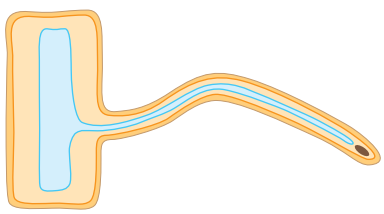
Cells are usually so small that most of them can only be seen under microscopes. The small size allows a high surface-area-to-volume ratio, which allows them to exchange material with the surroundings efficiently. Figure 1.6 illustrates how the surface-area-to-volume ratio varies with increasing size.



Surface area (SA)	6	24	54
Volume (V)	1	8	27
SA : V	6:1	3:1	2:1

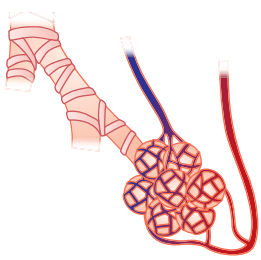
Figure 1.6 How surface-area-to-volume ratio changes with increasing cube size

From time to time, cells need to take in nutrients and remove metabolic waste to the surroundings. As the cell size increases, its metabolic rate and surface area increases too. However, the increase in surface area cannot catch up with the increase in metabolic needs. As a result, overly large cells may face survival problems, e.g. accumulation of toxic waste.



Root hair cell for absorption of water and minerals for plants

Red blood cell for carrying oxygen in blood

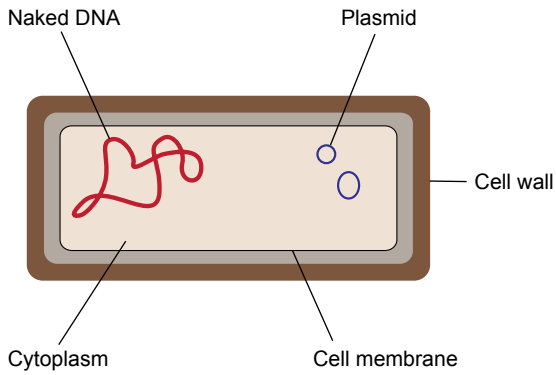


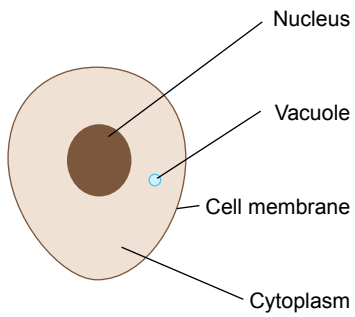
Alveoli in the lungs for gas exchange

Figure 1.7 Modified structures with a high surface-area-to-volume ratio

1.3 Cell structure

Different living organisms consist of cells with different structures. The cell structure of bacteria, animals and plants are shown in Figure 1.8.





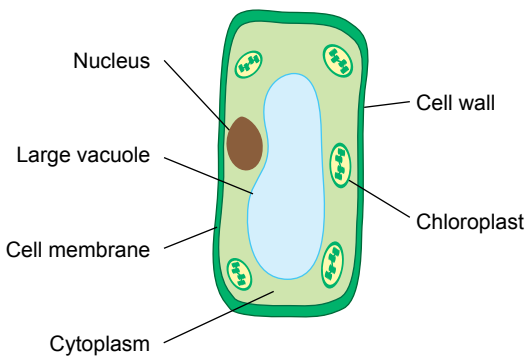


Figure 1.8 Structure of a bacterial (top), animal (middle), and plant (bottom) cell

The following table compares plant and animal cells.

	Plant cells	Animal cells
Cell wall	Present	Absent
Chloroplasts	Present	Absent
Vacuole	Large central vacuole	Usually small or absent
Nucleus	Present	Present

Table 1.1 Comparisons of the structure between plant and animal cells

Functions of different parts of cells are listed as follows:

Cell structures	Functions
Cell membrane	• Controls entry or exit of substances to or from cells
Cell wall	• Maintains cell shape • Prevents the cell from bursting
Chloroplast	• Contains green pigment called chlorophyll, which absorbs light energy for photosynthesis
Nucleus	• Contains genetic materials to instruct cell activities
Cytoplasm	• Contains organelles such as the nucleus and chloroplasts • Allows metabolic reactions to take place
Large vacuole	• Contains cell sap, which stores water and sugars • Maintains the shape of plant cells by turgidity
Plasmids	• Small circular DNA strand, which can be used to transfer genetic materials to other living organisms

Table 1.2 Functions of different cell structures

1.4 Cell wall and support

Upon absorption of water, animal cells may burst, since the cell membrane is too thin for protection. However, plant cells have thick, rigid cell walls, which prevent the cells from bursting. The hydrostatic pressure in plant cells pushes the cell membrane against the cell wall, keeping the cell rigid and erect, or in other words, **turgid**. The turgidity of plant cells maintains the cell shape and also provides support to the plant's body.

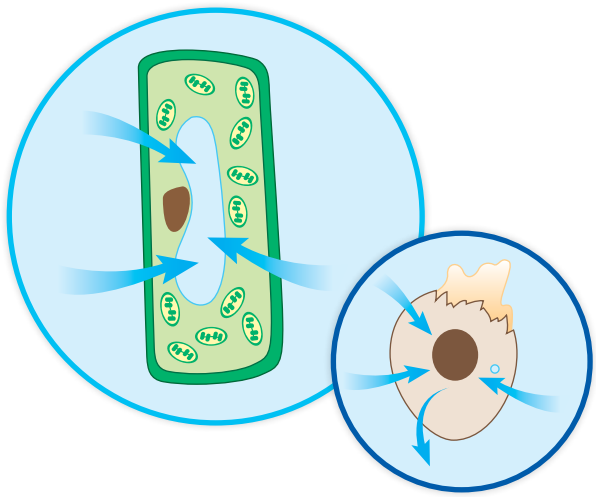


Figure 1.9 A plant cell becomes turgid when it absorbs a lot of water (left), while an animal cell bursts due to absence of a cell wall (right).

1.5 Single-celled and multicellular organisms

Some living organisms, like bacteria, are single-celled. They can perform all life functions within one cell.

Figure 1.10 A biofilm formed by one or more types of bacteria. This structure allows the single-celled organisms to survive better, as they cooperate with each other.

Multicellular organism, like animals and plants, consist of more than one cell. The cells in their body are grouped at different levels: tissues, organs and organ systems.

Exercise 1

1. A human removes different wastes from his / her body every day. Put a tick against the material(s) excreted. (2)

   ☐ Carbon dioxide

   ☐ Indigestible matter

   ☐ Urea

   (2 marks)

2. State the characteristic(s) of living organisms described by the following statements: (8)

Statement	Characteristic(s)
Plants absorb light for photosynthesis.	
Penguins release energy from food to stay warm.	
The development of root cells in plants.	
A hen lays eggs.	
A goal-keeper catches the football in a match.	
The maintenance of the blood glucose level.	

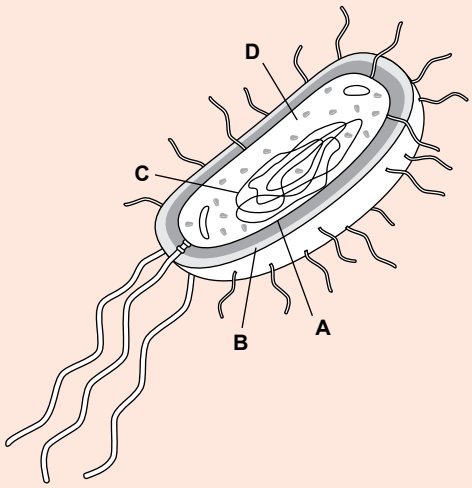
(8 marks)

3. Complete the following table by naming the correct process for each description. (5)

Name of process	Description
	Removal of metabolic wastes from the body
	Obtaining food
	Maintaining constant internal conditions
	Getting energy from food
	Producing offspring

(5 marks)

4. (a) Name the structures in the bacterial cell shown below. (4)



A: _____ **B**: _____

C: _____ **D**: _____

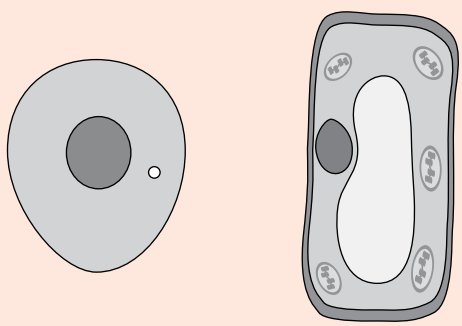
(b) State one function of (2)

Structure **C**: _____

Structure **D**: _____

(6 marks)

5. The following diagram shows two different cells, **A** and **B**.



Cell **A** Cell **B**

(a) State and explain which cell is a plant cell. (2)

_____

_____

_____