# Chapter 2
# Life processes

Unit
**1A**

## Unit content

**Cells, metabolism and regulation**

Cells carry out life processes to survive.

Life processes:
- respiration, feeding (including digestion and absorption), excretion, movement, reproduction, responses, growth and differentiation
- distinguish between living and non-living.

**Figure 2.1** Living organisms have characteristics that enable us to distinguish them from non-living things

## Characteristics of life

All of the photographs in Figure 2.1 are living things. Usually it is fairly easy for us to tell a living organism from something that is non-living. Trees, mushrooms, seaweed, cats, snails and earthworms are all clearly living. Metal, sand and plastic are obviously non-living. Some materials are made from organisms or parts of organisms that were once living. Things like wood, cotton and leather are produced from parts of dead organisms.

It is not possible to state any one characteristic that distinguishes a living organism from non-living objects. What we can say is that all living things, from single-celled bacteria to complex organisms like humans, carry out certain processes. These are known as **life processes**. All living things:

- move
- reproduce
- are sensitive
- require nutrition
- excrete waste
- respire
- grow.

Some non-living things may be able to carry out *some* of these processes. For example, crystals can grow, robots can move, cars 'excrete' waste and burglar alarms are sensitive to movement—but only living things can carry out *all* of the processes.

## Life processes in humans

The list of life processes that living things have in common can be modified a little for humans. Most plants make their own food by photosynthesis but humans are animals. We must take in food and change it for use in the cells. Bacteria have just one cell that carries out all of the life processes. Human bodies have billions of cells and so cells become specialised for particular tasks. The process by which cells become specialised is called **differentiation**.

The life processes that occur in humans and other multi-cellular animals are:

- movement
- reproduction
- responsiveness
- feeding, which involves digestion and absorption
- respiration
- excretion
- growth
- differentiation.

### *Movement*

Humans are able to move. The whole body is able to move from place to place or just a part of the body may move. Movement of body parts is brought about by muscles. In many cases the muscles pull on bones to produce movement. Movement of internal organs like the heart and the stomach occurs through muscles that are not attached to bones.

Most types of cells in the human body do not move but there are some exceptions. Muscle cells are able to decrease their length. White blood cells can move out of the blood vessels and make their way between the surrounding cells. Sperm cells are able to swim by lashing their tails. Cells lining the wind pipe have projections called **cilia**. The cilia move rhythmically to stop mucus and particles from getting into the lungs.

Movement is an essential process for humans and all other living organisms.

**Figure 2.2** Human movement

## Reproduction

If it were not for reproduction, a species would die out. The human species, like all others, would become extinct if those who died were not replaced by the process of reproduction.

Humans reproduce by sexual reproduction. A sperm from a male must combine with an egg from a female to form a cell that will grow into a new person.

Individual cells are also able to reproduce. From a single fertilised egg cell, the billions of cells in the body are produced. Cell reproduction also occurs to replace cells that have died or been damaged. The cells lining the intestine live for less than two days and must be replaced. Red blood cells live for about 120 days. There are so many of them that 2.5 million new red blood cells are produced every second!

**Figure 2.3** Human reproduction

## Responsiveness

Responsiveness and sensitivity go together. The body is sensitive to changes that occur both outside and inside. It responds in an appropriate way that keeps the body functioning normally.

If you sit on a drawing pin your bottom is sensitive to the painful stimulus. You will leap up and probably exclaim 'ouch!' (or make some other statement!). Your response has removed you from the painful stimulus. Responses like this help to protect the body from injury.

Responses also occur when changes take place inside the body. If your cells begin to become dehydrated you will feel thirsty and will drink. If your blood temperature begins to rise you will start to sweat, which will have a cooling effect. These responses help to keep the conditions inside the body at a constant level.

Some responses are involuntary; we have no conscious control over them. For example, when you see a luscious cream cake covered with strawberries you will start to salivate. This happens automatically without you having to think about it.

Other responses are voluntary. When the bell goes to tell you to return to class after lunch, you may respond immediately or you may decide to continue talking to your friends. Such responses require conscious thought. In humans, voluntary responses may be very complex because we are able to think about the consequences of our actions.

**Figure 2.4** Responsiveness: Drinking water when thirsty

**Figure 2.5** Ingestion

## Feeding

Feeding or **ingestion** is taking food and drink into the body through the mouth. Animals must ingest food to get the nutrients that they need for normal functioning.

In most animals, including humans, the food ingested has to be broken down into smaller particles and smaller molecules before it can be taken into the cells. The process of breakdown is called **digestion**. Taking digested food into the blood is called **absorption**.

The teeth and the churning motion of the stomach are important for breaking the pieces of food into smaller particles. Digestive enzymes break down large food molecules, like starch and protein, into small molecules that can be absorbed into the blood and into the cells.

## Respiration

Some of the food we take in is used to make energy available for the body. The process by which energy is released from food is called **respiration**. Because the chemical reactions of respiration occur inside the cells, it is often called **cellular respiration**. Cellular respiration uses oxygen to break down glucose to carbon dioxide and water. The energy released by this process can then be used for things like cell movement, cell division or building up complex molecules.

## Excretion

Chemical reactions in the cells produce some substances that the body is not able to use. The removal of these waste products is called **excretion**. If wastes are allowed to accumulate they can affect body functions.

**Figure 2.6** Excretion: kidneys excrete nitrogenous waste as urine

Cellular respiration produces carbon dioxide and water. Carbon dioxide cannot be used by cells, so it is excreted from the lungs. The air that we breathe out contains much more carbon dioxide than the air we breathe in. Cells can use water but if there is too much in the body fluids it will be excreted.

When proteins are broken down in the cells, nitrogen compounds are produced. Some of this **nitrogenous waste** is toxic (poisonous). Nitrogenous waste is excreted by the kidneys, along with water, as **urine** (Fig. 2.6). Urine also contains hormones, drugs, salts and other substances. Penicillin is a drug that is excreted in urine. Other drugs may be broken down before excretion.

The sweat glands are also involved in excretion. Sweat contains salts and other substances that are being removed from the body.

It is important to note that defaecation, the removal of the faeces, is *not* excretion. The faeces are made up of material that could not be digested. That material has not been inside the cells and is therefore not a product of cellular reactions.

## Growth

**Growth** is simply an increase in size but in most organisms the increase does not occur evenly. For example, a human baby's brain more than doubles in size during the first year after birth. The sex organs in humans only grow and begin to function during puberty, which occurs from about age 9 to 16.

The different rates of growth of different organs and the changes that are associated with growth are known as development. **Development** is a gradual change in the body proportions and in the functioning of the organism (see Fig. 2.7).

Unlike plants, animals eventually stop growing. Humans reach their adult height at about age 15 to 19, depending on the individual. Most growth occurs through cells dividing and producing more cells. Some growth can occur through the enlargement of existing cells. For example, when muscles increase in size as a result of exercise, it is due to the muscle cells getting larger. Even when a person reaches mature size, cell division continues to replace cells that die.

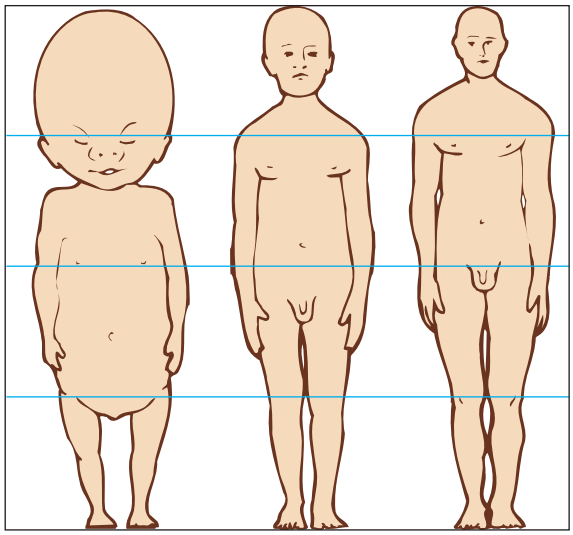


**Figure 2.7** Growth and development: notice the change in body proportions from baby to child to adult

## Differentiation

There are over 200 different types of cells in the human body, yet all of these different cell types came from the one original fertilised egg cell. The different cell types arise by differentiation. Differentiation is the process by which unspecialised cells become specialised for particular functions, such as bone cells, muscle cells or nerve cells.

Unspecialised cells that can differentiate into different types of cell are called **stem cells** (see Fig. 2.8). In the early stages of the human embryo there is a clump of **embryonic stem cells**. Each of these cells is able to differentiate into any one of the many types of human cell. Stem cells are also found among the differentiated cells in a tissue or organ. These **adult stem cells** are not as versatile as the embryonic ones. They can normally only differentiate into a few different cell types. For example, blood stem cells produce the different types of cell found in the blood. Although they are called adult stem cells, these cells are also found in children.

All the cells in an individual have the same genes and chromosomes. This is because the process of cell division, by which new cells are produced, ensures that each new cell receives exactly the same genetic material as the parent cell.

A video of cell differentiation in an embryo can be seen at http://www.teachersdomain.org/resources/tdc02/sci/life/stru/different/index.html

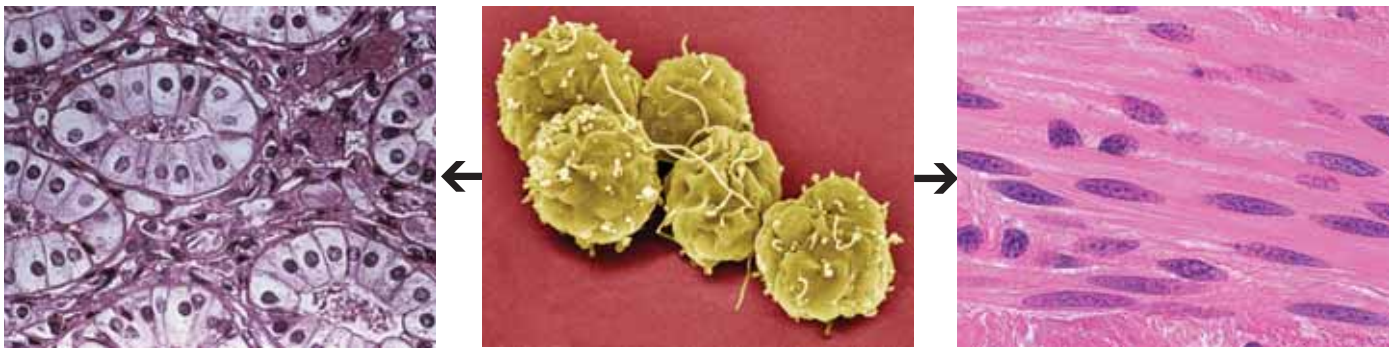

**Figure 2.8** Differentiation: stem cells (centre) can differentiate into specialised cells

# Working scientifically

## Activity 2.1 Skin sensitivity

The skin is sensitive to touch, pressure, pain and temperature. If the skin detects changes in the external environment that may be beneficial or harmful we can respond in an appropriate way.

The purpose of this activity is to compare the touch sensitivity of different areas of the skin.

### You will need (for each pair)

Blindfold; dividers or mounted needles (two); plasticine; ruler (with mm scale)

### What to do

One member of each pair should act as the subject, the other as investigator. If you have time you could reverse roles and repeat the investigation.

Touch sensitivity of the skin can be tested by determining how far apart two separate touches must be before the subject can distinguish them as two sensations. To touch the blindfolded subject's skin you can use dividers or two mounted needles held together by plasticine. Sometimes use one touch and sometimes two so that the subject cannot guess. Test different areas of skin and find out how far apart the two touches have to be before the subject can detect the two stimuli.

In designing your investigation think about:

- how many times you should test each area of the subject's skin
- what areas of skin you will test
- how you will record your results
- whether it would be useful to combine your results with others in the class.

Write a paragraph summarising your conclusions. Discuss any difficulties that you had in performing the investigation and suggest improvements.

## REVIEW QUESTIONS

1. Describe the processes that are carried out by all living organisms.
2. **(a)** What cells in the body are responsible for movement of body parts?
   **(b)** What are some other cells that are capable of movement, either of the whole cell or a part of the cell?
3. Explain why reproduction is essential for continuation of a species.
4. Using examples, explain the difference between a voluntary and an involuntary response.
5. Explain the difference between ingestion and digestion.
6. **(a)** Why do living cells have to respire?
   **(b)** What substances are needed for cellular respiration?
   **(c)** What substances are produced by cellular respiration?
7. **(a)** What is excretion?
   **(b)** What organs are involved in excretion from the human body?
8. Explain the difference between growth and development.
9. What is meant by cell differentiation?

## APPLY YOUR KNOWLEDGE

1. What is the difference in nutrition between plants and animals?
2. Explain why defaecation is not considered to be a form of excretion.
3. Explain the role of stem cells during the early stages of an embryo. What is the role of stem cells in an adult?
4. Santorio Santorio was an Italian doctor who carried out the first controlled experiments on human inputs and outputs. He was also the first person to use measurement in biological investigations. His results were published in 1614.

   Santorio constructed a platform on which he had a bed, a chair and a work table. The whole device was suspended from scales on the ceiling. While he conducted his experiments over a period of thirty years, Santorio slept, ate and worked in the weighing contraption. By weighing his inputs of food and drink and his outputs of solids and liquids he was able to record how much his weight changed with different activities. Although he did not explain the role of nutrition in weight changes, or respiration, he did inspire others to conduct research using measurement.

   **(a)** What inputs and outputs was Santorio unable to measure?

   **(b)** How would failure to measure all inputs and outputs have affected Santorio's results?

   **(c)** What aspect of science does the story of Santorio demonstrate?
5. Each person inherits the potential to grow to a certain height. Whether a person actually reaches that height depends on environmental factors. What factors in a person's environment could limit growth?
6. Suggest how the rate of chemical reactions in a person's body could be influenced by the amount of clothes the person was wearing. (Hint: heat is a form of energy.)