Body Systems and Responses

Human presence causes major changes to the Earth, but how does our environment influence us? How does your body interact with the world around it? Your body maintains a fine balance of internal conditions to survive, through the coordinated and integrated internal systems that respond to changes in our internal and external environments.
4.1 Coordination Systems

Each body system is responsible for a major process that maintains the functioning of a multicellular organism. Coordination systems monitor and maintain the correct functioning of these body systems. The nervous system coordinates other systems through the use of electrical signals, while the endocrine system communicate with chemicals. The nervous and endocrine systems influence each other, and work together to ensure the organism functions properly and survives.

Students:
- describe how coordination systems maintain humans as functioning organisms
- describe examples of function of endocrine glands in humans (additional)

4.2 Responding to Change

All organisms experience change in their external and internal environments. It is vital to respond to these changes otherwise individual cells will not be able to function optimally or possible stop functioning entirely, resulting in illness or death of the individual. Multicellular organisms have dedicated body systems with specific roles in maintaining a relatively stable internal environment for optimum cellular functioning. Different systems respond to different changes, but all are coordinated by a combination of the nervous and endocrine systems.

Students:
- describe how multicellular organisms respond to changes in their environment
- describe how the coordinated function of body systems provides cells with oxygen, nutrients and water, and removes wastes

4.3 Responding to Disease

One critical response for all organisms is the response to disease. Disease can come in the form of invading pathogens, or as a malfunction of cellular, organ or system functioning. Without a response to these diseases, cells sicken and eventually die. Multicellular animals have an immune system whose job is to prevent invasion and to seek out and destroy any pathogens that enter the body.

Students:
- outline some responses of the human body to infectious and non-infectious disease
- discuss how the values and needs of contemporary society can influence the focus of scientific research such as the occurrence of infectious and non-infectious diseases in humans, plants and animals
COORDINATION SYSTEMS

To survive immediate danger, you need quick responses. For example, when you trip or slip on something you may respond by throwing your arms out and trying to stay upright. This is to prevent damage to your precious body. In addition to response to the external environment, the internal environment must be monitored and changes responded to. Receptors in your blood vessels detect the levels of dissolved carbon dioxide and oxygen, and can cause changes to your breathing rate to maintain the correct balance. The nervous system is integral to the detection of and response to changes in internal and external conditions in the human body and consists of the brain, spinal cord and nerve tissue that spreads throughout all parts of the body.

The nervous system

To humans are constantly receiving stimuli (incoming information about internal and external conditions) that they need to respond to. The nervous system makes it possible to detect and respond very quickly to certain stimuli. The nervous system uses electrical messages that are passed through nerves.

Your body requires many responses at every moment of the day and night that rely on the coordinated and efficient working of the two main parts of the nervous system. Your brain and spinal cord make up the central nervous system (CNS), which is responsible for processing the information received from the peripheral nervous system (PNS), which includes all the other nerves. The peripheral nervous system is responsible for detecting stimuli and initiating the response as dictated by the central nervous system.
**ACTIVITY 4.1.1: HOW FAST IS THE NERVOUS SYSTEM?**

What you need: metre ruler

1. Working in pairs, one student holds a metre ruler between their thumb and forefinger so the ruler hangs with the zero mark at the bottom. The other student needs to wait with their thumb and forefinger at the bottom of the ruler, level with the zero mark.

2. The first student drops the ruler without warning, while the other student catches the ruler as fast as they can between their thumb and forefinger.

3. Record the number of centimetres the ruler has dropped by looking at the location of the second student’s thumb and forefinger on the ruler (Figure 4.2).

4. Repeat until you have 10 results for each student.

5. Work out the average reaction distance for each student.

6. Measure the approximate distance the messages must have travelled if they travelled from your eye to your brain, then to your fingers.

7. Blindfold one student to test touch. Tap the person on the head at exactly the same time as you drop the ruler. Does this make a difference to the reaction distance?

8. Blindfold one student to test hearing. Say ‘now’ when you drop the ruler. Does this make a difference to the reaction distance?

9. Which test had the fastest results? Why might this be?

10. How could you make sure the results are as accurate as possible?

11. Do you think this is a ‘fair test’? Why or why not?

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**Nerves**

The basic unit of the nervous system is a nerve cell, or neuron. Scientists believe we may have up to 100 billion neurons in our bodies, connected in bundles called nerves.

Neurons have many highly specialised features. Each neuron has a large cell body where the nucleus of the cell can be found, which connects to a long thin axon on one side and to the dendrites on the other. Dendrites are nerve endings that branch out of the cell body. These highly sensitive, thin branches receive information and form contacts with the axons of other neurons, allowing the message to be transmitted. The axon carries the message away from the cell body towards another neuron or effector cell. The axons connecting your spinal cord to your foot can be up to 1 metre long! The messages that travel along neurons are called impulses. An impulse involves a series of electrochemical changes and movement of charged ions across membranes.
Just like electrical wires require insulation, so do neurons. A fatty layer called the myelin sheath covers the axons. This helps to speed up a nerve impulse along an axon by controlling its path. People with multiple sclerosis have damaged myelin sheaths. This means the nerve impulse is disrupted, blocked or able to escape along the length of the axon, which causes movement and sensory problems.

The axon usually branches at the end to increase the number of connections with other neurons. At the end of each axon branch is a small bulb called a synaptic terminal, or terminal button.

Neurons communicate with each other and different types of cells at the junction where the two cells meet. The two cells don’t actually touch – they are separated by a tiny gap called the synaptic gap. This point of communication is called the synapse, and includes the terminal buttons of the neuron sending the message, the synaptic gap and the dendrites of the next neuron receiving the message.

An electrical impulse cannot cross the synaptic gap. When an electrical impulse reaches the end of a neuron at the synaptic gap, the terminal buttons release chemicals called neurotransmitters into the gap. These chemicals diffuse across the synaptic gap and bind to the surface of the dendrites, which triggers a new electrical impulse in the second cell to continue the message.
There are three specialised types of neuron, all with different jobs:

**Sensory neurons** are sensitive to various stimuli, collecting information either from the body’s internal environment or the outside world. Sensory neurons send the information they have collected to the central nervous system for processing. One example is the specialised cells in the retina, which sense the intensity and colour of light and send messages to the brain so that we can see. Sensory neurons are only found in the peripheral nervous system.

**Interneurons** link to sensory and motor neurons, as well as to other interneurons. Interneurons only make connections with other neurons. They are also known as connector or relay neurons and are only found within the central nervous system, the spinal cord and the brain. They process incoming information and determine the responses.

**Motor neurons** carry messages from the central nervous system to muscle cells or endocrine glands throughout the body, which then carry out the response. Motor neurons are also known as effector cells. Motor neurons are only found in the peripheral nervous system.

**ACTIVITY 4.1.2: PIPECLEANER NEURONS**

What you need: 5 different coloured pipecleaners representing different parts of the neuron (cell body, axon, dendrites, myelin sheath, and synaptic terminal), A3 or A4 paper, sticky tape, red felt-tip pen

1. Construct a model of a neuron with a key to indicate the different parts of the neuron.
2. Tape your finished pipecleaner neuron onto a piece of A3 or A4 paper and label the parts.
3. Mark the path of the nerve impulse, from start to finish, along the neuron.

**QUESTIONS 4.1.1: THE NERVOUS SYSTEM**

**Remember**

1. With a partner, identify a way to remember the difference between sensory neurons, motor neurons and interneurons. Be creative! Share your memory trick with the class.
2. Name and describe the features of a neuron that enable it to carry messages.
3. Identify where sensory neurons are that detect:
   a. smells
   b. tastes
   c. sounds
   d. touch
   e. sights

**Apply**

4. Explain the role of the myelin sheath.
5. Using a diagram, explain what problems may result from damage to the myelin sheath.
6. Write a story or draw a cartoon about the travels of a message communicated from...
The largest part of the brain is the cerebrum. It is divided into two paired cerebral hemispheres, joined by the corpus callosum. All of our conscious activities are controlled by the cerebrum. The outer layer of the cerebrum is called the cerebral cortex (also known as grey matter).

The thalamus processes and carries messages for sensory information, such as information sent from the ears, nose, eyes and skin, to the cortex.

The brain stem sits mostly inside the brain. At its base it becomes the spinal cord. The brain stem is made up of three major parts—the medulla, the pons and the midbrain.

The cerebellum is like a smaller version of the cerebrum and is responsible for movement, balance and coordination.

The hypothalamus is primarily responsible for homeostasis. This includes maintaining a constant heart rate, body temperature and sleep pattern. The hypothalamus is also involved in hormone production by control of the pituitary gland.

The brain is the processing centre of the body. Its main functions relate to our survival. The brain is a soft, heavy organ, mostly made up of neurons, and surrounded by a tough skull. The brain receives information from the senses and other receptors throughout the body, via sensory neurons, about what is going on inside and outside the body. It then makes decisions about things like internal changes and movements. It is also home to memories, personality and thought processes. The brain connects to the spinal cord and also to 12 pairs of cranial nerves that connect directly to some internal organs and the face and head.

The human brain is easily the most complex and fascinating organ of any living thing. Neuroscientists are learning a lot about how it works. They already know the brain is divided into different parts, each of which has a specific function but works with the other parts. Neuroscientists also know the brain demonstrates ‘plasticity’, which means it can change as you grow and develop and heal – previously thought impossible.

The brains of most complex animals follow the same basic structure as the human brain. Relative sizes of the different parts of the brain can be an indication of the complexity and intelligence of that animal.
Lobes of the brain

The cerebrum is the top layer of the brain and is where most of the processing is done. The cerebrum is divided into two hemispheres. They appear to be mirror image of each other but they do have some slight differences in structure and function. The hemispheres are joined in the middle of the brain by the corpus callosum, a bundle of neurons that enable the two hemispheres to communicate. Each hemisphere is then divided into four lobes or sections. These lobes have specific functions:

- The frontal lobe is located at the front of the brain. Its functions include emotions, reasoning, movement and problem-solving.
- The parietal lobe, found in the centre of the brain, manages the perception of senses, including taste, pain, pressure, temperature and touch.
- The temporal lobe is located in the region near the ears. It deals with the recognition of sounds and smells.
- The occipital lobe is at the very back of the brain. It is responsible for various aspects of vision.

**EXPERIMENT 4.1.1: SHEEP BRAIN DISSECTION**

**Aim**
To explore the structure of a sheep’s brain.

**Materials**
- Lab coat, safety goggles and vinyl gloves
- Sheep’s brain
- Dissecting board
- Scalpel
- Dissecting scissors
- Coloured pins
- Microscope, slide and cover slip (optional)
- Wear a lab coat, safety goggles and gloves. Be careful with the scalpel because it is likely to be very sharp.

**Method**

1. Examine the outside of the brain. Set the brain down so that the flatter side, with the white spinal cord at one end, rests on the board. Using the different coloured pins, identify the two hemispheres, the four lobes of the brain, the spinal cord, the cerebellum and the cerebrum. Check this with your teacher before continuing.

2. Turn the brain over. Identify the medulla and pons.
The spinal cord

If you have ever accidentally touched something very hot you will remember how quickly you snatched your hand away, so quick that you didn't even have time to think about it – it was automatic. This involuntary and nearly instantaneous movement in response to a stimulus is called a reflex, or reflex action.

The spinal cord is a cylinder of nerves that runs from the brain through the vertebrae of the spine and branches out into 31 pairs of spinal nerves. During a reflex action, an impulse is passed along a sensory neuron to the spinal cord, where it crosses a synapse to a motor neuron. Activating motor neurons without having to wait for signals to pass through the brain allows reflex actions to occur quickly. Of course, the message is eventually sent to the brain so the brain can record what has happened. This explains why, after a fraction of a second after you pull your hand away from a hot stove, you feel the pain in your hand.

3 Place the brain with the curved top side of the cerebrum facing up. Use a scalpel to slice through the brain along the centre line, starting at the cerebrum and going down through the cerebellum, spinal cord, medulla and pons. Separate the two hemispheres of the brain. Record what you see.

4 Cut one of the hemispheres in half lengthwise. Record what you see.

Discussion

1 Was the sheep’s brain similar to a human brain in structure? Account for the differences between a human brain and that of a sheep.
2 What did the brain feel like? Was it easy to dissect?

Conclusion

Write a sentence to address the aim.

(a) Use pins to identify the different parts of the upper brain

(b) Identify the medulla and pons.

(c) Separate the two hemispheres.

(d) Examine the internal structure.

Figure 4.9
Figure 4.10 Our reflexes protect us from dangerous situations. Closing your eyes and ducking protects your face and the many sensory organs located there.

Spinal cord Injury

Spinal cord injury is a major cause of injury in Australia, especially to young men. These injuries commonly result from motor vehicle accidents, everyday falls and sports.

When the spine is badly damaged, messages to and from the brain cannot pass through the spinal cord normally as the injury blocks the neurological signal. How much of the body is able to move after a spinal injury depends on where the injury is in the spine and how severe the injury is. If severe damage is high up, most of the body is ‘cut off’ from the brain; if it is lower down, then the upper body and arms should be able to work as they normally would.

People with severe damage to the upper part of the spinal cord may have quadriplegia and are unable to use their arms or their legs. If the injury is very high, they may even have trouble breathing on their own. People with severe spinal cord damage around their waist region may have paraplegia and are still able to use their arms but not their legs.

Figure 4.12 Paraplegia is spinal damage that affects the lower part of the body.
ACTIVITY 4.1.3: TESTING REFLEXES

1 Look at the pupils (the black spots in the middle of the eyes) in the eyes of a classmate. Note the size of the pupils.
2 As a class, dim the lights in the room. After a few minutes, look at your classmate’s eyes and note the size of the pupil.
   - How big are the pupils? Have they changed in size?
   - Why do you think this happened?
3 Turn the room lights back on. Check the size of your classmate’s pupils again.
   - How big are the pupils this time?
   - Why do you think this happened?
   - What other reflexes do you think you could safely test?

With a partner, design a test of your own. Make sure you write a full report, including your aim, equipment and method. If you have time, carry out your experiment, record the results and discuss any trends you may discover. Draw a conclusion using your results as evidence.

QUESTIONs 4.1.2: THE CENTRAL NERVOUS SYSTEM

Remember

1 Identify two parts that make up the central nervous system.
2 Explain what protects your:
   a brain
   b spinal cord
3 Identify the name for the individual bones that make up the spine.
4 Explain the difference between quadriplegia and paraplegia.
5 Identify the part(s) of the central nervous system involved in a reflex reaction. Explain.
6 Draw a scientific diagram of the brain that shows the four lobes. In each of the lobes:
   a write what functions are carried out in that lobe
   b draw something to remind you of the functions carried out in that lobe
7 Draw a diagram of the human brain. Identify and label the main sections and lobes of the brain.

Apply

8 Suggest a reason why reflex actions exist.
9 What kind of reflex action do you think other mammals may have? Would it be similar or different to ours? Justify your answer.
10 Describe the differences between the cerebrum and the cerebellum.
11 Explain why, if you slipped and hit the back of your head, everything might go black.
12 Explain some of the potential effects of trauma to the frontal lobe.
13 Compare the structure of the human brain to that of fish, birds and frogs (refer back to Figure 4.7). Identify the animal with the largest and smallest of each part and suggest an explanation for the differences.
THE PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system is a large system made up of all the nerves outside the central nervous system. The peripheral nervous system carries information to and from the central nervous system to the rest of the body, such as the limbs and organs.

The peripheral nervous system is divided into two parts:

- The **somatic nervous system** controls voluntary skeletal muscle movements, such as waving or reaching out to take something.

- The **autonomic nervous system** controls involuntary actions, which happen without our conscious control. This includes heartbeat, digestion, respiration, salivation and sweating. The autonomic nervous system maintains your body’s internal environment.

The autonomic nervous system also has two parts: the sympathetic division and the parasympathetic division.

The sympathetic nervous system is responsible for a group of responses that are often simply called the flight or fight responses. Stimuli that trigger these responses are usually unexpected or potentially life threatening. The main response of the sympathetic nervous system is to activate the endocrine system to produce the hormone adrenalin. Adrenalin travels around the body in the blood stream and causes many other responses, including increased heart rate and blood pressure, and the release of stored glucose into the blood stream.

The parasympathetic nervous system is responsible for returning the body back to its normal state after a period of stress. So the sympathetic and parasympathetic divisions often have opposite effects. For example, the parasympathetic division slows down the heart rate, whereas the sympathetic division speeds up the heart rate. Together, the systems maintain a relatively stable internal environment for the body.

Figure 4.13 Together, the parts of the nervous system control both voluntary and involuntary actions.
**STUDENT DESIGN TASK**

**Skin sensitivity**

**Challenge**
Design and conduct an experiment to test skin sensitivity. Do not conduct a test that might hurt the person you are testing.

**Questioning and predicting**
Create your own hypothesis about the relationship between the amount of touch you can sense and the different parts of the body that you test.

**Planning and conducting**

- What will you do to test your hypothesis? Are there any areas of the body you think would be more sensitive than others? Why would it be more important to have more sensitivity in some areas than others? How would increased (or decreased) sensitivity be beneficial to your body in sensing and responding to changes and threats?
- Conduct your experiment and record your results in an experimental report so someone else could perform the same experiment.

**Processing, analysing and problem solving**

1. How can you explain your results?
2. Are there any variables you were unable to control? Suggest ways to improve your method.
3. What do you know about the connection between the sense of touch and different areas of the body?
4. Why do you think some areas of your body are more sensitive than others?
5. How do your results compare with those of other groups?
6. How could you test whether sense overload from hearing, sight, smell or taste interferes with the sense of touch?
7. Do you think the experiment would have different outcomes if done with a group of people who were blind? Why or why not?

**Communicating**
Present your findings in a formal experimental report.

**QUESTIONS 4.1.3: THE PERIPHERAL NERVOUS SYSTEM**

**Remember**

1. Outline the different components of the peripheral nervous system.
2. Identify the part of the nervous system responsible for maintaining a stable internal environment. Why is this an important role?
3. Recall the types of neurons found in the peripheral nervous system.

**Apply**

4. Explain how the peripheral nervous system and the central nervous system work together. Use an example to illustrate your answer.
5. Describe the difference between the somatic nervous system and the autonomic nervous system.
6. The sympathetic nervous system shuts down the digestive system in times of stress, while the parasympathetic nervous system activates the digestive system. Suggest a reason why this might be.
7. Suggest at least two other responses of the sympathetic nervous system.
THE ENDOCRINE SYSTEM

The endocrine and nervous systems are the systems largely responsible for sensing and responding to the environment. Part of this important job is communication: once a change or threat has been received, messages must be sent around the body to coordinate a response. The nervous system sends very fast electrical messages, and the **endocrine system** uses chemical messengers called **hormones** to maintain a stable internal environment and to regulate growth and normal functioning. These chemical messengers usually act more slowly than the nerve impulses sent around by the nervous system, but their effects often last for a lot longer.

The endocrine system is made up of glands that secrete (release) hormones. The glands and organs of the endocrine system are in different places throughout the body (Table 4.1). The hormones are usually secreted into the bloodstream and then travel through the blood to arrive at a target organ. How does the hormone know where to go? Different hormones have a different 3-dimensional shape that bind to a matching receptor on the target organ, working like a lock and key. The wrong hormone cannot bind to the target organ, and so it has no effect on that organ.

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**Table 4.1** Some organs and hormones of the endocrine system.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Hormone</th>
<th>Target tissue</th>
<th>Main effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Wide range of neurohormones</td>
<td>Pituitary gland</td>
<td>Links nervous system to endocrine system via pituitary gland to control many internal conditions, as well as hunger, thirst and sleep patterns</td>
</tr>
<tr>
<td>Ovaries</td>
<td>Progesterone</td>
<td>Uterus</td>
<td>Thickens wall of uterus. Progesterone is important for calcium in bones.</td>
</tr>
<tr>
<td></td>
<td>Oestrogens</td>
<td>Body cells</td>
<td>Develops female sexual characteristics, aspects of pregnancy and foetal development</td>
</tr>
<tr>
<td>Testes</td>
<td>Testosterone</td>
<td>Male reproductive system, body cells</td>
<td>Develops and controls male sexual characteristics. Controls production of sperm</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Insulin</td>
<td>Liver, muscle and fat cells</td>
<td>Lowers blood glucose level</td>
</tr>
<tr>
<td></td>
<td>Glucagon</td>
<td>Liver</td>
<td>Raises blood glucose level</td>
</tr>
<tr>
<td>Pituitary gland</td>
<td>Thyroid-stimulating hormone</td>
<td>Thyroid</td>
<td>Changes the rate of thyroxine release from the thyroid</td>
</tr>
<tr>
<td></td>
<td>Antidiuretic hormone</td>
<td>Kidneys</td>
<td>Reduces the amount of water reabsorbed from the kidneys</td>
</tr>
<tr>
<td></td>
<td>Pituitary growth hormone</td>
<td>Bones and muscles</td>
<td>Stimulates muscle growth. Controls the size of bones</td>
</tr>
</tbody>
</table>
### DEEPER UNDERSTANDING

#### Fight or flight?

Have you ever been in a dangerous or frightening situation? If you have, you may understand very well what the ‘fight or flight’ response is all about – you break out in a cold sweat, your heart beats wildly, everything around you seems to slow down and your senses are bombarding you with information.

Most of the symptoms are triggered by the release of the hormone adrenalin. Adrenalin is being constantly produced by the adrenal glands in small doses. The adrenal glands are located above the kidneys. Usually, this hormone is used for everyday things like regulating your heart rate and the size of your blood vessels. However, when you are in danger, adrenalin takes on a whole new role. At times like these it floods into your system, causing an increase in the strength and rate of the heartbeat, raising your blood pressure and speeding up the conversion of glycogen into glucose, which provides energy to the muscles. In this way, adrenalin prepares your body for the extra effort required if you need to defend yourself (fight) or run away (flight).

#### Figure 4.16

Adrenalin is responsible for the ‘fight or flight’ response in mammals.

### ACTIVITY 4.1.4: GLANDS AND ORGANS OF THE ENDOCRINE SYSTEM

**What you need:** large sheet of butcher’s paper, felt-tip pen, sticky tape

1. Working in pairs, draw an outline of your partner’s body onto the paper.
2. With your partner, draw in the different glands and organs of the endocrine system. Using the information in Table 4.1, label each gland with a brief description of its function in your own words.
3. Use colour-coding and arrows to show the path of the hormone(s) produced by each gland to its target organ.
4. Choose one gland or organ to research further. In your research, include:
   - the hormone it secretes
   - what the hormone does
   - disorders related to this organ or gland.
Types of hormone

Hormones are classified into two main types based on their chemical structure: peptide hormones and steroid hormones. Peptide hormones are made from proteins and are produced by the anterior pituitary, parathyroid gland, placenta, thyroid gland and pancreas. Most hormones are peptide hormones. Peptide hormones travel through the bloodstream until they find and interact with specific receptors on the surface of their target cells.

Steroid hormones include hormones secreted by the adrenal glands and the ovaries (women) or testes (men). Steroid hormones are produced from cholesterol and are lipid-soluble, which means they can pass thorough the cell membrane and move directly into the target cells.

Hormones at work

Hormonal effects are often controlled by feedback mechanisms. When a hormone (a messenger) is sent out into the body, information is received about what is going on. This then affects other responses by the body. The rate of hormone production and secretion is often regulated by a negative feedback mechanism. If a stimulus is received indicating that something in the body is happening ‘too much’, the response would be to produce less of that hormone to reduce the effects. Negative feedback also works the other way, where the stimulus detects that a condition in the body is ‘too low’, so the response is to increase that condition. The ‘negative’ part of this response really means to respond in the opposite way, rather than to always reduce it.

Positive feedback mechanisms are far less common, and often a sign of the body not functioning properly. Body temperature is a condition usually controlled by a negative feedback mechanism. If we get too cold, negative feedback causes an increase in core temperature. If we get too hot, negative feedback cools us down again. However, positive feedback causes the response to magnify the condition. If we are cold, positive feedback makes us colder; if we are too hot, positive feedback makes us hotter. This can be seen during severe illnesses when fevers can cause potentially fatal rises in core body temperature.

When things go wrong in the endocrine system

Disorders and diseases of the endocrine system are fairly common, often due to imbalances in feedback mechanisms within hormonal systems or problems with the production of hormones or their receptors. Diabetes, thyroid goitre and some forms of obesity are all caused by imbalances in the endocrine system.

Diabetes is one of the more serious and common results of hormone imbalance. Left untreated, it can result in blindness, kidney failure, heart disease or death. Diabetes occurs when the pancreas either produces too little insulin or doesn’t properly use the insulin it does produce, resulting in high blood sugar levels. Insulin is the hormone that assists the body to process sugar in the bloodstream. A message that blood sugar is low results in less insulin being produced. The opposite happens when blood sugar is high.

A goitre occurs when the thyroid gland, which is in the neck, becomes enlarged. The thyroid gland needs iodine to produce

overmatter
**QUESTIONS 4.1.4: THE ENDOCRINE SYSTEM**

**Remember**

1. Identify the name of the system in your body responsible for hormones.
2. Explain what is meant by the phrase ‘fight or flight’ and outline how it relates to hormones.
3. Describe the two different types of hormone.
4. Recall what a feedback mechanism is.
5. Explain the stimulus that triggers insulin production.

**Apply**

6. The hypothalamus is an important structure within the brain that secretes hormones. It is responsible for maintaining a stable internal environment in your body. Outline why this job is so important. Explain how the hypothalamus is an example of the nervous and endocrine systems working together.
7. Explain why the endocrine system is referred to as a communications system.
8. Explain how a hormonal response is different to a nervous response.
9. Suggest a reason why the response of the endocrine system tends to be slower than that of the nervous system.
Remember and understand
1 Outline the key components of the body’s nervous system. [3 marks]
2 Write a definition for each of these words:
   a autonomic nervous system [1 mark]
   b reflex action [1 mark]
   c peripheral nervous system [1 mark]
   d myelin sheath [1 mark]
3 Copy Figure 4.20 of a neuron and label the parts. [6 marks]
4 Identify two glands in humans that produce hormones. [2 marks]
5 Identify two diseases caused by hormonal problems in humans. [2 marks]
6 Explain why the nervous system and the endocrine system are both communication systems. [1 mark]
7 Describe how hormones are transported in the body. [1 mark]

Apply
10 Describe the relationship between the sympathetic and parasympathetic parts of the nervous system. [2 marks]
11 Complete the table about the autonomic and somatic parts of the nervous system. [5 marks]

<table>
<thead>
<tr>
<th>Action</th>
<th>Autonomic or somatic?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart beating</td>
<td></td>
</tr>
<tr>
<td>Sweating</td>
<td></td>
</tr>
<tr>
<td>Waving</td>
<td></td>
</tr>
<tr>
<td>Blinking when something is near your eye</td>
<td></td>
</tr>
<tr>
<td>Running</td>
<td></td>
</tr>
</tbody>
</table>

12 Copy and complete. A person with diabetes has a problem with the hormone ________________, which is secreted by the ________________. [1 mark]
13 Explain what a negative feedback mechanism is and give an example. [2 marks]

Analyze and evaluate
14 Imagine you are a doctor with a patient who is experiencing loss of control of her legs and lack of feeling in her hands. How would you link these symptoms to a problem with the nervous system? [2 marks]
15 Compare the central nervous system and the peripheral nervous system to current communications technology. You could use an example such as a mobile phone text message or an instant messaging service. [2 marks]

16 Design a survey that investigates the risk of potential spinal damage for your classmates. You might include types of sports played, opinions about fast driving and cars, and general risk-taking behaviour. [3 marks]

17 In 2006, a woman in northern Quebec fought off a polar bear with her bare hands when it attacked her daughter. She literally wrestled with the bear – and won! Compare arguments for and against this reaction being attributed to the hormone adrenalin. [2 marks]

Ethical understanding

18 Apply the results of your survey from question 16 and/or other relevant sources to devise a 60-second television commercial or highway billboard to discourage risk-taking behaviour on roads. [3 marks]

Critical and creative thinking

19 On poster paper or your computer, construct a scientific illustration showing how the structure of a neuron is suited to its function. [3 marks]

20 Imagine your body as a city. Construct a table with the organs of the endocrine system in one column. In a second column, write what would go wrong in the functioning of the city if the hormones produced by each organ were not produced. [5 marks]

21 Draw a cartoon strip with at least five squares illustrating a person receiving a stimulus and then responding. [5 marks]

Making connections

22 Prepare a report that compares the structure and function of the nervous and endocrine systems. Negotiate the format of your report with your teacher; formats could include a multimedia presentation, formal report, video, vodcast, podcast or poster presentation. [5 marks]

23 Explain how the endocrine system assists your body to ‘respond to the world’. Why couldn’t the endocrine system handle this big job on its own? [3 marks]
RESPONDING TO CHANGE

Changes occur in the external environments of all organisms on the Earth. Species have survived over thousands of years in a changing environment. Ice ages have come and gone, asteroids have struck the Earth and while some species have become extinct, many have survived. Changes also occur in the internal environments of organisms. Multicellular organisms rely on body systems to function together so all their cells have the right conditions, such as levels of nutrients and oxygen, and also so their toxic wastes are removed. The circulatory, respiratory, digestive and excretory systems in humans work together to provide a relatively stable internal environment for cells.

RESPONDING TO EXTERNAL CHANGE

Our bodies are constantly responding to changes, often without us consciously acknowledging a stimulus or the response. A stimulus is any information an organism receives that might cause it to respond. If you were consciously aware of every stimulus your body deals with, you would not have time to think about anything else!

Responding to stimuli

All living organisms respond to changes in their environment. It is one of the defining characteristics of living things. Responding to an external change can prevent major changes to the internal environment, which can cause the organisms to become ill or possibly die. The easiest stimuli to identify are those we detect with major sense organs and respond to physically. Table 4.2 summarises the major human sense organs and the types of stimuli they detect.

Table 4.2 Detecting stimuli.

<table>
<thead>
<tr>
<th>Sense organ</th>
<th>Type of stimuli detected</th>
<th>Sensory neurons involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes</td>
<td>Light intensity (brightness) and wavelength (colour)</td>
<td>Photoreceptors</td>
</tr>
<tr>
<td>Ears</td>
<td>Volume and frequency of sound</td>
<td>Mechanoreceptors</td>
</tr>
<tr>
<td>Nose</td>
<td>Smell</td>
<td>Chemoreceptors</td>
</tr>
<tr>
<td>Mouth</td>
<td>Taste</td>
<td>Chemoreceptors</td>
</tr>
<tr>
<td>Skin</td>
<td>Touch, temperature and pain</td>
<td>Mechanoreceptors, thermoreceptors and pain receptors</td>
</tr>
</tbody>
</table>

Figure 4.21 [a] Photoreceptors in the human eye transform received light into nerve impulses. (b) The human ear transfers vibrations to mechanoreceptors in the middle ear, which become nerve impulses.
Here are some examples of responses caused by stimuli:

- External temperature changes result in shivering or sweating.
- Pressure on a part of our body might be light and ticklish, or strong and painful; it might reduce blood circulation or simply make us look at what is causing it.
- Light might make us squint, close our eyes or look towards its source.
- Sound might make us look towards its source, follow an instruction or cover our ears.

**Figure 4.23** Some animals such as the chameleon and cuttlefish change colour when the background colour changes. Pigments in the special cells in the skin change distribution to bring about the response.

**Figure 4.24** Spiders are very sensitive to pressure and quickly detect prey that land on their webs.

**Figure 4.25** Kangaroos have a network of blood vessels close to the skin of their forepaws. Because kangaroos don’t sweat, instead they lick their forepaws so the evaporation from this area cools their body.

**Figure 4.26** Platypus have special receptors in their bills that detect electrical activity from the movement of invertebrates such as yabbies. Platypus hunt for food with their eyes and ears closed.

**Figure 4.27** A crocodile’s eye has an elliptical (oval-shaped) pupil, which helps to protect its sensitive retina from the bright light of day. At night, the pupil is fully open and rounded, maximising the amount of light entering.

**Figure 4.28** Elephants use their trunks as a sensory organ for a wide range of smelling tasks. It can also help them sense danger.

**Figure 4.29** Temperature sensors on the skin of the bird detect surrounding temperature. This then causes movement of hair and feathers, which help many mammals and birds maintain their body temperature.

### ACTIVITY 4.2.1: ENVIRONMENTAL CHANGE

As a class, brainstorm as many environmental changes you can think of that would require organisms to respond in some way. They could be as significant as a bushfire or as simple as a sudden noise. When every member of the class has contributed at least one example, try to identify the possible responses for each stimulus. Is there only one way to respond to each? How do plants respond differently from animals?
ACTIVITY 4.2.2: NAVIGATING WITHOUT VISION

What you need: blindfold
With a partner, explore how the senses of touch, hearing and smell can be used to navigate around a room without the use of sight.

1. Ensure all small or potentially hazardous obstacles are removed from around the room. Decide with your partner the path that the blindfolded student is required to take.

2. Take turns being blindfolded and navigating the room, with your partner walking with you to ensure your safe navigation and providing assistance if needed.
   - How was the sense of touch used in navigation?
   - How was the sense of hearing used to find your way around?
   - How was the sense of smell used?
   - Was one sense better than another to help you navigate around the room?

Other ways of responding

Humans detect changes to their external environment by using their senses of sight, hearing, taste, touch and smell. Some other animals have a different range of senses and very different responses.

In plants, odours may cause a plant to flower or fruit to ripen. Chemicals in bushfire smoke promote the germination of some seeds. Flowering plants respond to the direction of incoming light by growing towards it because of the production of hormones that cause cells to divide and grow in certain areas and prevent it in others. The hairs on the leaves of a Venus flytrap plant respond to pressure when an insect brushes past and the leaves respond by closing to trap the insect.

Plant responses are often called tropisms because they affect the way the plant grows or develops. Some of the more common plant tropisms are listed in Table 4.3.

<table>
<thead>
<tr>
<th>Tropism</th>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phototropism</td>
<td>Light intensity</td>
<td>Grow towards the light</td>
</tr>
<tr>
<td>Geotropism</td>
<td>Gravity</td>
<td>Shoots grow up, roots grow down</td>
</tr>
<tr>
<td>Hydrotropism</td>
<td>Presence of water</td>
<td>Grow towards water</td>
</tr>
<tr>
<td>Thigmotropism</td>
<td>Touch or contact</td>
<td>Grow towards a solid surface</td>
</tr>
</tbody>
</table>

Figure 4.30 Vine tendrils grow in random directions until they come in contact with a surface. Then, thigmotropism causes the vine to grow towards that surface.
STUDENT DESIGN TASK

Testing plant responses to stimuli
Select one response to a stimulus in a plant and design an experiment that allows you to validly test the conditions that stimulate the response. You may like to research other plant responses to investigate other than those listed in Table 4.3.

Questioning and predicting
- What is the main purpose of the response?
- What type of stimulus does it receive?

Planning and conducting
- How will you ensure your experiment is a fair test and that it validly tests your hypothesis?
- How can you be certain all other variables are controlled and the stimulus is the independent variable?
- How can you be sure you are accurately observing or measuring the response (dependent variable)?

Processing, analysing and problem solving
1. Was the response identical each time?
2. How would the number of repetitions affect your results?
3. Identify at least one problem you encountered during your experiment. Suggest an improved method to avoid this problem.
4. Suggest an alternative experiment on animals that could have been designed but was unethical. Discuss what would have made it unethical.
5. What can you conclude from your investigation?

Communicating
- Present your investigation in a format negotiated with your teacher.

QUESTIONS 4.2.1: RESPONSES TO EXTERNAL CHANGE

Remember
1. Define the term ‘stimulus’.
2. Stimuli can be changes in our immediate environment or changes within our bodies. Identify two examples of each.
3. Outline an example of a response to a stimulus that is a reflex.
4. Identify the five main senses in humans.
5. Describe five situations in which each of the five senses would need to bring about a response.

Apply
6. Explain how it is possible to survive without one or more of your senses.
7. Most of you may have heard of the five senses, but how many does a human actually have? Explain what a sense actually is, and see if you can identify another.

Analyse and evaluate
8. Evaluate the benefit of reflex responses over normal responses.
9. Chemotropism is another type of plant response. Suggest what the general stimulus would be for this type of response and a specific example where plants would grow towards the stimulus.
RESPONSES TO INTERNAL CHANGE

Our bodies experience internal changes every day. Requirements for oxygen and for removal of carbon dioxide from our muscle cells when we are sleeping are different to those when we are having a shower or exercising. If we have eaten sugary food, the production of insulin by the pancreas may be very different to when we eat meat. Our cells can only survive in a narrow range of temperatures. Sometimes our bodies generate too much heat, and this has to be removed.

Flowering plants rely on coordinated responses to changes in the internal environment. The root and shoot systems need to work together to ensure that cells have their requirements for photosynthesis and respiration, wastes are removed and excess food is stored appropriately.

Like the nervous responses we experience as reflex actions to external change, responses to changes in our internal environment are also automatic and regulated by the autonomic nervous system. However, they often involve the interactions of a range of body systems. One of the more obvious interactions is between the endocrine system and the circulatory system. Hormones are produced by glands and organs in the endocrine system, but they are carried around the body to their target tissues by the circulatory system.

Multicellular organisms have an amazing combination of cells, tissues, organs and systems working together to maintain a stable internal environment. The different systems communicate via the nervous and endocrine systems.

ACTIVITY 4.2.3: BODY SYSTEMS

What you need: A3 sheet of paper
You’ve most likely heard of a variety of different body systems and probably learned about them in year 8. Do you remember all the different body systems?

Figure 4.31 Our body systems work together.
SCIENCE SKILLS

Drawing a flow chart

Many people think of a flow chart as a series of arrows and text in boxes, something like a visual representation of a procedural text. Effective flow charts contain decision elements and alternative paths to the decisions, with the effects of the decision often indicated as loops.

Flow charts can be an effective way to demonstrate how the body systems interact to provide the body cells with the requirements for life.

Construct a flow chart to show changes that might occur when the human body starts exercising. Questions might include, ‘Do the cells have enough oxygen?’ ‘Does the blood have too much carbon dioxide?’ You may work in pairs, with one person constructing a flow chart for what happens when we start exercising and the other a flow chart for when we stop.

On an A3 sheet of paper, draw a mind map showing the links between the requirements for life (oxygen, nutrients, water and removal of waste) and the different body systems. You will get a point for each link that you make – there are lots of connections to be made!

Team up with a partner. Imagine you are both famous scientists who have been asked to speak to a year 9 class at a local secondary school about body systems and how they work together. Prepare two separate ‘fact files’ of at least half a page each, including a diagram, on the respiratory and circulatory systems.

- What interaction do these two systems have?
- What would happen if the two systems didn’t work together?
- Looking at the structure and position of the systems, what clues can you find that show they work together?

Copy and complete the table on the functions of different body systems.

<table>
<thead>
<tr>
<th>Function</th>
<th>Body systems working together</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen transported in the blood</td>
<td></td>
</tr>
<tr>
<td>Nutrients from food absorbed and transferred into the bloodstream</td>
<td></td>
</tr>
<tr>
<td>Unwanted nutrients transported out of the body</td>
<td></td>
</tr>
<tr>
<td>(Think of your own)</td>
<td></td>
</tr>
<tr>
<td>(Borrow one from a friend)</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 4.32](A flow chart for how to get to school on time.)
Body systems and nutrition

Cells require nutrients such as glucose for energy, minerals and lipids (fats) for growth and repair, and vitamins for cell functioning. We obtain these nutrients by eating and drinking.

Hunger and thirst are impulses controlled by the nervous system. Some parts of digestion, such as chewing and swallowing, are under conscious control. Most other processes in digestion, such as peristalsis and the secretion of digestive juices, happen automatically through the coordinated action of the nervous and endocrine systems.

Nutrients from food are carried to cells by the circulatory system. The nutrients are the result of the digestive system breaking down food so it is absorbed into the blood, mainly through the small intestine. Not all nutrients are required in the proportions absorbed at the time of digestion, so our bodies have a system of processing and storage. The liver plays a large part in providing stored nutrients when we need them. Some nutrients, such as soluble vitamins, cannot be stored, and so we need to eat foods that contain them on a regular basis.

Body systems and water

Water enters the body through the stomach and the small and large intestines of the digestive system. It leaves in perspiration, urine, faeces and the air we breathe out. The excretory system, through the action of the kidneys, ensures that water balance, blood pressure and blood volume are maintained. Water also makes up a large proportion of blood plasma (fluid). If the body is dehydrated, more water is absorbed in the lower intestines, the faeces become hard and dry, and constipation may result.

Body systems and wastes

Waste products of the cells are carried away by the circulatory system. The respiratory system works with the circulatory system to ensure carbon dioxide is expelled from the lungs. The kidneys in the excretory system ensure wastes such as urea are filtered out of the blood and expelled in the urine. The kidneys rely on blood pressure to filter efficiently, so they depend on the circulatory system and the absorption of water through the digestive system to provide the pressure.
QUESTIONS 4.2.2: RESPONSES TO INTERNAL CHANGE

Remember
1 Identify five ways that the body’s internal environment changes.
2 Identify which system is largely responsible for maintaining blood volume and pressure.
3 Give two examples of the conscious control and two examples of involuntary control of aspects of the digestive system.

Apply
4 Evaluate why coordination between the respiratory and circulatory systems is so important.
5 Explore what might happen if our bodies did not maintain a relatively stable internal environment.
6 Draw a flow chart to demonstrate some of the stimuli and responses made by the digestive and excretory systems during the process of maintaining correct water balance in the body.
RESPONDING TO CHANGE

Remember and understand

1. Define and give an example of the following words:
   a. stimulus [1 mark]
   b. reflex [1 mark]
   c. response [1 mark]

2. Describe three ways other organisms receive stimuli from the environment that the human body cannot. [1 mark]

3. Identify the most likely response to:
   a. walking on hot sand [1 mark]
   b. seeing something flying towards you [1 mark]
   c. realising you’ve put salt on your cereal instead of sugar [1 mark]
   d. throbbing in your head [1 mark]

4. Describe which body systems work together to ensure body cells receive the oxygen they need. [2 marks]

5. Identify the body systems involved in removing wastes from the body. [3 marks]

6. Recount the steps that happen to food between eating and when nutrients enter body cells. [4 marks]

Apply

7. Outline six different responses to a change in temperature – three for an increase and three for a decrease in temperature. [3 marks]

8. On the mind map you drew in Activity 4.2.3, add labels to explain how the nervous and endocrine systems control responses to change. [2 marks]

Analyze and evaluate

9. Humans body cells are extremely sensitive to change, which is why our systems work every hard to maintain a relatively stable internal environment. Plants are unable to get up and move to a new external environment. Evaluate whether plants would be more sensitive, less sensitive or have the same sensitivity to their internal environment. Justify your decision. [2 marks]

10. Imagine a situation where you are faced with a shortage of water. Construct a flow chart that outlines some of the possible responses within your body or in your behaviour and their effects. [3 marks]

Ethical understanding

11. Discuss the ethical issues about conducting research on animals to better understand how their body systems coordinate. [3 marks]

Critical and creative thinking

12. Imagine you wake up one day and one of your sense organs has stopped working. Write a creative story outlining this day in your life. [5 marks]

Making connections

13. Laparoscopic surgery (keyhole surgery) is becoming increasingly common. It offers patients advantages of smaller incisions, less pain and bleeding, and generally a quicker recovery. It relies on technologies such as fibre optics, tiny lenses or cameras and monitors. Often, carbon dioxide is pumped into the part of the body where the procedure is occurring to increase the working and viewing space. Methods such as epidurals mean that surgery can be carried out without general anaesthetics. Propose a ‘wish list’ for future advances in technology and surgery that would help patients recover. [5 marks]

TOTAL MARKS [ /40]
RESPONDING TO DISEASE

Many factors can make us sick or put us at risk of illness. Disease threats are not always obvious or even visible. There are two main types of disease threats: infectious and non-infectious. Infectious threats are pathogens, such as bacteria in food or a virus from the person next to you. Non-infectious factors include lifestyle (such as diet and exercise), environment (such as radiation and pollution), abnormal functioning of cells and inherited disorders. The human body has complex responses to fight disease. As a society, our values and needs influence which diseases and threats are the focus of scientific research.

INFECTIOUS DISEASE

A disease is an unhealthy impairment of the body that stops it from functioning as it should. There are two main types of disease: infectious and non-infectious. Non-infectious diseases are not contagious, and cannot be caught from another individual. Diseases, such as heart disease or diabetes, are called non-infectious diseases. Non-infectious diseases may be inherited genetic disorders, caused by lifestyle choices or inadequate diet, the result of abnormal cell functioning or division, or caused by non-living factors in the environment such as air pollution.

Infectious diseases are those that can be spread between individuals. Infectious agents or pathogens cause infectious diseases. There are a number of different types of pathogen including the virus that causes the common cold and bacteria that can give you food poisoning. Virulence is a measure of how easily an infectious disease is passed on to others.

ACTIVITY 4.3.1: HYGIENE AND DISEASE

List all the rules you can think of that relate to personal hygiene. What are the important rules about storing and handling food? Why is disease an issue after disasters such as tsunamis and floods? What are the issues in areas where there is no sewerage? Construct a concept map that links all the issues of food, water and personal hygiene with infectious disease.

Pathogens

Pathogens can vary in type and size, from unicellular microorganisms to larger multicellular macroparasites and fungi. Prions are a group that has only recently been added to the list of pathogens. They are responsible for diseases such as mad cow disease (bovine spongiform encephalopathy). Prions are not organisms – they are ‘faulty’ protein molecules that convert normal cellular proteins into the infectious form as they come in contact with them, which is how prions spread. Pathologists, scientist who specialise in disease, still have much research to do before we fully understand prions.

Bacteria are prokaryotic (without a true nucleus or membrane-bound organelles), unicellular microorganisms. Very few bacteria are pathogenic. Many bacteria are actually vital for the proper function of our bodies. We use bacteria in the production of many foods and drinks. Bacteria live on our skin and fight ‘bad’ bacteria before it enters our bodies. These bacteria and other
Table 4.4 Types of pathogen.

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Features</th>
<th>Example of disease</th>
</tr>
</thead>
</table>
| Macroparasite| • Multicellular organism, such as roundworm, fluke or tick  
• Usually parasitic  
• May have no independent digestive system – absorbs nutrients across the cell membrane | Cysticercosis – an infection from eating undercooked contaminated meat, caused by tapeworm, which can grow several meters in length |
| Fungus       | • Unicellular or multicellular organism  
• Cell wall  
• Nucleus  
• No chloroplasts or chlorophyll | Tinea – a fungal infection, often between the toes |
| Protozoan    | • Unicellular or simple multicellular organisms  
• Cell wall  
• Nucleus | Malaria – transmitted by mosquitoes and causes high fever and flu-like symptoms |
| Bacterium    | • Unicellular organism  
• Cell wall but no nucleus or membrane-bound organelles | Chlamydia – a sexually transmitted infection |
| Virus        | • Not a true cell  
• Contains genetic material surrounded by a protein coat  
• Not considered living – can only reproduce by hijacking a living cell to replicate its DNA | Hepatitis – inflammation of the liver |
| Prion        | • Not an organism  
• Protein molecule that is faulty and makes other proteins faulty through direct contact | • Mad cow disease in cows or variant Creutzfeldt–Jakob disease in humans – both are infections that affect the brain, which can be caused by eating infected material |
ACTIVITY 4.3.2: INVESTIGATING PATHOGENS

What you need: selection of research resources (such as books, medical dictionaries, journals and computers) for step 4.

1. Working in small teams, take three minutes to brainstorm and prepare a list of as many different infectious diseases as you can think of.

2. You now have two minutes to predict what sort of pathogen causes each of the diseases in your list. Next to each disease, write one of the following words as your prediction: macro parasite, fungus, protozoan, bacterium, virus, prion.

3. Spend a minute discussing how your team can use your resources for the best results. You must use at least two different types of resource.

4. Spend 15 minutes researching the list of diseases to confirm which group of pathogens causes the diseases in your list.

   • How many diseases did you think of? How many of your predictions were correct?
   • What resources did your team use? Which ones were fastest? Find out what resources were the most useful for the other teams.
   • Draw a bar graph showing the number of diseases you listed for each type of pathogen.
   • Was there a type of pathogen that dominated your list? If so, can you think of reasons why you might be more familiar with the causes of some types of disease?

DEEPER UNDERSTANDING

Science helping society respond to health threats

Dieback in Australian plants

The fungus *Phytophthora cinnamomi* was accidentally introduced into Australia a long time ago. It lives in the soil and plant roots and is spread naturally in ground water, causing a condition in plants called root rot or dieback. Recent human activity such as logging has increased its rate of spread, with disastrous effects on many native plant species as well as on some ornamental plants. Plants such as the Wollemi pine, waratah and grass trees are particularly at risk.

Dieback is common in Western Australia. It is also of concern in the national parks of New South Wales. Botanists at the Royal Botanic Gardens in Sydney and officers from New South Wales National Parks and Wildlife have collaborated to run research and

Figure 4.34 Signs in national parks in New South Wales educate visitors about the risk of spreading *Phytophthora cinnamomi.*
education programs to try to reduce its spread. These include ways to avoid spreading it through human activities such as carrying infected soil on shoes.

Avian influenza including the H5N1 strain
Viruses are challenging to researchers because they can change into different forms that make vaccines obsolete (no longer effective). In recent years, the movement of viral diseases from animals to humans has become of concern. The Spanish influenza (flu) between 1918 and 1920 killed at least 20 million people worldwide. It was the first human influenza pandemic caused by the avian (bird) virus (strain H1N1) adapting to humans. In 1997, the Hong Kong flu was the first time the deadly H5N1 strain was recognised. In 2004 and 2007, outbreaks of H5N1 resulted in the death or slaughter of hundreds of millions of chickens across Asia. In 2009 there was another pandemic of the H1N1 strain, called swine flu (the virus can also interchange with humans and pigs). The major concern is that the virus will remain in bird populations and suddenly change. It has the potential to become a form that can transmit directly from human to human, as happened in the case of the Spanish flu.

Quarantine reduces the risk of an outbreak of avian flu in Australia. CSIRO’s Australian Animal Health Laboratory conducted research into gene silencing, which can prevent the mechanisms that viruses use to take over their host’s cells. This research is in addition to research areas such as early detection of avian flu, development and testing of vaccines, and better understanding of the biology of the avian flu virus and its strains.

Devil facial tumour disease
The first photographs of Tasmanian devils with lesions and swelling on the face were taken in 1996. We now understand the disease, called devil facial tumour disease, is caused by one of the few contagious cancers. It is believed to be spread by biting. In areas where the disease is widespread, populations have declined by 95% and the Tasmanian devil is now protected and classified as endangered. The total devil population is now believed to be about half of the population of 10 years ago. This disease was new to science and only occurs in Tasmanian devils. The drastic effects on the population have prompted a range of research, and there is still a lot more to learn.

Scientists are focusing on three areas in their research: monitoring the amount and spread of the disease, learning more about the disease, and managing it to avoid extinction. Ways to avoid extinction include keeping infected populations separate and keeping a certain number of healthy Tasmanian devils in quarantine.

Dr Kathy Belov is a genetic researcher who has made a major breakthrough. She discovered Tasmanian devils lacked genetic diversity, particularly in a group of genes associated with helping fight infection. The cancer cells are not recognised as ‘foreign’ by the Tasmanian devils and so no immune response is triggered. Her research focuses on finding populations where these genes vary slightly, and developing and trialling vaccines.

Type 2 diabetes
The Garvan Institute of Medical Research in Sydney is conducting research into type 2 diabetes, which is becoming increasingly common. Currently, 85–90% of all people with diabetes have the type 2 form of the disease. It usually occurs in people over 45 years of age, but...
is now becoming more common in younger people and even children. Unhealthy eating, lack of exercise and being overweight can trigger type 2 diabetes. People with type 2 diabetes cannot process sugar in their bodies effectively because they may not produce enough of the hormone insulin, causing their muscles to become less responsive or insulin-resistant. The resulting high blood sugar levels damage organs and blood vessels.

There is no cure for type 2 diabetes, but there are ways to manage the symptoms. The Garvan Institute researchers have found that a hormone, called PYY, is released from the gut after eating. Low levels of PYY after eating is a predictor for developing type 2 diabetes. This hormone acts on the brain as a signal to stop eating. People who do not produce enough PYY are more likely to become overweight and so are at risk of type 2 diabetes.

**QUESTIONS 4.3.1: INFECTION DISEASE**

**Remember**
1. Recall the definition of a disease.
2. Identify what causes infectious diseases.
3. Identify what causes non-infectious diseases.
4. Explain how a virus is different from a bacterium.

**Apply**
5. What do you think a pathologist studies? Explain.
6. Draw a table to show the different diseases in the Deeper Understanding section. Identify the type of pathogen that causes each of the diseases and identify how scientists are trying to prevent further outbreak of these diseases.

**Evaluate**
7. The antibacterial chemicals in cleaning products kill all types of bacteria, including our natural flora. Evaluate whether you would encourage the use of antibacterial products in your home, and give reasons for your decision.
The role of your immune system is to protect you against foreign invaders by physically stopping them from entering your body, and then identifying and attacking them if they do manage to enter. Your immune system has three lines of defence against disease, each with a different role.

**First line of defence**

The first line of defence against pathogens is to stop pathogens from getting inside the body. This is done by the skin and mucous membranes. Orifices are natural gateways into the body and need to be protected. Hairs surround your eyes and are present in your nose and ears. They act like nets to catch pathogens as they try to enter your body. Tears, wax and mucous also line these areas, and help to trap, and in some cases kill pathogens.

Your skin itself is too thick for pathogens to pass through, and your natural flora kills most pathogens that land on it. However, any breaks or damage to your skin are prime entry zones for pathogens. Viruses, unlike bacteria, contain a protective coating that allows them to slip more easily through the first line of defence. If they or other pathogens get past the first line of defence, a second stage of general defence is in place to stop them.

**Second line of defence**

If a pathogen manages to get inside our body, a general ‘seek and destroy’ approach is initially taken, regardless of the type or structure of the pathogen. This is a general or non-specific immune response that includes:

- blood clotting - to stop additional infection through skin damage
- inflammation - to increase the amount of blood (carrying white blood cells) reaching an infected area
- fever - to heat up the body and destroy pathogens that cannot survive in extreme heat
- phagocytosis - large white blood cells that envelope pathogens and destroy them via enzymes.

White blood cells are produced by the body to destroy pathogens. An increase in the amount of blood reaching an

![Figure 4.37](image-url) The skin and mucous membranes are the first line of defence against pathogens.
infected area of the body, as a result of inflammation, means more white blood cells are available to attack the pathogen. The white blood cells may also release substances that increase the amount of fluid in the infected area, causing swelling.

White blood cells can only do their job if they can recognise the difference between body cells and pathogens. Every cell has chemical markers on its surface called **antigens**. Every cell in your body has the same antigens, which flag to white blood cells that they are ‘good’ cells. Pathogens will have their own specific antigens that are different to your body cells. White blood cells ‘read’ the antigens and recognise the pathogens as ‘non-self’ and attack them.

There are a few different types of white blood cell. Each type does its own job but they all work together. Only some white blood cell types are involved in the non-specific immune response. These are called **phagocytes** (the term comes from Greek words meaning ‘cells that eat’). A phagocyte envelops a pathogen, and once inside the phagocyte it is destroyed with enzymes. This process is called **phagocytosis**.

**Third line of defence**

Any pathogens remaining after a non-specific response are targeted according to their type. This is called a **specific immune response**.

The specific immune response creates antibodies. **Antibodies** are protein molecules that bind specifically to target antigens, like a key fitting in a lock. Antigens may be the pathogen itself or marker molecules on the surface of a pathogen.

When a person is infected with a pathogen, specific antibodies are produced to combat the pathogen. These antibodies remain in the blood long after the infection has been fought, sometimes for the rest of the person’s life. If the person is infected with the same pathogen again, the antibodies react immediately to attack and destroy it. This is called **natural active immunity**. The body may take up to a week to make the antibodies needed to combat a new antigen. This is why recovering from an illness takes time. Once the body has learned how to make the particular antibody, it is more likely to be protected from reinfection in the future. If a person gets infected, but fights off the infection without getting sick, the person is said to be **immune** to that disease.

Unborn babies obtain some natural immunity by receiving some of their mother’s antibodies across the placenta. Antibodies are also passed to babies who drink breast milk. This is called **natural passive immunity**. However, because the baby isn’t making those antibodies themselves, they are not replaced when those molecules breakdown. The baby’s immunity may drop after a few months of not breastfeeding until they make enough of their own antibodies.

One other way to acquire immunity is by ingestion (by swallowing) or injection with specific antigens. This is called **vaccination**, or inoculation. Vaccination is an example of **acquired active immunity**.
A vaccine can be:

- the dead pathogen
- an alive but non-virulent (weak or non-infectious) form of the pathogen – the pathogen in this case is called **attenuated**
- antigens of the pathogen that have been separated from the pathogen itself.
- the weakened or inactive toxin that some bacteria produce.

Through vaccination, a person is prompted to produce antibodies without the disadvantage of becoming ill, which usually leads to immunity. Vaccinations are often given as a preventive measure. For instance, the influenza vaccine is recommended for people over 65 years of age because complications from influenza can be life-threatening in older people. Vaccinations can also be given when there is an urgent need to provide immunity. Tetanus vaccine is often given for this reason after a tetanus-prone injury, such as an open wound caused by a rusty or dirty object, because tetanus can be fatal. The use of vaccinations has resulted in many diseases becoming extremely rare.

Antibiotics

Today, antibiotics are a common solution to kill the bacteria that infect us. However, it was only around the time of World War II that the first antibiotic, penicillin, started being used by doctors to treat bacterial infections. Before then, treating infections, such as infected wounds, was difficult. Amputation was one way to deal with serious infections.

In 1928, Alexander Fleming discovered penicillin from a mould. The Australian scientist Howard Florey then played an important part in developing penicillin into a form suitable for mass production. Both men were awarded the Nobel Prize in Physiology or Medicine for their work. By 1945, penicillin was being produced on an industrial scale and was used by the Allies to treat wounded soldiers in World War II. Eventually, penicillin became available to people outside the military.

Penicillin works by breaking down the cell walls of bacteria, but not human cell membranes. This means it will kill the bacteria in your body but not your own body cells. Antibiotics are medicines specific for treating bacteria. They are largely ineffective in the treatment of other types of pathogens. Other pathogens that infect people require different types of medicine. Most viruses cannot be treated by any readily available medicines and we need to rely on our own immune system.
Medicines usually work in one of several ways:
• changing how cells work
• replacing substances missing from your body
• destroying microorganisms and abnormal cells
• reducing the symptoms of illness.

Before a medicine can be sold in Australia, it needs to be approved for use by the Therapeutic Goods Administration. This agency decides which medicines are available to you and whether the medicines can be sold without prescription, over the counter without having to see a doctor first.

**QUESTIONS 4.3.2: THE IMMUNE SYSTEM**

**Remember**
1 Recall the main component of the body’s first line of defence.
2 Outline other ways the body can prevent pathogens from entering.
3 Describe in your own words how the non-specific immune response works.
4 Identify the different types of immunity.
5 Define the difference between a vaccination and a vaccine.

**Apply**
6 Explain what a vaccine might contain and how a vaccine might work.
7 Explain how antigens help white blood cells to fight pathogens.
8 The story of how Alexander Fleming discovered penicillin is fascinating. Conduct some Internet research and write a short article about its discovery. Which Australian scientist was also involved in the production of the first antibiotic?
**NON-INFECTIONOUS DISEASE**

Invading pathogens do not cause non-infectious diseases. Non-infectious diseases are a result of things like poor diet or lifestyle choices, genetic mutations, poor mental health or environmental factors. They are not contagious – you cannot ‘catch’ a non-infectious disease from someone. However, they can be passed down from parent to child in the case of genetic disorders like Huntington’s disease or Down syndrome.

**Diet and lifestyle**

The nutrients you supply your body can affect how well the individual cells do their job. The right balance of nutrients is very important. Too much or not enough of some nutrients can cause diseases like scurvy, type 2 diabetes, heart disease and obesity. Smoking or excessive alcohol consumption can lead to cancers, liver failure and increased likelihood of accidents and injury.

**Genetic disorders**

All genetic disorders are a result of a mutation in the DNA at some stage. If these mutations occur in the DNA of sperm and eggs, they can be passed on to future children. Some common genetic diseases and disorders include:

- haemophilia
- cystic fibrosis
- sickle-cell anaemia
- muscular dystrophy
- Down syndrome
- fragile X syndrome.

**Environmental factors**

We are exposed to toxins, carcinogens (cancer-causing substances) and radiation on a daily basis. Some of these are harmless in very small amounts, but with prolonged exposure or extreme exposure they can cause non-infectious disease.

Nuclear reactions release radiation such as gamma rays. Radiation of this type is called ionising radiation. Exposure to ionising radiation can either be intentional, for example in some medical treatments and diagnosis (such as X-rays), or unintentional, such as everyday exposure or accidents. But what does radiation actually do to us?

Radiation is energy. Energy is required to make and break chemical bonds, which means radiation can interfere with the molecules in your body’s cells.

The nucleus of each of your cells contains the instructions for every task and substance required for healthy functioning. The instructions take the form of the molecule DNA (deoxyribonucleic acid). Any change to these instructions can result in damage, which may be major or minor depending on where the change occurs.

We often think of DNA as being most important for human reproduction. However, DNA is vital for the reproduction of all cells, not just the ones that make new
organisms. Many of your other cells need to be regularly replaced and cells need to be reproduced for healing to occur.

Your body is quite incredible in its ability to protect itself from harm and repair or to destroy faulty cells. However, sometimes parts of the body’s cellular systems don’t function as they should. Tumours are faulty cells that continue to multiply, replicating the fault with each cell division. These tumours can cause physical blockages in the body or interfere with certain chemical processes. Location, size and type determine whether a particular tumour is considered **malignant** (cancerous) or **benign** (not cancerous). Tumours that continue to grow and spread, forming new tumours, are considered to be cancers.

Some, but certainly not all, types of cancer are caused by radiation. Ionising radiation can also be used to diagnose and treat cancer.

During radiation treatment of cancer, high doses of radiation are focused to destroy the cells of a tumour. Using

**Activity 4.3.3: Interpreting Scans**

What you need: selection of X-ray, CT (computerised tomography) or MRI (magnetic resonance imaging) images, overhead projector or light box

1. Bring to class any X-ray, CT or MRI images you or your family might have (ask their permission first) showing a broken bone, or download some images from the Internet.
2. Show the images to the class and ask whether anyone can suggest what the problem was.
3. Explain what happened to warrant a scan.
   - What body parts can be seen clearly in each image?
   - What body parts are difficult or impossible to see?
   - When might a CT or MRI scan be used instead of an X-ray?
   - When might an MRI scan be used instead of a CT scan?

**Questions 4.3.3: Non-infectious Disease**

**Remember**

1. Compare and contrast infectious disease and non-infectious disease.
2. Identify which part of a cell is most vulnerable to radiation exposure. Why?
3. Explain why our body needs to reproduce cells.
4. Identify what a tumour is.
5. Outline how radiation can be used to control tumours.

**Apply**

6. Draw a flow chart to explain how radiation affects body cells.
7. Malnutrition diseases are a result of not enough of one or more nutrients. Explain how these diseases should be treated.

**Ethical understanding**

8. As technology and our understanding of genetics improve, techniques for detecting...
Remember and understand

1. Recall the major features of the body’s first line of defence. [2 marks]

2. Identify an example of an infectious disease. [1 mark]

3. Describe what an antibody is. [1 mark]

4. Describe what radiation is. [1 mark]

5. Discuss why you think it is important to have certain vaccinations before travelling overseas. Give two examples of diseases you may need to be vaccinated against. [3 marks]

6. Explain how the specific immune system identifies pathogens. [2 marks]

7. Summarise the beneficial uses of radiation. [2 marks]

8. Complete following table about different diseases. [5 marks]

<table>
<thead>
<tr>
<th>Disease</th>
<th>Caused by</th>
<th>Infectious or non-infectious?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza (flu)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haemophilia (blood clotting disorder)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ringworm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Apply

9. Transmission of pathogens can cause mass outbreaks of disease that affect large numbers of people. Examples are HIV and AIDS, the SARS virus, swine flu and cholera. Choosing one example, explain how you think such diseases can spread so quickly. [2 marks]

10. Analyse what can be done to prevent the spread of diseases such as those listed in the previous question. [2 marks]

11. The Tasmanian devil facial tumour disease is a cancer, yet it is infectious. Explain how the term ‘infectious’ can be applied to this cancer. [2 marks]

12. Give an example of a disease that can be prevented more easily than it can be treated. Explain. [2 marks]

13. Given that people have natural active immunity, discuss why we continue to catch colds. [1 mark]

14. Choose one of the genetic disorders listed in this chapter, or choose another that you are interested in. Research the disorder, what the specific mutation is and the symptoms associated with it. Find out if there is any treatment for the disease. Present your information as an informative poster or pamphlet. [5 marks]

Analyse and evaluate

15. Compare viruses, bacteria and protozoa, which are all pathogens. How are they similar? How are they different? [3 marks]

16. Antibodies generally clump pathogens together in an antibody–antigen complex. Outline how you think this stops the pathogens from causing disease. [2 marks]

17. Explain how tumours can interfere with the healthy functioning of the human body. [2 marks]

18. Louis Pasteur, Joseph Lister, Robert Koch, Edward Jenner, Alexander Fleming and Howard Florey were all scientists who played a role in our current understanding and treatment of infectious diseases. Investigate the work of one of these scientists and present it as a biography, an interview or some other audio-visual presentation. [5 marks]

Ethical understanding

19. Babies can be vaccinated against a wide range of diseases in the first months and years of their lives. They are not old enough to choose to be vaccinated. [2 marks]
1 Fill in the gaps using the words in the Word Bank below:

Changes in the _______________ environment can causes changes in the _______________ environment of a multicellular organism, disrupting the normally functioning of cells. These changes are called _______________, and the resulting action is the organism’s _______________. The _______________ function of the body systems provides multicellular organisms with the requirements of life; water, nutrients, gas exchange and the removal of wastes. All body systems in humans are coordinated by the _______________ of the nervous system and the hormone production of the _______________.

All organisms must respond to _______________ or potentially they will die. _______________ diseases are caused by _______________, while _______________ diseases are caused by environmental, lifestyle or genetic factors. The _______________ is responsible for responding to disease on three increasingly specific levels. Scientific _______________ into disease is often driven by the contemporary needs of society, based on the disease they commonly experience or are particularly concerned by.

<table>
<thead>
<tr>
<th>WORD BANK</th>
<th>Disease</th>
<th>Electrical impulses</th>
<th>Endocrine system</th>
<th>External</th>
<th>Immune system</th>
<th>Infectious Pathogens</th>
<th>Integrated</th>
<th>Research</th>
<th>Internal</th>
<th>Non-infectious</th>
<th>Response</th>
<th>Stimuli</th>
</tr>
</thead>
</table>

Describe how multicellular organisms respond to changes in their environment

2 Examine how the responses of plants to environmental changes are similar to responses of animals. [2 marks]

3 Recall at least five external stimuli that animals commonly respond to. [5 marks]

4 Chemotropism is plant growth in response to chemicals. Suggest at least two chemicals that a plant may need to grow towards. [2 marks]

5 Analyse the benefits of responding to changes in the internal and external environment. [2 marks]

Describe how the coordinated function of body systems provides cells with oxygen, nutrients and water, and removes wastes

6 Identify two body systems that are mainly responsible for maintaining the correct levels of carbon dioxide and oxygen in body cells. [2 marks]

7 Explain how the excretory system influences the circulatory system. [2 marks]

8 Identify the main organ in the circulatory system essential to that system’s function and to human life. [1 mark]

9 Describe how the respiratory and circulatory systems work together to control removal of wastes and supply of oxygen to body cells. [2 marks]

Outline some responses of the human body to infectious and non-infectious disease

10 Identify an animal disease that has negatively affected an animal population. [1 mark]

11 ‘The immune response is the most important response to change.’ Discuss. [2 marks]

12 Ionising radiation is useful in the detection and treatment of some diseases, and is also a cause of some disease. Overall, is ionising radiation more beneficial or harmful? Explain. [2 marks]
Describe how coordination systems maintain humans as functioning organisms

13 Identify the body systems responsible for control and coordination of responses to change. [2 marks]

14 Recall the main control organ in the nervous system. [1 mark]

15 Minamata disease affects the nervous system. Research this disease and explain why its symptoms affect mobility and coordination. [3 marks]

Discuss how the values and needs of contemporary society can influence the focus of scientific research such as the occurrence of infectious and non-infectious diseases in humans, plants and animals

16 Some people argue that death is determined when the heart stops beating, while others argue it is when the brain no longer functions. Analyse how this issue relates to organ transplantation. [2 marks]

17 If you were a medical researcher, which disease would you like to find a cure for or find a way of preventing? Why? [3 marks]

18 Is animal dissection ethical? Explain. [2 marks]

19 Research and experiments about the function of human body systems are sometimes carried out on animals before humans, and sometimes animals are used instead of humans. In groups of four or six, form two teams and conduct a debate about the topic: Biological research involving animals is acceptable as long as it is ethical, humane and justified. [5 marks]

Describe examples of function of endocrine glands in humans (additional)

20 List two glands from the endocrine system and identify the main hormones they secrete. [2 marks]

21 Analyse how a negative feedback mechanism is like an oven thermostat. [2 marks]

22 Complete the following table comparing the nervous and endocrine systems. [5 marks]

<table>
<thead>
<tr>
<th></th>
<th>Main organs</th>
<th>Type of message – chemical or electrical?</th>
<th>Speed of message</th>
<th>Length of response – how long does it last for?</th>
<th>Target tissue – where does the message end up?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nervous system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Choose one of the following topics for a research project. A few guiding questions have been provided but you should add more questions that you wish to investigate. Present your report in a format of your own choosing.

Stem cells for spinal injury
Nerve cells do not regenerate naturally. To date, damage to the spinal cord is permanent, but scientists have been researching the use of stem cells in the treatment of spinal cord injury. What are stem cells? What types of stem cell are used? What sorts of advances have been made in this field of research? What issues have affected such research?

Obesity
Obesity is increasing in our society. Why is this? What is the cause of it? What complications can result from obesity? What can you do to prevent obesity?

Artificial skin
Investigate the work of Australian scientists Dr Fiona Wood and Dr Marie Stoner on skin regeneration, including spray-on skin. Why is their area of research so important? How is it related to the treatment of the Bali-bombing victims?
Me
1. What have you learned that has helped to better understand how your body detects and responds to change?
2. What kinds of things are you more aware of now?
3. What else would you like to find out about how your body ensures your survival?

My world
4. Vaccinations have eliminated smallpox and largely eradicated poliomyelitis. What are the controversial issues associated with access to vaccinations and world health?

My future
5. What could be done to raise awareness of spinal cord damage?
6. What can you do to reduce your risk of developing type 2 diabetes as you get older?

KEY WORDS
acquired active immunity
antibody
antigen
attenuated
autonomic nervous system
axon
benign
brain stem
cell body
central nervous system
cerebellum
cerebrum
dendrite
disease
endocrine system
feedback mechanism
goitre
hormone
immune
immune system
impulses
infectious disease
insulin
interneuron
malignant
motor neuron
myelin sheath
natural active immunity
natural flora
natural passive immunity
negative feedback mechanism
nerve system
neuron
neuroscientist
neurotransmitter
non-infectious disease
non-specific immune response
pathogen
peripheral nervous system
phagocyte
phagocytosis
prion
radiation
reflex
sensory neuron
somatic nervous system
specific immune response
stimulus
synapse
synaptic gap
terminal button
tumour
vaccination
vertebrae
virulence
white blood cell
We rely very heavily on our ability to sense our world. Taste and smell enhance our enjoyment of life. Loss of either sight or hearing has many implications for the life of the person affected. Sounds, flashing lights and textured sections on the footpath are some examples of ways to assist people with sight or hearing impairment. But what if you lost your sense of touch and ability to feel pain?

Congenital analgesia is a disorder in which people are unable to feel pain. This might sound like a lovely way to live – you could take a few more risks, knowing that a little burn or grazed knee would not hurt, and immunisations would be a breeze!

Women would experience no pain during childbirth and you could possibly stay awake during operations and see your own insides! But how would you know if you were sick or injured? How would the absence of any touch sensation affect your life?

1. Research congenital analgesia (sometimes known as congenital insensitivity to pain) to find out more. What causes it? What are the major symptoms? What are the minor symptoms? How common is it?

2. From your research, prepare a detailed creative writing piece that outlines a typical day for a person with congenital analgesia. You might choose to present your task as a video.