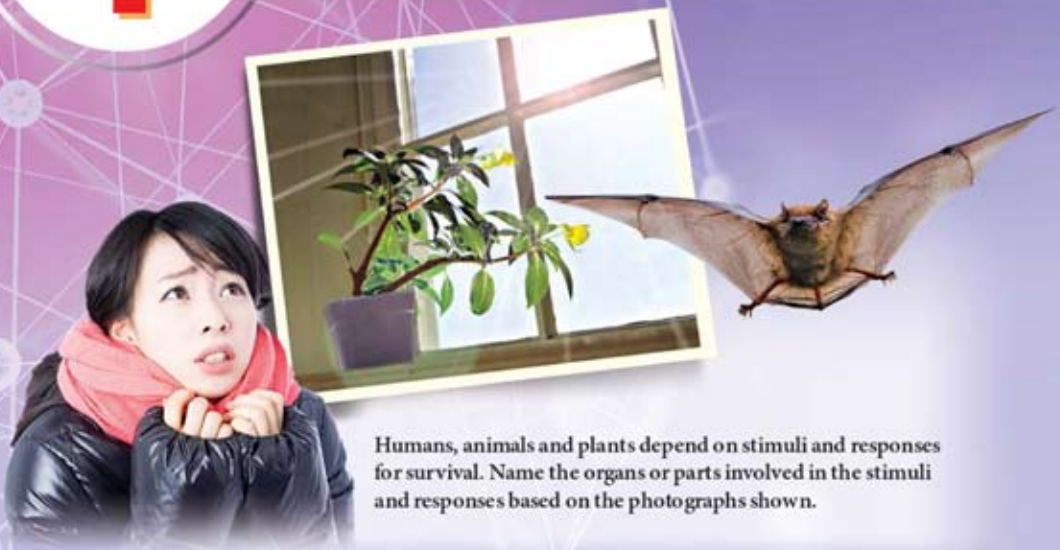
THEME

1 Maintenance and Continuity of Life

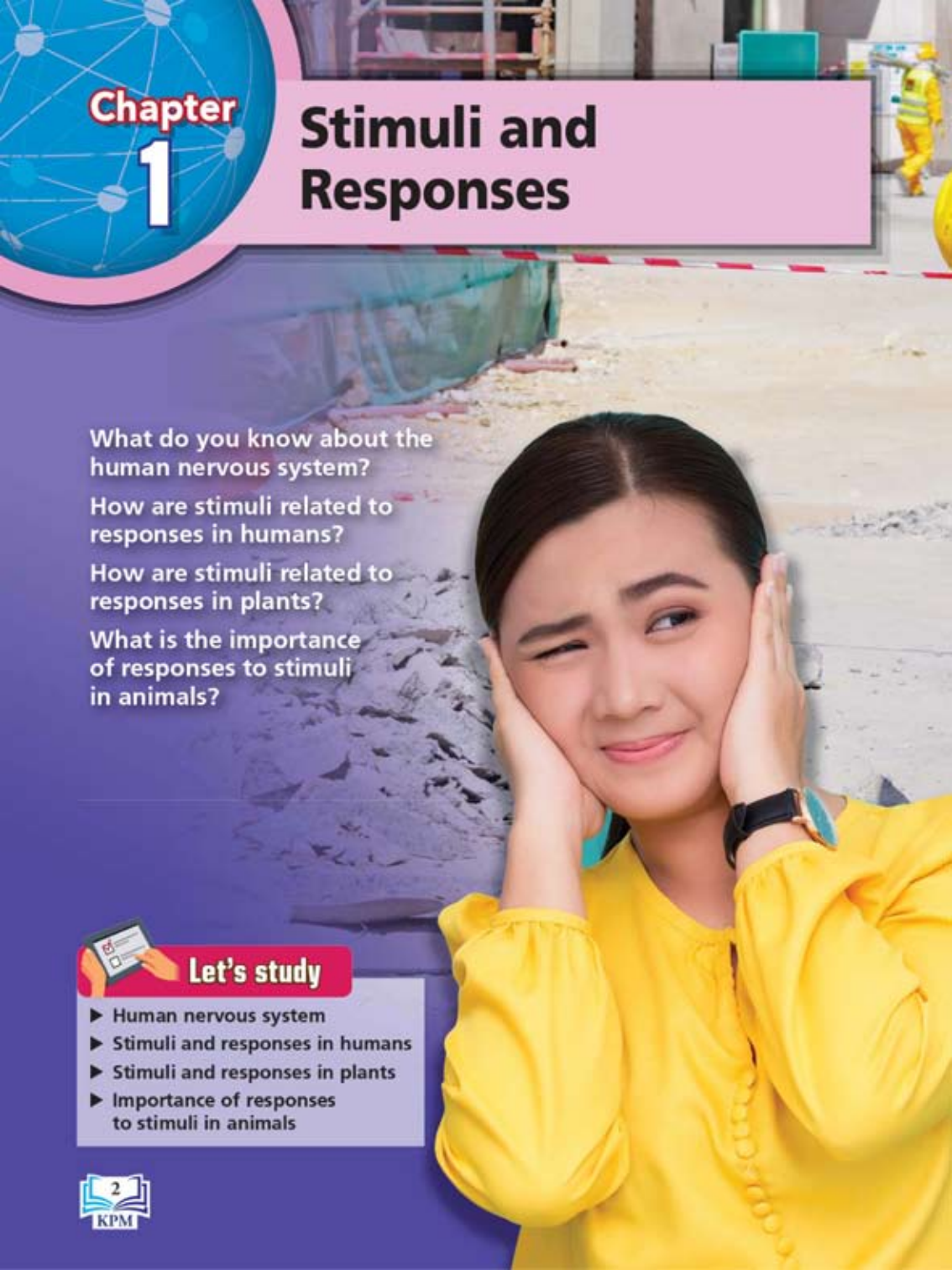


Humans, animals and plants depend on stimuli and responses for survival. Name the organs or parts involved in the stimuli and responses based on the photographs shown.

Why is it healthier for us to exercise during the day than at night?

Chapter 1

Stimuli and Responses



What do you know about the human nervous system?

How are stimuli related to responses in humans?

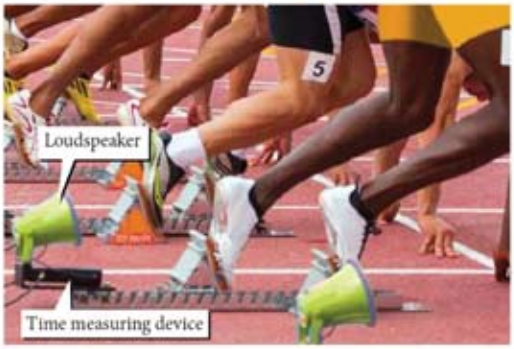
How are stimuli related to responses in plants?

What is the importance of responses to stimuli in animals?

Let's study

- Human nervous system
- Stimuli and responses in humans
- Stimuli and responses in plants
- Importance of responses to stimuli in animals

Science Gallery



The sprint event in international sports competitions such as the Olympics uses loudspeakers and time measuring devices as shown in the above photograph. The time measuring device measures the time interval between the sound from the loudspeaker and the first push exerted by the runner's foot against the time measuring device. This time interval is known as the reaction time.

In the 100 m sprint event at the 2016 Olympics, the reaction time of the gold medal winner, Usain Bolt, was 0.155 s. If the measured reaction time of a runner is less than 0.1 s, the runner will be disqualified from competing. Why?

Keywords

- Stimulus
- Response
- Spinal cord
- Peripheral nerve
- Affector
- Effector
- Voluntary action
- Involuntary action
- Photoreceptor
- Taste bud
- Optical illusion
- Geotropism
- Hydrotropism
- Thigmotropism
- Nastic movement
- Stereoscopic vision
- Monocular vision
- Stereophonic hearing

1.1 Human Nervous System

In a game of badminton...

The **human nervous system** is an important control system in body coordination. Other than sight, thinking and body movement, the human nervous system also controls and coordinates organ functions in the body and maintains a balanced internal environment through a process. What is this process?

Structure of the Human Nervous System

Look at Figure 1.1. The human nervous system consists of:

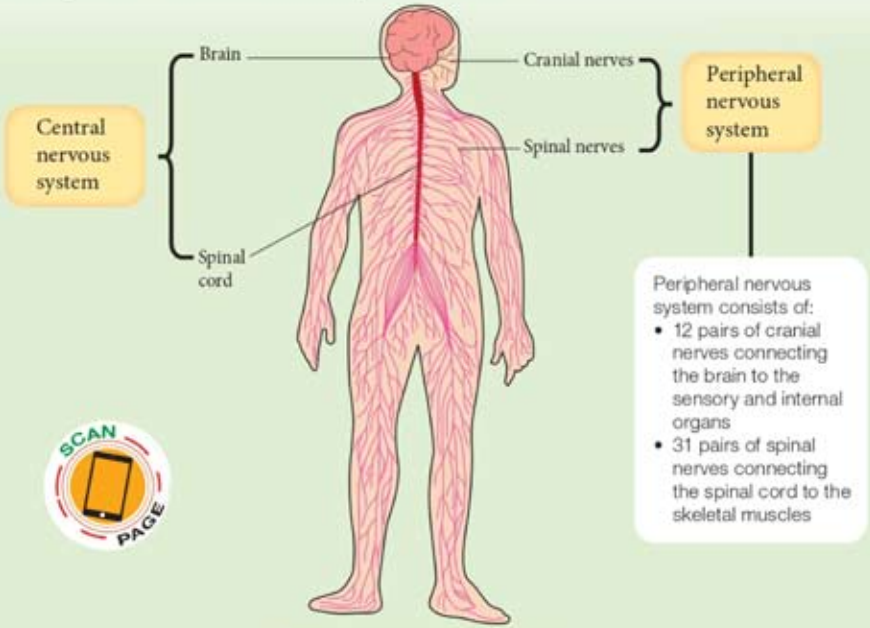


Figure 1.1 Human nervous system

Functions of the Human Nervous System

The human nervous system **controls** and **coordinates** organs and parts of the body. The human nervous system:

- detects **stimuli**
- sends **information** in the form of impulses
- interprets **impulses**
- produces appropriate **responses**

Photographs 1.1, 1.2 and 1.3 show examples of daily activities that involve detection of stimuli and production of responses to the stimuli detected. State the stimulus and response in each of the daily activities shown.

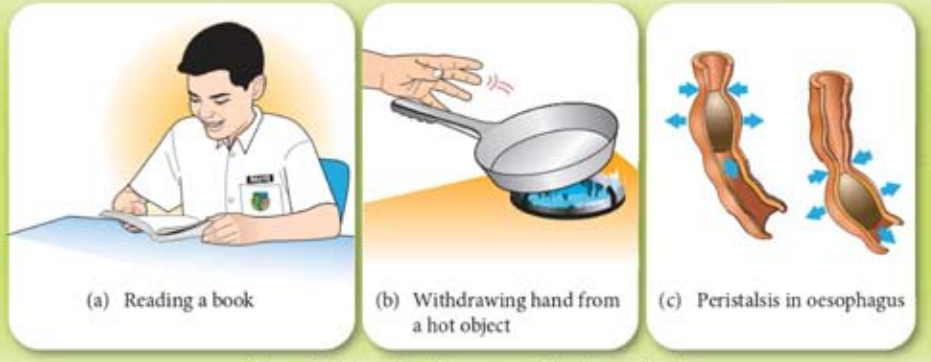
Photograph 1.1 *Collecting garbage*

Photograph 1.2 *Sneezing*

Photograph 1.3 *Surfing the Internet*

Voluntary and Involuntary Actions

The responses of the human body to stimuli can be divided into **voluntary actions** and **involuntary actions**. Observe the examples of responses of the human body in Figure 1.2.



(a) Reading a book

(b) Withdrawing hand from a hot object

(c) Peristalsis in oesophagus

Figure 1.2 *Examples of responses of the human body*

Based on Figure 1.2, which response is a voluntary action and which is an involuntary action?

Voluntary Actions

Voluntary actions are conscious actions and conducted under one's will. All voluntary actions are controlled by the **brain**. Examples of voluntary actions include reading, writing, speaking, eating, drinking, walking, running and exercising. Figure 1.3 shows the pathway of impulse in a voluntary action.

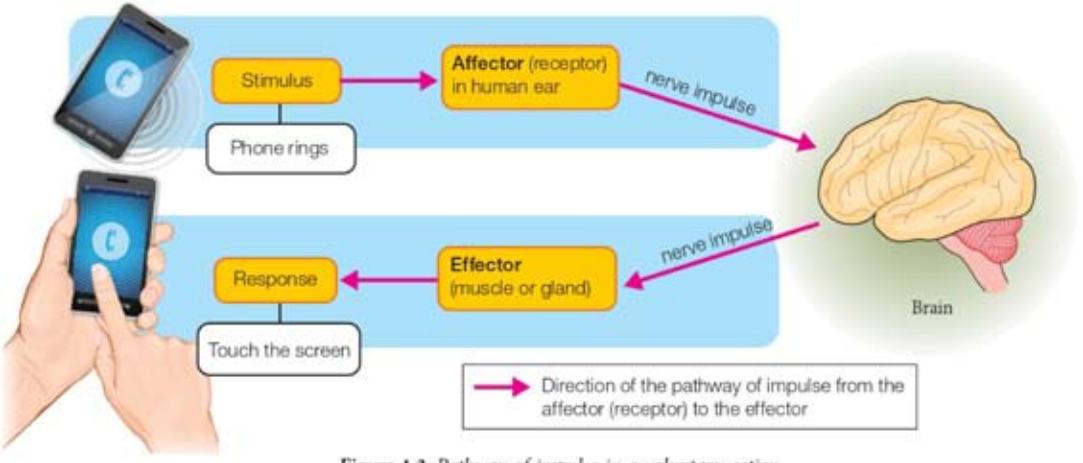


Figure 1.3 *Pathway of impulse in a voluntary action*

Let us learn more on voluntary actions by carrying out Activity 1.1 on page 7.

Activity 1.1

Inquiry-based activity

Measuring the reaction time by catching a free-falling ruler (voluntary action)

Aim: To measure reaction time

Apparatus
Half metre rule

Instructions
1. Work with a partner.
2. Ask your partner to hold the end of a half metre rule as shown in Figure 1.4.

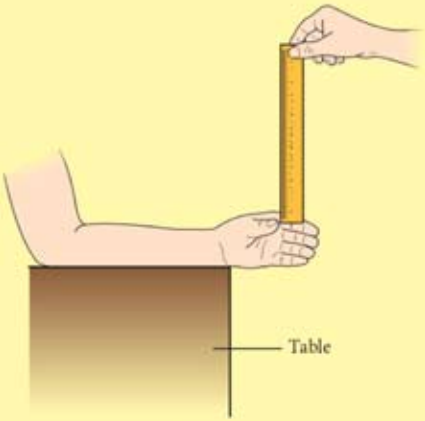


Figure 1.4

Safety Precautions

- Make sure that the hand used to catch the ruler remains stationary on the table.
- Be careful when releasing or catching the ruler.

3. Place your hand at the end of the ruler close to the zero mark without touching it as shown in Figure 1.4.
4. Your partner will release the ruler without warning and you must try to catch the ruler as quickly as possible.
5. Record the distance the ruler fell, x, that is, the scale on the ruler when you catch it. The distance, x, is the measurement of your reaction time.
6. Repeat this activity four times. Then, calculate the average distance, $x_{average}$.

Questions
1. In this activity, state the stimulus and its response. Is the response a voluntary action or an involuntary action? Explain.
2. Why is the distance the ruler fell considered as the reaction time?
3. Explain the difference in the reaction time among the students in the class.
4. What is the importance of reaction time in our daily life?

Conclusion
Draw a conclusion on the reaction time of the students in your class.

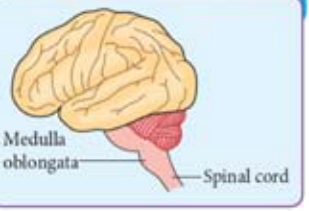
Involuntary Actions

Involuntary actions are actions that occur immediately **without conscious control** or **prior thoughts**. Involuntary actions can be classified into two.

Involuntary actions

Involving medulla oblongata	Involving spinal cord (reflex actions)
• Heartbeat	• Withdrawing hand when it accidentally touches a hot object
• Breathing	• Withdrawing foot when it accidentally steps on a sharp object
• Peristalsis	• Sneezing when dust enters the nose
• Secretion of saliva	

i SCIENCE INFO



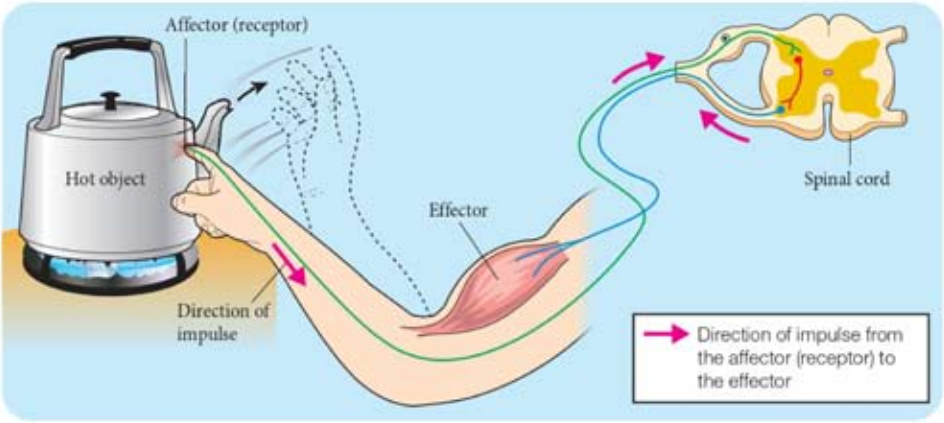


Figure 1.5 *Pathway of impulse in an involuntary action (reflex action)*

Let us learn more on involuntary actions by carrying out Activity 1.3 on page 9.

Activity 1.2

21st Century Skills
- ICS
- Innovation-based activity

To create a presentation on:
- the parts involved in the transmission of impulse from the affector to the effector
- the pathway of impulses in voluntary and involuntary actions

Instructions
1. Work in groups.
2. Each group is required to create a presentation to illustrate the following:
   - The parts involved in the transmission of impulse from the affector to the effector
   - The pathway of impulses in voluntary and involuntary actions

Activity 1.3

Inquiry-based activity

Detecting changes in the size of the pupil in the eye towards light intensity (involuntary action)

Aim: To observe changes in the size of the pupil of the eye towards different light intensities

Apparatus
Mirror and lamp

Instructions
1. Identify the pupil of the eye in Figure 1.6.

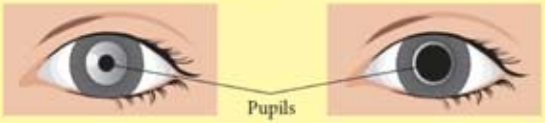


Figure 1.6

2. Observe the pupil using a mirror in bright light. Sketch the size of the pupil.
3. Observe the pupil in dim light. Sketch the size of the pupil.
4. Compare and contrast the size of the pupils in bright and dim lights.

Questions
1. In this activity, state the stimulus and its response. Is the response a voluntary or an involuntary action? Explain.
2. What is the relationship between the size of the pupil and light intensity?
3. What is the importance of this response?

Conclusion
Draw a conclusion about the changes in the size of the pupil towards light intensity.

SCIENCE INFO

The pupil in the human eye is circular. Is the pupil in other animals' eye circular as well?


(a) Goat: Rectangular


(b) Stingray: Crescent


(c) Crocodile: Vertical slit


(d) Squid: W-shaped

BRAIN TEASER

Other than the nervous system, what other body systems help in body and internal organ movements?

STEM
- Science, Technology, Engineering, Mathematics

Humanoid robot

SCAN PAGE

Importance of the Network of Human Nervous System in Daily Life

The network of the human nervous system controls and coordinates the organs and parts of the body to carry out processes in the body such as breathing and body movements.

A damaged nervous system normally causes a person to become temporarily, partially or completely paralysed. For example, if the nerves in the muscles of a leg or hand are injured, the person will face difficulty in moving his leg or hand. In the case of a more serious problem, he might have to depend on machines to carry out his physiological processes such as breathing or heart beating.

Humans are blessed with a nervous system, so they should use and take good care of it.

Photograph 1.4 *Partially-paralysed individual*

Photograph 1.5 *Patient using a breathing machine*

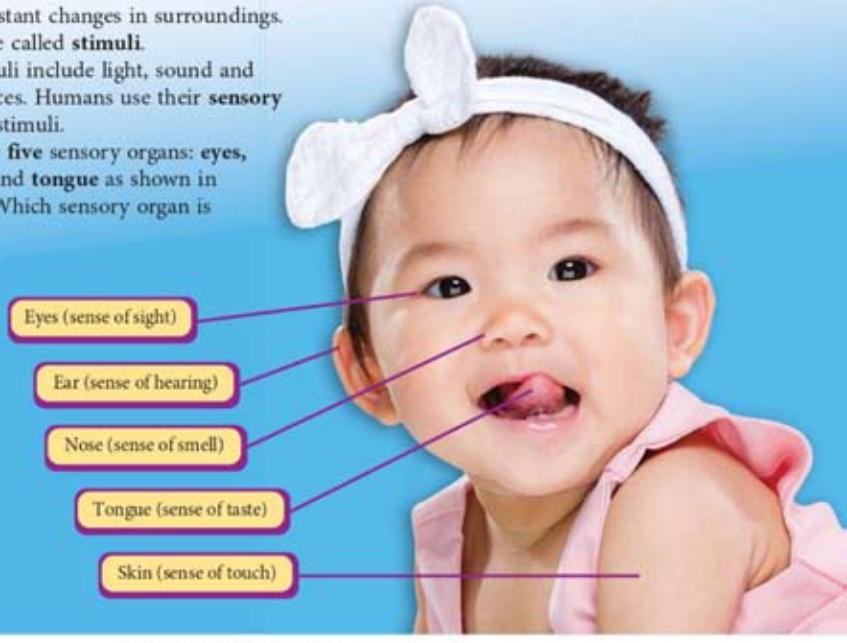
Formative Practice 1.1

1. State **two** main parts of the human nervous system.
2. (a) What is voluntary action? Give **one** example of a voluntary action.
   (b) What is involuntary action? Give **one** example of an involuntary action.
3. What happens if a person has brain injury?
4. What is the importance of the network of human nervous system in life?

1.2 Stimuli and Responses in Humans

Humans face constant changes in surroundings. These changes are called **stimuli**. Examples of stimuli include light, sound and chemical substances. Humans use their **sensory organs** to detect stimuli.

Humans have **five** sensory organs: **eyes, ears, nose, skin** and **tongue** as shown in Photograph 1.6. Which sensory organ is the largest?



Photograph 1.6 *Human sensory organs*

Eye

Study Figure 1.7. Can you identify the parts of the eye? Let us learn more about the parts of the eye by referring to Figure 1.8 on page 12.

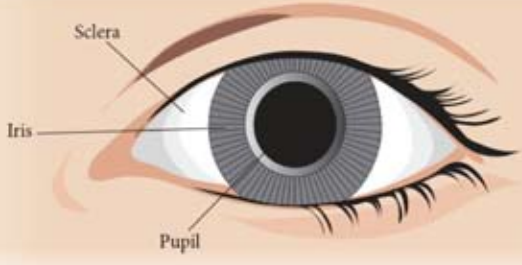


Figure 1.7 *Front view of the eye*

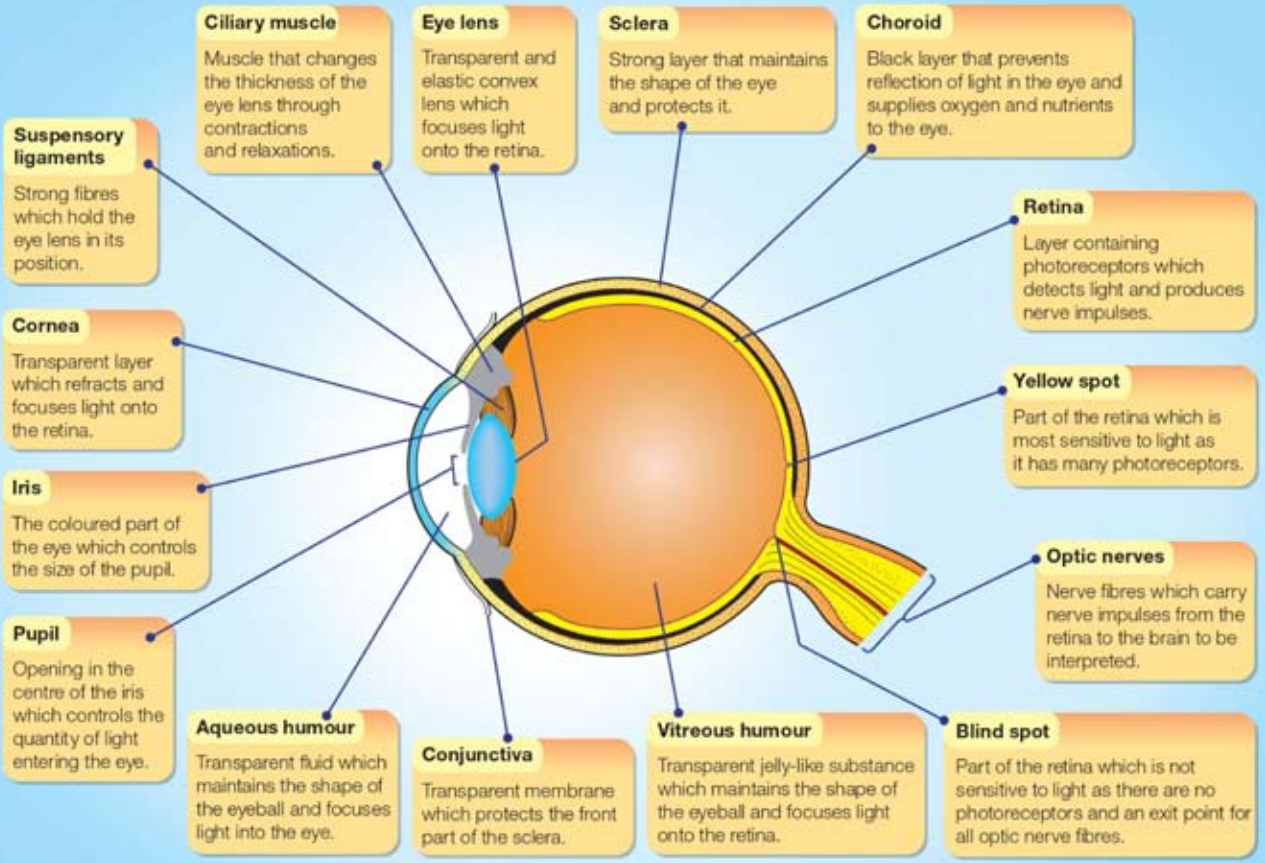


Figure 1.8 Parts of the human eye and their functions

What is the Colour of the Object Seen?

The retina has two types of photoreceptors: **rod cells** and **cone cells** as shown in Figure 1.9.

Rod cells are sensitive to different light **intensities** including faint light but are not sensitive to the colours of light.

Cone cells are sensitive to the **colours of light** under bright conditions. There are **three** different types of cone cells, where each is sensitive to **red** light, **green** light and **blue** light.

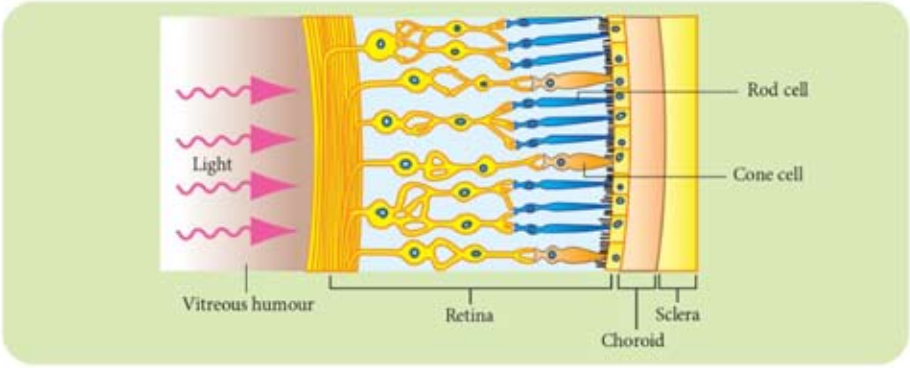


Figure 1.9 *Photoreceptors – rod and cone cells*

Ear

What are the parts of the ear and their functions? Study Figure 1.10 and Table 1.1 on page 14.

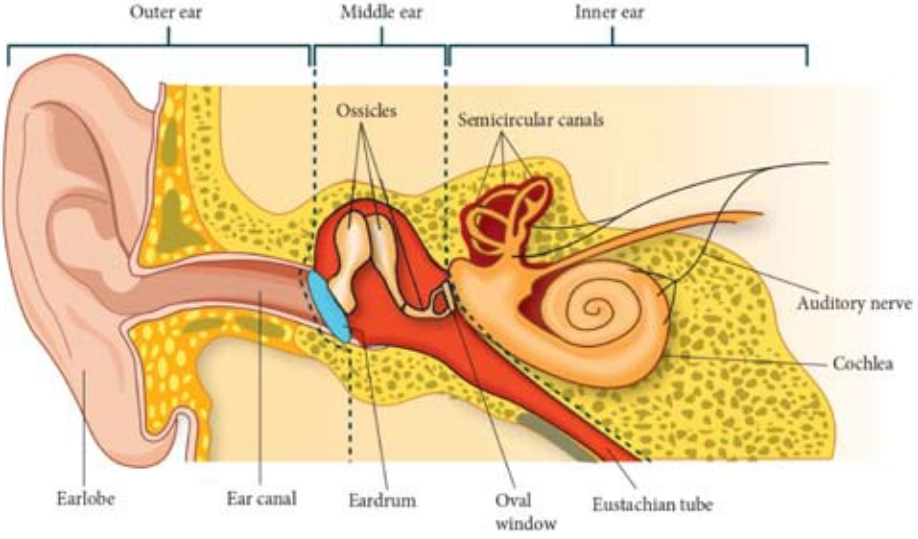


Figure 1.10 *Parts of the human ear*

1.2.1

Table 1.1 Functions of the parts of the human ear

Part of ear	Structure of ear	Functions
Outer ear	Earlobe	Collects and directs **sound waves** into the ear canal
	Ear canal	Directs **sound waves** to the eardrum
Middle ear	Eardrum (thin membrane)	Vibrates according to the frequency of the sound waves received and transfers the **vibrations** to the ossicles
	Ossicles (made up of three small bones)	Amplify **sound vibrations** and transfer them to the oval window
	Oval window	Collects and transfers **sound vibrations** from the ossicles to the cochlea
	Eustachian tube	Balances the air pressure on both sides of the eardrum
Inner ear	Cochlea (contains fluid)	Detects and converts sound vibrations into **nerve impulses**
	Semicircular canals (contain fluid)	Detect the position of the head and help to balance the body
	Auditory nerve	Sends **nerve impulses** from the cochlea to the brain to be interpreted

Nose

What are the parts of the nose? Study Figure 1.11.

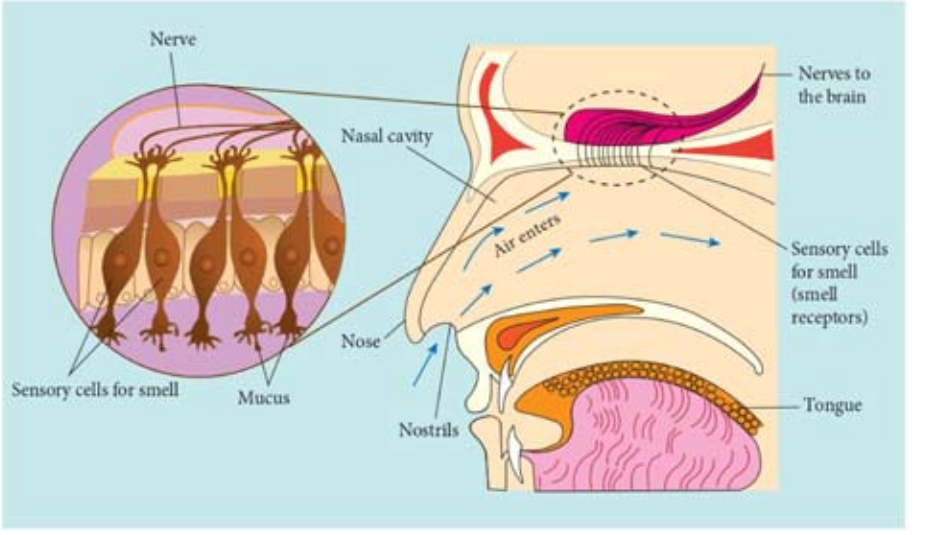


Figure 1.11 Parts of the human nose

Structure of the Nose

The **nose** is the sensory organ of smell. **Smells** are chemical substances present in the air. About 10 million **sensory cells for smell** are located at the roof of the nasal cavity as shown in Figure 1.11.

BRAIN TEASER

Why is a person suffering from flu normally unable to detect smells?

Function of Sensory Cells for Smell

Sensory cells for smell are tiny and covered with a layer of **mucus**. Chemical substances in the air will dissolve in this layer of mucus and stimulate the cells to produce **nerve impulses**. The nerve impulses are then sent to the brain to be interpreted to determine the type of smell.

Tongue

What are the parts of the tongue? Study Figure 1.12.

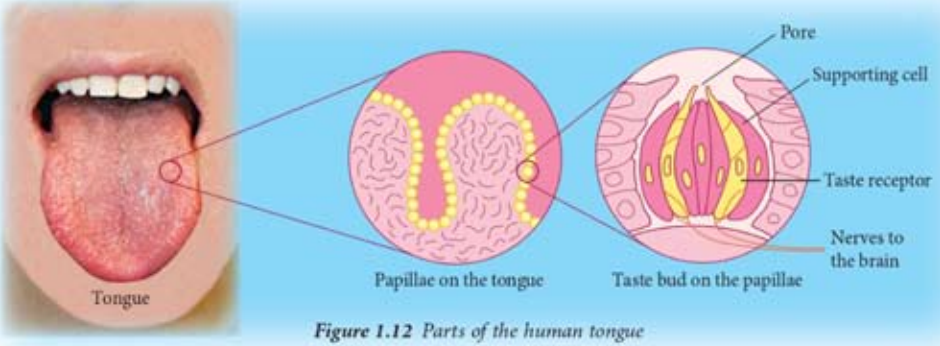


Figure 1.12 Parts of the human tongue

Structure of the Tongue

The **tongue** is the sensory organ of taste. Observe the surface of your tongue using a mirror. There are tiny nodules known as **papillae** on the surface of the tongue. The surface of a papillae is covered by hundreds of **taste buds**. Each taste bud contains 10 to 50 taste receptors. These **taste receptors** can detect **five** types of basic tastes which are **sweet, salty, sour, bitter** and **umami**.

SCIENCE INFO

Umami is classified as a basic taste because there are taste receptors that can only detect umami taste. This is the same as other basic tastes such as sweet, salty, sour and bitter. Umami taste is related to delicious tastes such as the taste of meat in soups or the taste of fermented foods such as cheese and mushrooms or monosodium glutamate (MSG).

Function of Taste Buds

When food is chewed, part or all the chemical substances in the food dissolve in the **saliva**. These dissolved chemical substances will diffuse into the **taste buds** through their pores and stimulate the **taste receptors** in them to produce **nerve impulses**. These nerve impulses are then sent to the brain to be interpreted as **sweet, salty, sour, bitter, umami** tastes or a combination of the basic tastes.

Skin

What are parts of the skin? There are five types of receptors found in the skin. What are their functions? Study Figure 1.13.

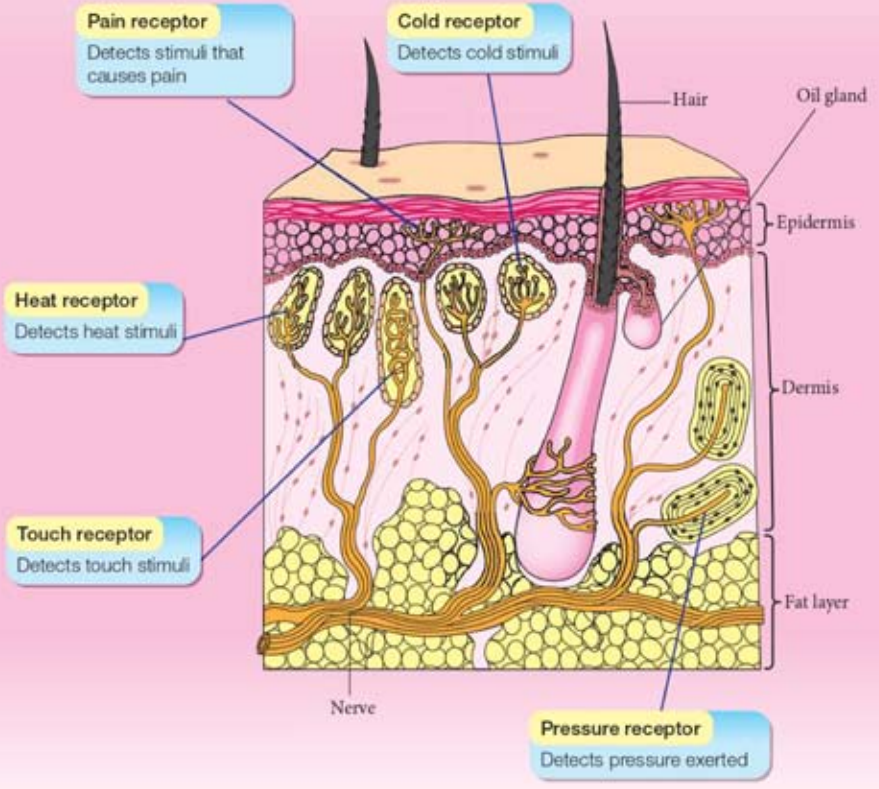


Figure 1.13 *Parts of the human skin*

The **skin** is the **largest sensory organ** in the human body. The human skin is made up of a thin outer layer known as **epidermis** and an inner layer known as **dermis**.

The skin has **five** types of receptors at different positions to detect different stimuli as shown in Figure 1.13. State the five types of stimuli which can be detected by the receptors in the skin.

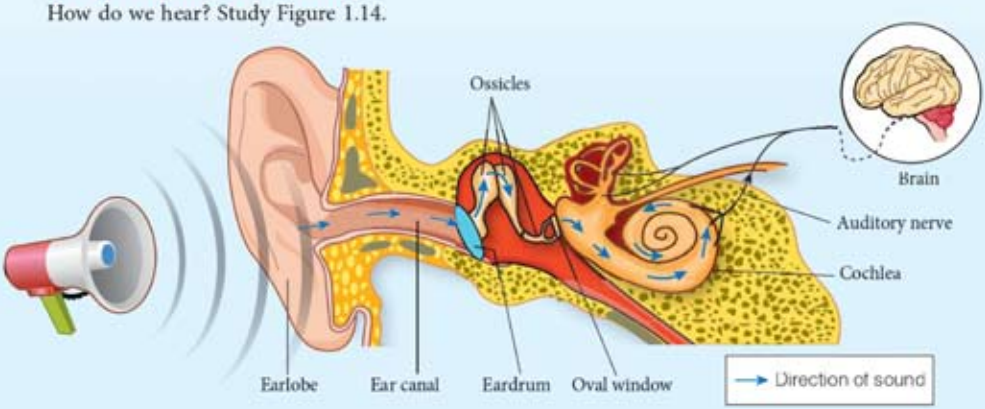
BRAIN TEASER

How does the skin function as a sense of 'sight' for the blind?

When the receptor in the skin is stimulated, **nerve impulses** are produced and sent through the nervous system to the brain to be interpreted and to produce an appropriate response.

Mechanism of Hearing

How do we hear? Study Figure 1.14.



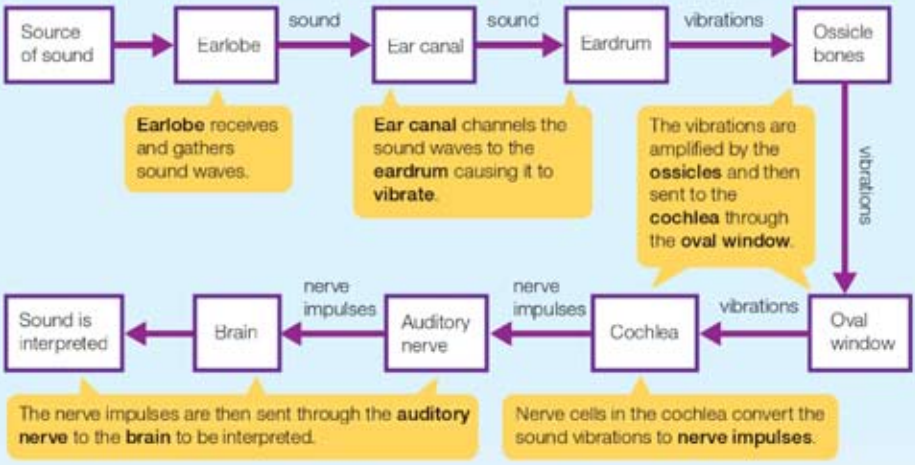


Figure 1.14 Mechanism of hearing in humans

Activity 1.4

21st Century Skills
- CPS, ICS
- Innovation-based activity

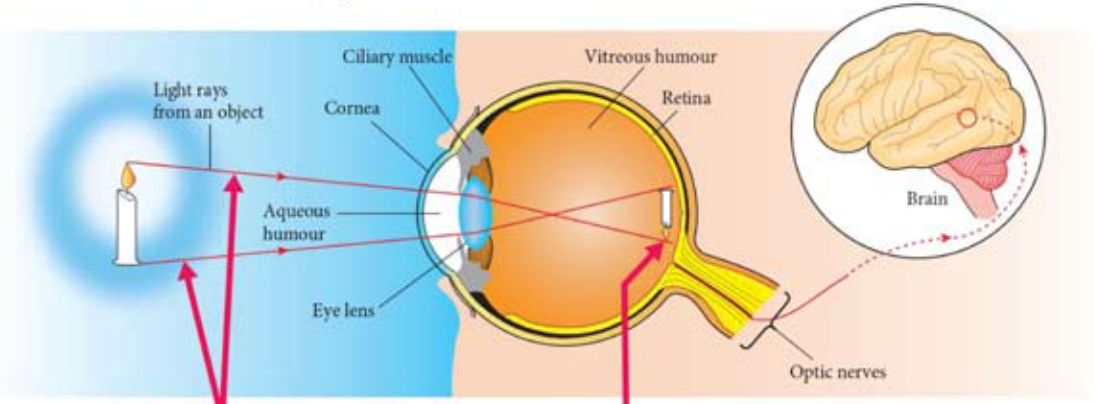
To study the mechanism of hearing using a model

Instructions

1. Work in groups.
2. Each group is required to present the mechanism of hearing using a model prepared by the teacher.
3. Construct a flow chart that shows the direction of sound in the mechanism of hearing.

Mechanism of Sight

How do we see? Study Figure 1.15.



Light rays from an object enter the eye through the cornea, aqueous humour, eye lens and vitreous humour before reaching the retina. These parts of the eye focus the light rays from the object onto the retina. The object appears smaller and inverted.

The light rays stimulate photoreceptors to produce nerve impulses that are sent to the brain.

The brain interprets the nerve impulses. The smaller inverted image on the retina will then appear upright.

***Figure 1.15** Mechanism of sight in humans*

Activity 1.5

21st Century Skills
- CPS, ICS
- Innovation-based activity

To study the mechanism of sight using a model

Instructions

1. Work in groups.
2. Each group is required to present the mechanism of sight using a model prepared by the teacher.
3. Construct a flow chart that shows the direction of light in the mechanism of sight.

***Photograph 1.7** A human eye model*

Sensitivity of the Skin on Different Parts of the Body towards Stimuli

Photograph 1.8 shows a few examples of daily activities of humans which make use of the sensitivity of skin on different parts of the body towards different stimuli.

Photograph 1.8 *Sensitivity of the skin on different parts of the body*

Why are the daily activities shown in Photograph 1.8 carried out on different parts of the body? Let us investigate this in Activity 1.6.

Activity 1.6

Inquiry-based activity

To investigate the sensitivity of the skin on different parts of the body towards the touch stimulus

Material
Cellophane tape

Apparatus
Ruler (30 cm), toothpick and handkerchief (or blindfold)

Instructions
1. Work in pairs.
2. Set up the apparatus as shown in Figure 1.16.

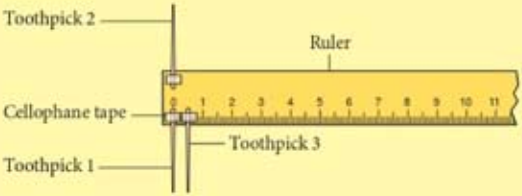


Figure 1.16

Using the cellophane tape, attach:
- Toothpick 1 on the 0 mark of the ruler.
- Toothpick 2 opposite the first toothpick on the ruler.
- Toothpick 3 on the 0.5 cm mark of the ruler.

3. Cover your partner's eyes with a handkerchief.
4. Prick the back of your partner's hand with one or two toothpicks as shown in Figure 1.17.

Figure 1.17

CAUTION!

- Hold the sharp end of the toothpick with care.
- Do not press the sharp end of the toothpick too hard onto the skin.
- Throw away all used toothpicks into the rubbish bin.

Ask your partner if he or she feels it as one or two toothpicks.

5. Mark '✓' if the answer is correct and 'x' if the answer is wrong in the table below.
6. Repeat steps 4 and 5 three times.
7. Repeat steps 4 to 6 on different parts of the body such as the tip of the index finger, elbow and arm.

Part of Body	Touch stimulus by using					
	one toothpick			two toothpicks		
	1st attempt	2nd attempt	3rd attempt	1st attempt	2nd attempt	3rd attempt
Back of the hand						
Tip of the index finger						
Elbow						
Arm						

Questions

1. At which part or parts of the body is the skin most sensitive to touch stimulus? Explain your observation.
2. At which part or parts of the body is the skin least sensitive to touch stimulus? Explain your observation.
3. Which type of receptor is stimulated in this activity?
4. State **two** factors that affect the sensitivity of skin on different parts of the body towards touch stimulus.

The sensitivity of skin towards stimuli depends on **the number of receptors** and **the thickness of the skin epidermis**. For example, the tip of the finger is very sensitive towards touch because at the tip of the finger, there is a large number of touch receptors and the epidermis is thin. The tongue, nose and lips are also very sensitive to touch. The elbow, the sole of the foot and the back of the body are less sensitive to touch. Why?

Sensitivity of the Tongue towards Different Taste Stimuli

The tongue can detect **five** types of tastes which are **sweet**, **salty**, **sour**, **bitter** and **umami**. Each type of taste is detected by a different receptor. Let us investigate the areas of the tongue that detect different tastes in Activity 1.7.

Activity 1.7

Inquiry-based activity

To show that the sensitivity of the tongue towards taste stimuli is related to the number of receptors

CAUTION!

Do not taste any chemical substance in the laboratory without your teacher's permission.

Materials

Sugar solution (sweet), salt solution (salty), lime juice (sour), strong coffee without sugar (bitter), mushroom soup (umami) and distilled water

Apparatus

Drinking straw, handkerchief (or blindfold) and six cups

Photograph 1.9

Instructions

1. Work in pairs. Your teacher will provide each pair of students with five solutions of different tastes which are sweet, salty, sour, bitter and umami, in different cups.
2. Cover your partner's eyes with a handkerchief.
3. Ask your partner to gargle with distilled water.
4. Using a drinking straw, place a drop of sugar solution on part A of his tongue as shown in Figure 1.18.
5. Ask your partner to identify the taste of the solution without pulling the tongue back into the mouth.
6. Mark '✓' if your partner correctly identifies the taste of the solution and '×' if your partner incorrectly or fails to identify the taste of the solution in a table as shown below.
7. Repeat steps 3 to 6 on parts B, C, D and E.
8. Repeat steps 3 to 7 using the four other solutions provided.

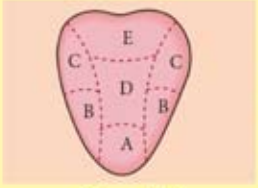


Figure 1.18

Part of the tongue	Type of taste				
	Sweet	Salty	Sour	Bitter	Umami
A					
B					

Questions

1. Why does your partner have to gargle each time before tasting the solutions?
2. Which part of the tongue is able to identify all the tastes of the solutions?
3. Which part of the tongue is most sensitive to taste? Explain your observation.
4. Which part of the tongue is least sensitive to taste? Explain your observation.
5. What conclusion can you draw from this activity?

Different Areas of the Tongue are More Sensitive to Specific Taste

Areas of the tongue are sensitive to all five tastes. However, different areas of the tongue have different sensitivities towards specific taste. For example, the area in front of the tongue is more sensitive to **sweet** taste whereas the sides are more sensitive to **sour** and **salty** tastes. The area at the back of the tongue is more sensitive to **bitter** taste. The area at the centre of the tongue, however is more sensitive to **umami** taste. Study Figure 1.19.

Figure 1.19 *Different areas of the tongue are more sensitive to specific taste*

BRAIN TEASER

Nowadays, there is a toothbrush equipped with a tongue cleaner. Does the use of the tongue cleaner reduce the sensitivity of the tongue?

Combination of the Sense of Taste and the Sense of Smell

Look at Photograph 1.10. Can the child enjoy the fried chicken? Does the sense of smell play a role when a person tastes food? Let us investigate this matter in Activity 1.8.

Photograph 1.10 *Food eaten without smelling*

Activity 1.8

Inquiry-based activity

To investigate the relationship between sense of taste and sense of smell

Materials

Cordial drinks of different flavours (grape, orange, mango, strawberry) and distilled water

Apparatus

Handkerchief (or blindfold) and cups

Instructions

1. Work in pairs. Your teacher will provide each pair of students with cordial drinks of different flavours such as grape, orange, mango and strawberry in different cups.
2. Cover the eyes of your partner with a handkerchief and ask him to pinch the nose as shown in Photograph 1.11.
3. Give your partner a cup of distilled water and ask him to gargle.

4. Give your partner a cup of grape-flavoured cordial drink and ask him to identify and state the flavour of the cordial in the given cup.
5. Mark '✓' if your partner answers correctly and '×' if your partner is unable or fails to answer correctly in a table as shown below.
6. Repeat steps 3 to 5 using cordial drink of other flavours.
7. Repeat steps 2 to 6 without pinching the nose.

Condition of the nose	Flavour of cordial drink			
	Grape	Orange	Mango	Strawberry
Pinched				
Without being pinched				

Photograph 1.11

CAUTION!

Make sure your partner is not allergic to all the flavours of the cordial drinks investigated.

Questions

1. Under what condition is your partner able to identify the flavours of the cordial drinks more easily, with his nose pinched or not being pinched?
2. State **one** inference based on your answer.
3. Why should your partner's eyes be covered in this activity?
4. Why does hot food taste better?

Case Study

1. The judges in a cooking competition as shown in Photograph 1.12 use several types of senses.
   (a) State the types of senses used by the judges to carry out their evaluation.
   (b) What sensory organs are related to the sense of taste?

Photograph 1.12

2. Have you ever carried out the daily activity as shown in Photograph 1.13?
   (a) What is the combination of senses used in this activity?
   (b) What is the importance of the combination of sensory organs in carrying out this activity?

Photograph 1.13

How do Limitation of Senses, Defect in Sensory Organs and Ageing Affect Human Hearing and Sight?

Audio visual which combines the senses of hearing and sight, plays an important role in daily life. Let us investigate how limitation of senses, defect in sensory organs and ageing affect the sensitivity of hearing and sight of humans.

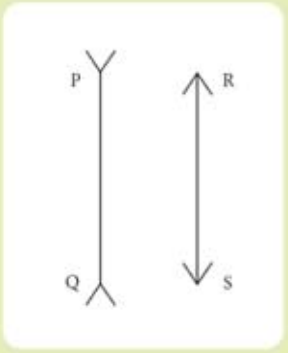
SCIENCE INFO

Audio visual refers to the use of two components, sound component (**audio**) and graphic component (**visual**).

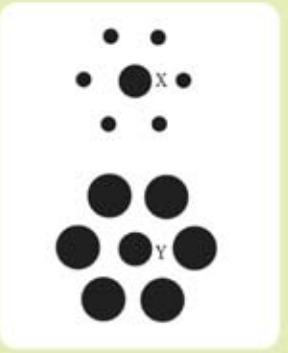
Limitations of Sight

Limitation of sight is the limitation in the ability of the eye to see objects. We **cannot see very tiny** objects such as microorganisms as well as **very distant** objects such as planet Jupiter. Limitations of sight include **optical illusions** and **blind spot**.

Optical Illusions



(a) Which line is longer?



(b) Which spot in the centre is larger?

(c) Are the sides of the square straight or curved?

Figure 1.20 *Optical illusions*

Look at Figure 1.20 and answer the questions given. Check your answer using a straight ruler. Is your answer correct or wrong? Why?

Optical illusion occurs when an object that is seen differs from its actual state. Optical illusion occurs because the brain is unable to accurately interpret the object seen by the eye due to distractions around the object. Look at Figure 1.21.

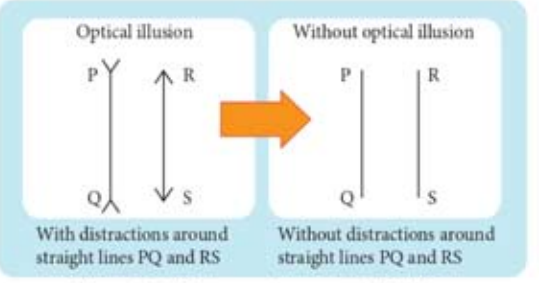


Figure 1.21 *Factor causing an optical illusion*

Blind Spot

Refer to the blind spot shown in Figure 1.8 on page 12. Why are images that fall on the blind spot invisible?

We are unaware of the presence of the blind spot in the eye because it is not possible for the image of the same object to fall on the blind spots of both eyes simultaneously. Carry out the following simple activity to investigate the blind spot.

Figure 1.22 *Investigating the blind spot*

Instructions

1. Hold this book with your right hand and straighten your arm.
2. Cover your left eye and look at the cat in Figure 1.22 with your right eye.
3. Move this book slowly towards your eyes. Does the bird disappear from your sight at a certain position? Why?

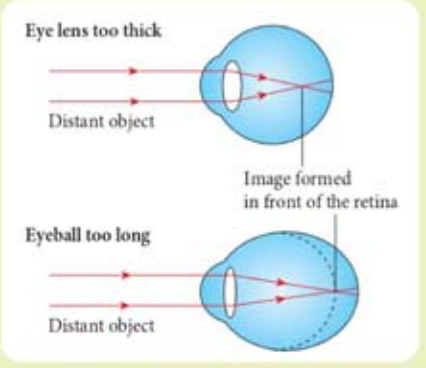
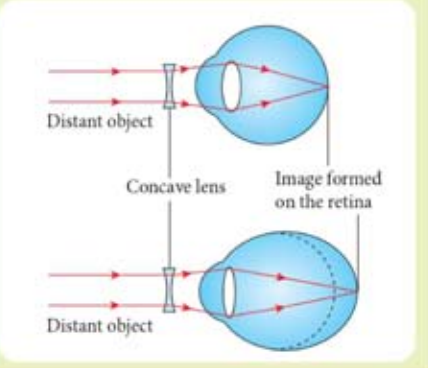
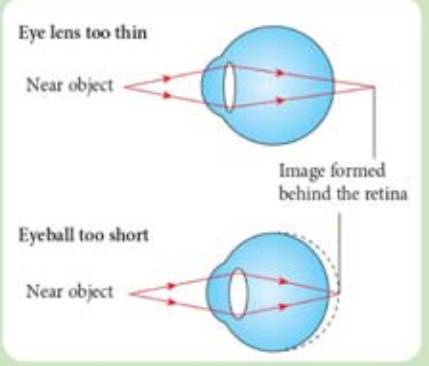
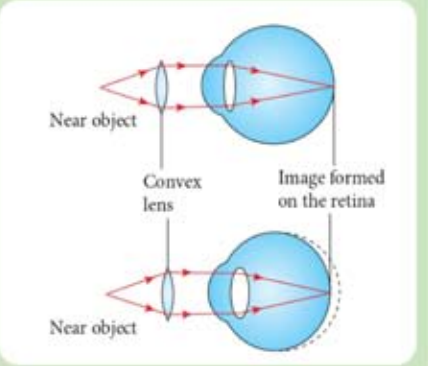
Photograph 1.14 shows examples of various devices used to overcome the limitations of sight. Name these devices. Gather information on the use of these devices from the Internet, magazines, books, newspapers and other sources. Discuss the information gathered. Present the findings of your discussions collaboratively using multimedia presentation.

Photograph 1.14 *Examples of devices to overcome limitations of sight*

Defects of Sight and Ways to Correct Them

Defects of sight include **short-sightedness, long-sightedness** and **astigmatism**. How can these defects of sight be corrected? Study Table 1.2.

Table 1.2 Defects of sight and ways to correct them

Defect of sight	How it is corrected
Short-sightedness (a) Inability to see distant objects clearly. (b) Distant objects appear blurry because the image is focused **in front of the retina**. (c) This defect is caused by the eye lens being too thick or the eyeball being too long.	Short-sightedness can be corrected using **concave lens**.
	
Long-sightedness (a) Inability to see near objects clearly. (b) Near objects appear blurry because the image is focused **behind the retina**. (c) This defect is caused by the eye lens being too thin or the eyeball being too short.	Long-sightedness can be corrected using **convex lens**.
	

Defect of sight	How it is corrected
Astigmatism (a) Seeing part of an object clearer than the rest of the object. (b) This defect is caused by the uneven curvature of the cornea or eye lens.  *Figure 1.23* Test your eyes by looking at Figure 1.23. Can you see all the lines clearly? If you cannot, you have astigmatism.	Astigmatism can be corrected using **cylindrical lenses**. 

Limitations of Hearing

Limitations of hearing are limitations in the ability of the ear to hear sound. We can only hear sounds of frequencies between the range of 20 Hz to 20 000 Hz. The ears are unable to detect sounds which lie outside this frequency range. The **frequency range of hearing** of every individual is different. When a person gets older, the frequency range of his hearing gets narrower as his eardrum becomes less elastic. Examples of devices invented and used to overcome the limitations of hearing are shown in Photograph 1.15.

Today in history

The first stethoscope made of wood was invented by Rene Laennec at Necker-Enfants Malades Hospital, Paris in 1816.

Stethoscope helps us to listen to the heartbeats.

A loudspeaker amplifies sound so that it can be heard from far away.

Photograph 1.15 Examples of equipment used to overcome limitations of hearing

Defects of Hearing and Ways to Correct Them

Defects of hearing occur when the sense of hearing of a person does not function well. Defects of hearing are normally caused by damage to the ear due to infection by microorganisms, injury, ageing process or continuous exposure to loud sounds.

Damages to the **outer ear** and **middle ear** can be corrected easily. For example, the clearing of foreign objects in the ear canal. Punctured eardrum and damaged ossicles can also be corrected using medicine or surgery. Damage to the **inner ear** is more difficult to correct. A damaged cochlea can be corrected using a cochlear implant but a damaged auditory nerve cannot be corrected using medicine or surgery.

Photograph 1.16 shows how innovation and technology are applied to invent smaller and more sophisticated hearing aids.

Photograph 1.16 *Advancements in hearing aids*

The Five Senses – a Gift

The five senses is a gift from God that we should appreciate. However, unhealthy lifestyles and high risk careers can affect the sensitivity of the sensory organs.

Based on Photographs 1.17 and 1.18:

- name the sensory organ whereby the sensitivity is affected in each situation
- describe how each situation can affect the sensitivity of the sensory organ
- what are the devices or safety measures taken to maintain the safety and health of the sensory organ in each situation?

Photograph 1.17 *Unhealthy lifestyle*

Photograph 1.18 *High risk careers*

Activity 1.9

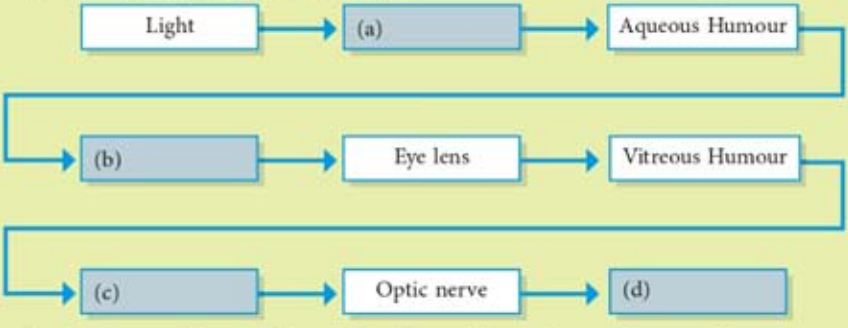
21st Century Skills
- CPS, ISS, ICS
- Technology-based activity

Instructions

1. Work collaboratively in groups.
2. Each group is assigned by your teacher to create a multimedia presentation such as MS PowerPoint or animation on one of the following topics:
   - Optical illusion and blind spot
   - Various types of audio visual defects such as short-sightedness, long-sightedness, astigmatism and defects of hearing
   - Correction of audio visual defects using concave lenses, convex lenses and hearing aids
   - Examples and effects of unhealthy lifestyles or high risk careers that can affect the sensitivity of the sensory organs
   - The five senses – a gift and the importance of practising safety and healthcare of the sensory organs

Formative Practice 1.2

1. Complete the following mechanism of sight.



2. Which structure of the ear, if damaged, will not influence the mechanism of hearing?

3. Where is the sensory cell for smell located?

4. State the **five** tastes that can be detected by the tongue.

5. State **two** factors that influence the sensitivity of the skin to stimuli.

6. (a) State the type of stimulus that can be detected by the tongue.
(b) Explain how the stimulus in question **6**(a) can be detected.

1.3 Stimuli and Responses in Plants

Like humans and animals, **plants** can also **detect stimuli** and **respond** to them. The stimuli that can be detected by plants include **light, water, gravity** and **touch**. The responses of plants can be divided into two as shown in Figure 1.24.

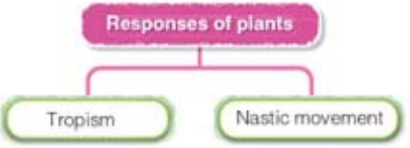


Figure 1.24 *Responses of plants to stimuli*

Tropism

Tropism is a directional **response of plants** to **stimuli** such as light, water, gravity and touch coming from a certain direction. A certain part of a plant will grow towards or move away from the detected stimulus. The part of a plant which grows towards a stimulus is known as **positive tropism** whereas the part of a plant which grows away from a stimulus is known as **negative tropism**. The directional response of plants normally occurs slowly and less significantly. Let us carry out Experiment 1.1 to determine the direction of response of plants to light, water, gravity and touch.

Experiment 1.1

A Response of plants towards light or phototropism

Aim: To study the response of plants to light

Problem statement: Which part of plants responds to light?

Hypothesis: Shoots of plants grow in the direction of light.

Variables

(a) manipulated variable : Direction of light towards the shoots of the seedlings
(b) responding variable : Direction of growth of the shoots of the seedlings
(c) constant variables : Seedlings of the same type and height, volume of water

Materials
Green pea seedlings, soil, water and three boxes (one box with an opening at the top and two other boxes with openings at the side)

Apparatus
Three beakers

Procedure

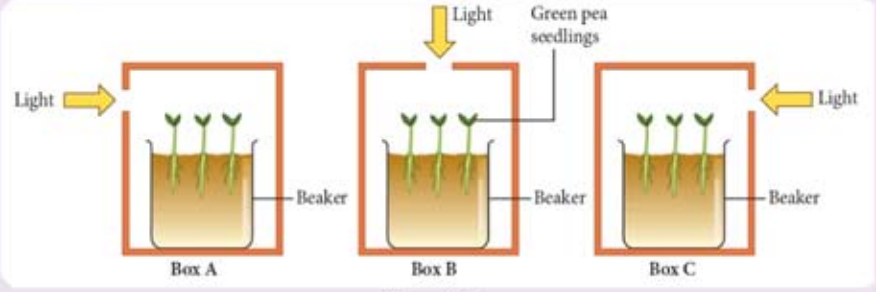


Figure 1.25

1. Set up the apparatus as shown in Figure 1.25.
2. Observe and sketch the positions of the shoots of the seedlings in boxes A, B and C.
3. Keep all three boxes in the laboratory for five days. Keep the soil moist by watering it with the same amount of water daily.
4. After five days, observe and sketch the positions of the shoots of the seedlings in boxes A, B and C.

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Questions
1. What is the stimulus used in this experiment?
2. State the part of the plant that responds to the stimulus.
3. Does the part of the plant in question 2 show positive or negative phototropism? Explain your answer.

B Response of plants to gravity or geotropism

Aim: To study the response of plants to gravity

Problem statement: Which part of plants responds to gravity?

Hypotheses: (a) Roots of plants grow in the direction of gravity.
(b) Shoots of plants grow in the opposite direction of gravity.

Variables
(a) manipulated variable : Position of the seedlings relative to the direction of gravity
(b) responding variable : Direction of growth of the roots and shoots of the seedlings
(c) constant variables : Presence of water, absence of light, seedlings with straight roots and shoots

Materials
Green pea seedlings with straight roots and shoots, moist cotton wool and plasticine

Apparatus
Petri dish

Procedure
1. Set up the apparatus as shown in Figure 1.26. Make sure that the green pea seedlings are arranged in different positions in the Petri dish.
2. Observe and sketch the position of the shoots and roots of the seedlings in the Petri dish.
3. Keep the apparatus in a dark cupboard for two days.
4. After two days, observe and sketch the position of the shoots and roots of the seedlings in the Petri dish.

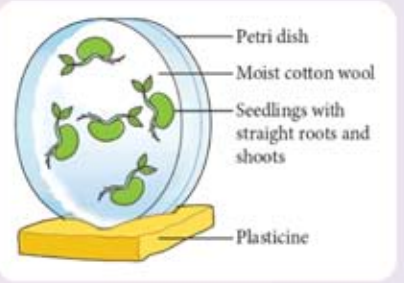


Figure 1.26

Conclusion
Are the hypotheses accepted? What is the conclusion of this experiment?

Questions
1. Why is the apparatus kept in a dark cupboard?
2. Based on your observations, state the direction of growth of the:
   (a) shoots of the seedlings
   (b) roots of the seedlings
3. Do plants show positive geotropism or negative geotropism? Explain your answer.

C Response of plants to water or hydrotropism

Aim: To study the response of plants to water

Problem statement: Which part of plants responds to water?

Hypothesis: Roots of plants grow in the direction of water.

Variables
(a) manipulated variable : Presence of a source of water
(b) responding variable : Direction of growth of roots of seedlings
(c) constant variables : Gravity, absence of light and seedlings with straight roots

Materials
Green pea seedlings with straight roots, moist cotton wool and anhydrous calcium chloride

Apparatus
Rough wire gauze and two beakers

Procedure
1. Set up the apparatus as shown in Figure 1.27.
2. Observe and sketch the positions of the roots of the seedlings in beakers X and Y.
3. Keep both beakers X and Y in a dark cupboard.
4. After two days, observe and sketch the positions of the roots of the seedlings in beakers X and Y.

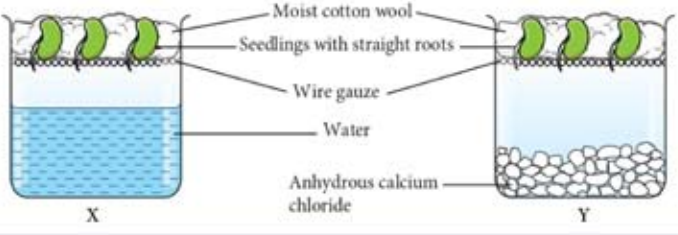


Figure 1.27

Conclusion

Is the hypothesis accepted? What is the conclusion of this experiment?

Questions

1. What is the stimulus used in this experiment?
2. State the part of the plant that responds to the stimulus.
3. What is the function of the anhydrous calcium chloride in beaker Y?
4. Does the part of the plant in question 2 show positive or negative hydrotropism? Explain your answer.

Plants need to be responsive towards stimuli such as light, gravity and water so that they can respond appropriately to ensure their sustainability and survival. Why do plants need light and water? Name one stimulus that can be detected by plants but not investigated in Experiment 1.1.

Phototropism

Phototropism is the response of plants towards **light**. **Shoots of plants** show **positive phototropism** which is growth towards the direction of light (Photograph 1.19). As plants need light to carry out photosynthesis, positive phototropism ensures that shoots and leaves of plants obtain enough sunlight to make food through photosynthesis.

Photograph 1.19 *Shoots of plants show positive phototropism*

Hydrotropism

Hydrotropism is the response of plants towards **water**. **Roots of plants** show **positive hydrotropism** which is growth towards the direction of water (Figure 1.28). Positive hydrotropism allows roots of plants to obtain water to carry out photosynthesis and absorb dissolved mineral salts to stay alive.

Figure 1.28 *Roots showing positive hydrotropism*

1.3.1 1.3.2 1.3.3

Geotropism

Geotropism is the response of plants towards **gravity**. **Roots of plants** show **positive geotropism** which is downward growth towards the direction of gravity. Positive geotropism allows the roots of plants to grow deep into the ground to grip and stabilise the position of the plant in the ground. On the other hand, **shoots of plants** show **negative geotropism** which is upward growth in the opposite direction of gravity. Negative geotropism allows the shoots and leaves of plants to grow upwards to obtain sunlight for photosynthesis (Figure 1.29).

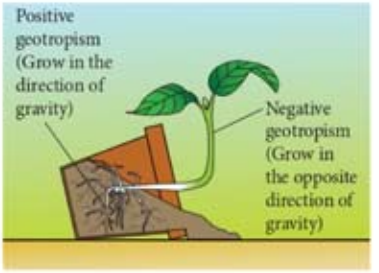


Figure 1.29 *Roots show positive geotropism whereas shoots show negative geotropism*

Thigmotropism

Thigmotropism is the response towards **touch**. **Tendrils** or **twining stems** show positive thigmotropism when they cling onto whatever objects or other plants they come into contact with (Photograph 1.20). This response enables plants to grow upwards to obtain sunlight and grip objects to obtain support. Roots show negative thigmotropism since they avoid any object that obstructs their search for water.

(a) Cucumber plant has tendrils that twine around objects in contact with it

(b) Morning glory plant has stems that twine around objects in contact with it

Photograph 1.20 *Tendrils and stems which twine around objects show positive thigmotropism*

Nastic Movement

Nastic movement is the response towards a stimulus such as **touch** but does not depend on the direction of the stimulus. What are other stimuli that can cause nastic movement? Why is nastic movement not a type of tropism?

Nastic movement occurs **more rapidly** than tropism. For example, the *Mimosa* sp. responds to touch by folding its leaves inwards when touched as shown in Photograph 1.21. This nastic movement serves as a **defence** of the *Mimosa* sp. against its enemies and strong wind.

VIDEO

Nastic movement of the *Mimosa* sp.

SCAN PAGE

Photograph 1.21 *Nastic movement of a leaf of Mimosa* sp.

Activity 1.10

21st Century Skills
- CPS
- Inquiry-based activity

To investigate responses of plants in different situations

The responses of plants towards Earth's gravity and the period of exposure to sunlight in a day influence the growth of shoots and roots of plants. These ensure the sustainability and survival of the plants.

At the International Space Station (ISS), scientists investigate the growth of plants in the following situations:
(a) No gravity
(b) Period of exposure to sunlight

Photograph 1.22 *A scientist carrying out investigations at the ISS*

Instructions
1. Work in groups.
2. Gather information on the results of the investigations of the scientists on the growth pattern of shoots and roots of plants towards stimuli (gravity and sunlight).
3. Present the outcome of the discussion of each group using multimedia presentation.

Formative Practice 1.3

1. (a) What is tropism?
(b) State the type of tropism towards the following stimuli:
(i) Touch
(ii) Gravity
(iii) Light

2. (a) Which parts of a plant show:
(i) positive phototropism?
(ii) positive geotropism?
(iii) positive thigmotropism?
(b) What is the importance of hydrotropism to plants?

3. State **one** similarity and **one** difference between the responses of tropism and nastic movement.

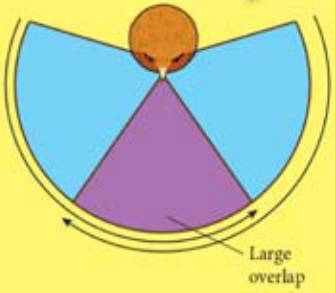
1.3.1 1.3.2 1.3.3

1.4 Importance of Responses to Stimuli in Animals

Stereoscopic and Monocular Visions

Study Figure 1.30 to understand stereoscopic and monocular visions. Table 1.3 shows the characteristics and importance of stereoscopic and monocular visions in animals.

- Humans and animals such as cats and owls have a pair of eyes located **in front of their head**.
- They have **stereoscopic vision**.



(a) Stereoscopic vision

- Animals such as rats, chickens and rabbits have a pair of eyes located on opposite **sides of their head**.
- They have **monocular vision**.

(b) Monocular vision

Figure 1.30 *Stereoscopic and monocular visions*

Table 1.3 *Differences between stereoscopic and monocular vision*

Stereoscopic vision	Monocular vision
Both eyes located in **front of** the **head**.	Both eyes located at the **sides of** the **head**.
A **narrow** field of vision.	A **wide** field of vision.
Fields of vision overlap to a great extent. Overlapping fields of vision produce vision in three dimensions.	Fields of vision do not overlap or overlap only **slightly**.
Three dimensional images formed in the overlapping fields of vision allow the distance, size and depth of objects to be estimated accurately.	**Two dimensional images** formed in the non-overlapping fields of vision prevent the distance, size and depth of objects from being estimated accurately.
The ability to estimate distance accurately helps animals to hunt.	A wide field of vision helps animals to detect their enemies coming from any direction.
Humans and most **predators** have stereoscopic vision.	Most **prey** have monocular vision.

Stereophonic Hearing

What is the importance of having a pair of ears to humans and animals? **Stereophonic hearing** is hearing using **both ears**. Stereophonic hearing allows us to **determine the direction of the sound** accurately. Look at Figure 1.31.

The importance of stereophonic hearing to humans is to determine the **location** of a source of sound. Stereophonic hearing helps predators to determine the location of their prey. Conversely, stereophonic hearing also helps prey to determine the location of their predators and to escape from them.

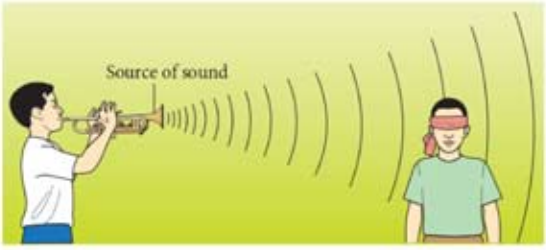
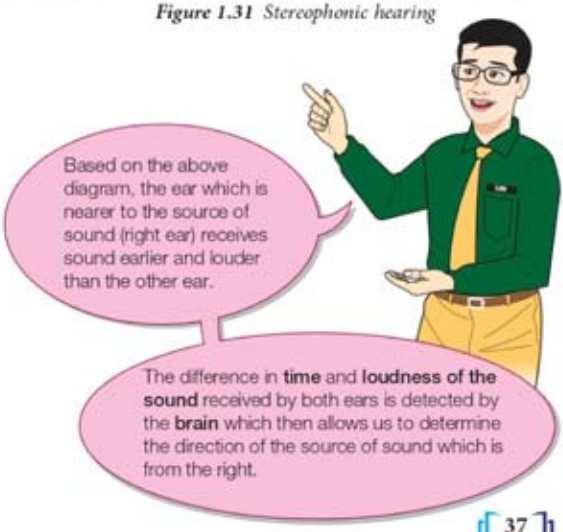


Figure 1.31 *Stereophonic hearing*



BRAIN TEASER

How does the ear function as a sense of 'sight' for the blind?

1.4.1

Hearing Frequencies of Animals

Different animals can hear sounds of different frequencies as shown in Figure 1.32.

I CAN REMEMBER!

Frequencies of sounds that can be detected by the human ear are limited to the range of 20 Hz to 20 000 Hz.

Figure 1.32 *Frequencies of hearing range of different animals*

Activity 1.11

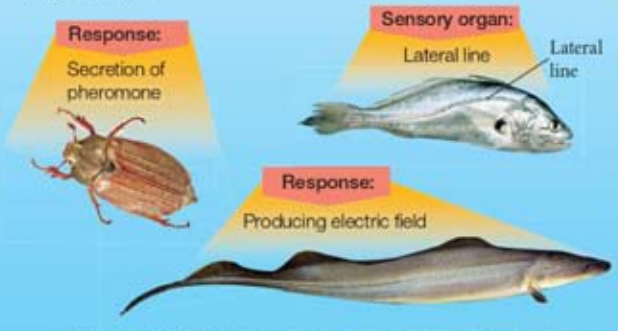
21st Century Skills
- CPS, ISS, ICS
- Technology-based activity

Instructions

1. Work collaboratively in groups.
2. Each group will be assigned by your teacher to create a multimedia presentation such as MS PowerPoint or animation on one of the following topics:
   (a) Stereoscopic and monocular visions in animals
   (b) Stereophonic hearing
   (c) Different hearing frequencies for different animals

Sensory Organs Ensure the Survival of Animals on Earth

Responses to stimuli ensure the survival of animals on Earth. The sensory organs and responses of several animals are shown in Photograph 1.23. Carry out Activity 1.12 to investigate the sensory organs and responses of several other animals.



Photograph 1.23 *Sensory organs and responses of animals*

MARVELS OF SCIENCE

Animals such as ants, snakes, frogs and birds are believed to be able to predict earthquakes. Scientists are investigating the types of stimuli detected by these animals before earthquakes occur.

Websites

Electric field of an electric eel
http://bt.sasbadi.com/sc3039

Activity 1.12

21st Century Skills
- ICS
- Discussion activity

To explain the sensory organs and responses of other animals on Earth

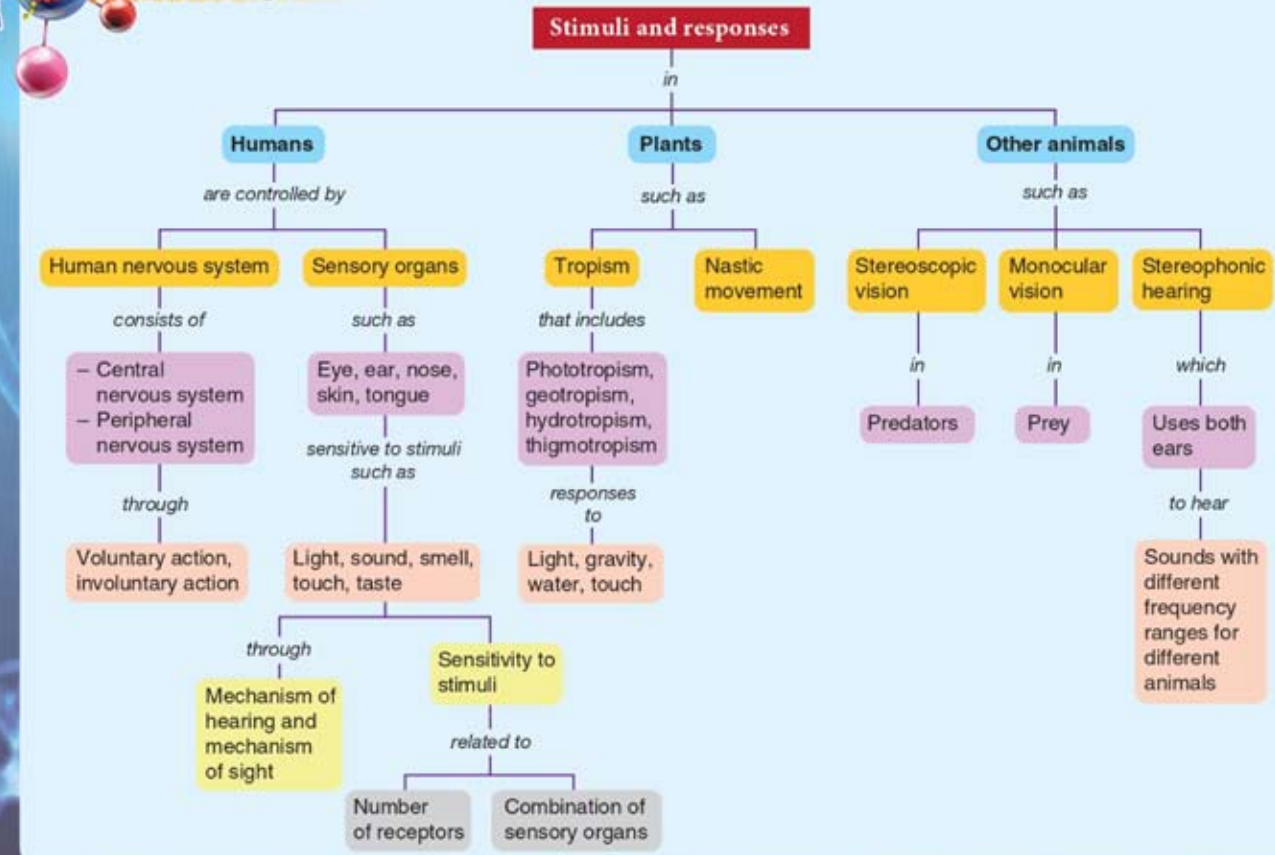
Instructions

1. Work in groups.
2. Each group is required to gather information on how responses of animals in Photograph 1.23 are able to ensure their survival on Earth.
3. Discuss the information gathered.
4. Present the outcome of the discussion of each group in class using multimedia presentation.

Formative Practice 1.4

1. State **two** types of vision of animals.
2. State the factor that determines the type of vision of animals.
3. What is the type of vision of a primary consumer? Give your reasons.
4. What is the importance of stereophonic hearing?
5. In the dark, Azman can determine the location of a mewing cat. Explain how Azman is able to determine the location of the cat.

Summary


Stimuli and responses
in
Humans
are controlled by
Human nervous system
consists of
– Central nervous system
– Peripheral nervous system
through
Voluntary action, involuntary action
Sensory organs
such as
Eye, ear, nose, skin, tongue
sensitive to stimuli such as
Light, sound, smell, touch, taste
through
Mechanism of hearing and mechanism of sight
Sensitivity to stimuli
related to
Number of receptors
Combination of sensory organs
Plants
such as
Tropism
that includes
Phototropism, geotropism, hydrotropism, thigmotropism
responses to
Light, gravity, water, touch
Nastic movement
Other animals
such as
Stereoscopic vision
in
Predators
Monocular vision
in
Prey
Stereophonic hearing
which
Uses both ears
to hear
Sounds with different frequency ranges for different animals

Self-reflection

After studying this chapter, you are able to:

1.1 Human Nervous System
- ☐ Describe the structures and functions of human nervous system through drawings.
- ☐ Make a sequence to show the pathway of impulses in voluntary and involuntary actions.
- ☐ Justify the importance of human nervous system in life.

1.2 Stimuli and Responses in Human
- ☐ Draw the structures of sensory organs and explain their functions and sensitivities towards stimuli.
- ☐ Explain the mechanism of hearing and sight through drawing.
- ☐ Relate human sensory organs to the sensitivity towards various combination of stimuli.
- ☐ Explain through examples how the limitation of senses, defect in sensory organs and ageing affect human hearing and sight.
- ☐ Justify how innovations and technologies can improve the ability to sense in sensory organs.

1.3 Stimuli and Responses in Plants
- ☐ Describe the parts of a plant that are sensitive towards stimuli.
- ☐ Justify how responses in plants ensure their sustainability and survival.
- ☐ Carry out experiments to study responses in plants towards various stimuli.

1.4 Importance of Responses to Stimuli in Animals
- ☐ Explain with examples the types of sight and hearing in animals.
- ☐ Communicate how sensory organs ensure the survival of animals on Earth.

Summative Practice 1

Answer the following questions:

1. Mark '✓' for the correct statement and '×' for the incorrect statement about the human nervous system.

(a) The peripheral nervous system is made up of nerves connecting the brain with the spinal cord.	
(b) Without a functioning brain, voluntary actions cannot be carried out.	
(c) Playing badminton is an involuntary action.	
(d) Impulses can only be interpreted by the brain.	

2. Figure 1 shows structures P, Q and R of the human nervous system.

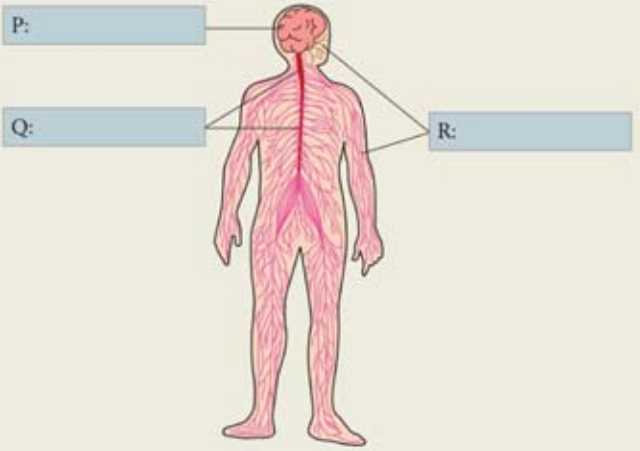


Figure 1

Label P, Q and R in Figure 1.

3. Figure 2 shows responses A and B of the eye.

Response A

Response B

Figure 2

(a) State the responses shown in Figure 2.
(b) State the stimuli that cause these responses.
(c) How do the stimuli cause these responses?
(d) These responses protect the eye especially the retina by preventing light of excessive intensity from entering the eye. During the solar eclipse, explain why we should observe this event on the water surface in a basin of water.

4. In a science class, Azura studies the mechanisms of hearing and sight.
(a) Draw **one** flow chart that shows the pathway of sound from a source of sound entering the ear.
(b) Draw **one** flow chart that shows the pathway of light from an object entering the eye.

5. Figure 3 shows the structure of the human skin.

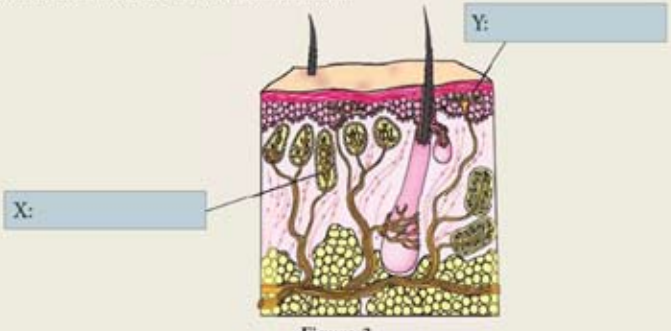


Figure 3

(a) Label X and Y in Figure 3.

(b) Explain why the fingertip and not the palm of the hand is used to detect Braille symbols.

(c) Mazlan classifies the tongue as skin that possesses taste receptors. Do you agree with the classification of the tongue as skin? Explain your answer.

6. (a) What is the importance of the sense of smell when we are in the science laboratory? Give **one** example.

(b) Why are dogs in police units trained to detect the presence of drugs kept in bags?

7. (a) State **two** responses in plants that help photosynthesis.

(b) How do the two responses of plants in question **7**(a) help photosynthesis?

8. (a) Name the type of vision of an eagle.

(b) What is the importance of the type of vision in question **8**(a) to the survival of the eagle?

Focus on HOTS

9. Pak Dollah who is long-sighted forgot to bring his glasses during breakfast in a restaurant. You are required to invent a lens to enable Pak Dollah to read the newspaper. Your invention must make use of the materials shown in Figure 4.

Figure 4