3 Control and Coordination

LEARNING OUTCOMES

- Sense organs and their function: eye, ear, nose, skin, and tongue
- Coordination
- Response to internal stimuli
- Endocrine system

In class 7, you must have learned that the human body is made up of ten different organ systems, each of which performs vital functions in the body. Two of these organ systems (the *nervous* and *endocrine* systems) control the functioning of all organ systems in the body.

The nervous system is helped in this by the *sense organs*. The sense organs connect the external world to our nervous system. There are five sense organs that capture the five senses of vision (eyes), hearing (ears), smell (nose), taste (tongue), and touch (skin).

List the names of the eight organ systems whose functioning is controlled by the nervous and endocrine systems:

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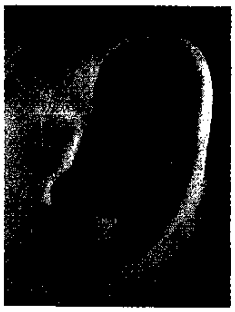
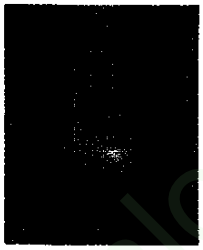
Eyes (vision)



Ears (hearing)



Nose (smell)

Tongue (taste)

Skin (touch)

FACT FILE

Sharks have two additional senses: an electrical sense that helps them detect tiny electrical currents in the water and a vibration sense that enables them to detect low-frequency vibrations.

In this chapter we will explore the functions of each of these sensory organs in detail. We will also discuss the functioning of nervous and endocrine systems. Let us start by learning about different sense organs and their functions.

FACT FILE

Although the whole of the retina has light- and colour-sensitive cells, an area called the yellow spot present in the centre of the retina has the greatest number of cone cells. Thus, this area has the most accurate vision.

EYE

Eyes have the ability to detect light, which enables us to see. Each eye is contained in a socket in front of the skull. The eye is nearly spherical in shape.

The wall of the eye consists of three layers. The outer layer is called the *sclera*. It is a tough, protective layer. The sclera is opaque, but has a transparent bulge called *cornea* in the front. The second or the middle layer is the *choroid*, which forms the *iris*, the coloured part of the eye. *Pupil*, which is situated in the middle of the iris, regulates the amount of light entering the eye. Behind the iris is the *lens*, which is kept in place by suspensory ligaments. The third layer is the *retina*, which has light-sensitive cells called *rods* and *cones*.

FACT FILE

An ostrich's eye is bigger than its brain!

Rods are sensitive to dim light and cones to bright light and colour. There are three kinds of cones, each responding to a different colour: red, green, or blue. The lens focuses the light on the retina, which stimulates the rods and cones. The rods and cones pass on the light stimulation in the form of an electrical discharge (or *impulse*) to the *optic nerve*. The optic nerve carries this impulse to the brain, where it is interpreted. Figure 3.1 shows the internal structure of the human eye.

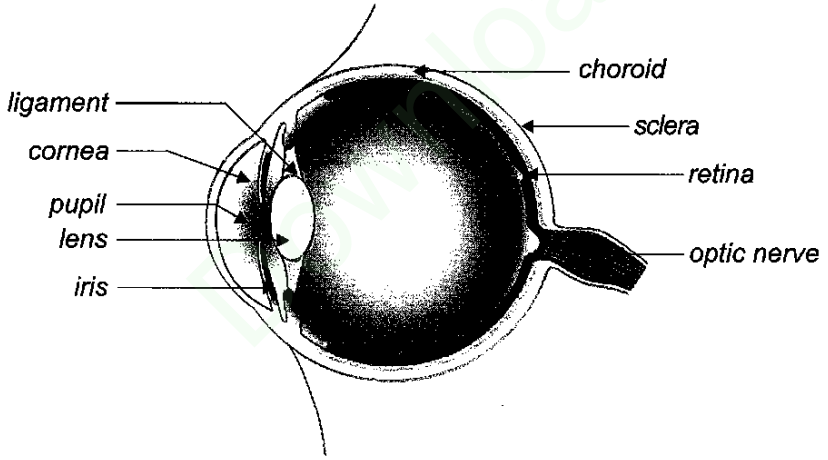


Fig. 3.1 *Human eye*

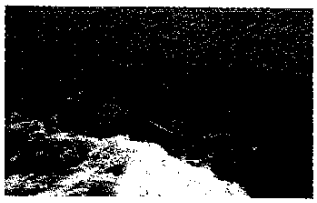
EAR

The ear may be divided into three regions: the *external ear*, the *middle ear*, and the *internal ear*. The external ear consists of the ear lobe or *pinna* and the auditory canal. The auditory canal carries sound waves to the *tympanum* or the *ear drum*.

The middle ear is a small chamber within a bone of the skull. A chain of three bones called ear ossicles connects the tympanum with the membrane covering the oval opening. From the outer end of the chain, these bones are *malleus*, *incus* (anvil), and *stapes* (stirrup).

The internal ear consists of a complex set of membranous tubes and sacs collectively called the membranous labyrinth. It is situated in a bony cavity containing a fluid. The membranous labyrinth consists of two sacs called the *utricle* and the *saccule*. Associated with the utricle are three *semicircular canals*, which help us in maintaining our balance. Associated with the saccule is the *cochlea*, a spirally coiled tube that resembles a snail's shell. The cochlea is involved in hearing. It contains thousands of hair cells that vibrate when sound waves strike it. These vibrations are converted to electrical signals, which are conducted by the auditory nerve to the brain. The brain interprets the sound we hear and gives it meaning. Figure 3.2 shows the internal structure of the human ear.

FACT FILE



Dolphins can hear better than human beings. In dolphins, the lower jaw also plays a role in the process of hearing—by conducting sound vibrations to the middle ear. Also, the teeth in the lower jaw are arranged in such a manner that they act as antennae, which receive the incoming sound. This ability, called echolocation, enables dolphins to point out the location of an object.

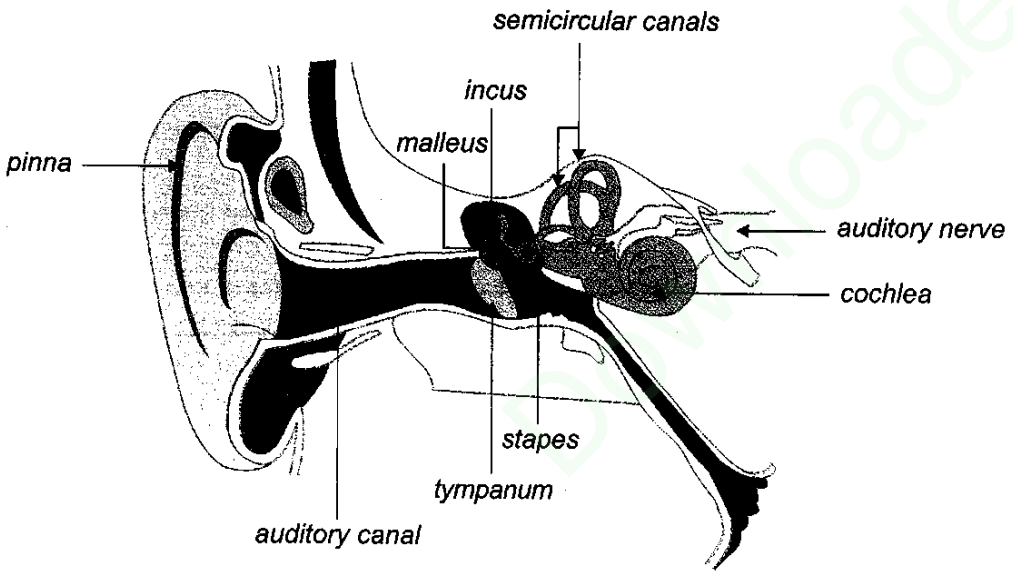


Fig. 3.2 Human ear

NOSE

The nose is the organ of smell as also of breathing.

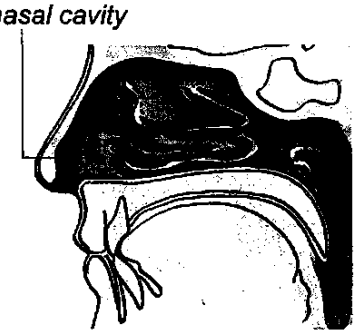


Fig. 3.3 Human nose

The nose opens externally through two holes called the *nostrils.* The nostrils and the corresponding nasal passages are separated by a wall called the *septum.* In the middle of the face there is a hollow space called the *nasal cavity.* The *palate* separates the nasal cavity from the mouth. The nasal cavity is lined with a type of epithelium called *olfactory epithelium.* This epithelium has special receptors that catch the molecules of matter floating in the air that passes through the nose. There are different kinds of receptors for different molecules of matter. One type of molecule may stimulate several different kinds of receptors. All of these signals are sent through the olfactory nerve to the brain, which interprets the particular smell. Figure 3.3 shows the internal structure of the human nose.

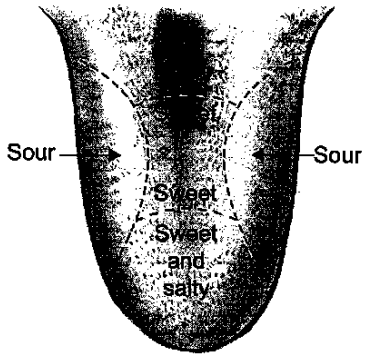


Fig. 3.4 Taste receptors on the tongue

TONGUE

The tongue is the organ of taste. It is covered with a number of taste buds, each taste bud having a number of taste receptor cells. There are specific areas on the tongue for identifying a particular taste. The four primary tastes recognized are: sweet, salty, bitter, and sour (Fig. 3.4).

SKIN

The skin forms a protective covering for the entire body and serves as an important sense organ.

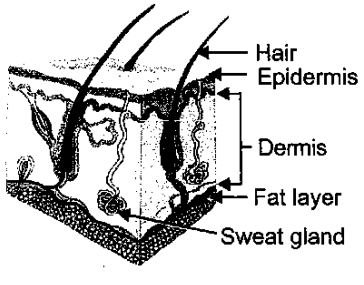


Fig. 3.5 Cross-section of skin

It is about 5 mm thick and consists of an outer thin layer of epidermis and an inner thick layer of dermis. The innermost layer of cells in the epidermis is made up of living cells that divide actively to form new cells. They gradually replace the outer dead cells at the surface of the skin that are being constantly rubbed off and lost from the body. The inner cells contain a dark pigment melanin that protects the body from ultraviolet rays and gives a characteristic colour to the body. The darker your skin is, the more melanin you have. The dermis is thicker than the epidermis and is richly supplied with blood vessels and nerves. Sweat glands, oil glands, and hair follicles are also embedded in the dermis (Fig. 3.5).

The sensation of touch is due to the millions of microscopic receptors that the skin has. These receptors are placed at different depths in the skin and have an uneven distribution. At some places, such as the fingertips, they are very close to each other and large in number, so your fingertips are quite sensitive. In some other places they are spaced apart. Whenever you touch something these receptors send electrical signals to the brain which collects all of them and forms an overall picture. There are three main kinds of receptors:

(a) light, touch and pressure receptors that detect movement or pressure;
(b) heat and cold receptors that detect changes in temperature; and
(c) pain receptors that respond to pain. They are the most numerous.

FACT FILE

A fine, slightly acidic film called acid mantle present on the surface of the skin protects it from microorganisms such as bacteria and viruses.

CARE OF SENSE ORGANS

We must take proper care of our sense organs to keep them healthy.

Eyes

1. Moving the eyeballs up and down, sideways, and clockwise and anticlockwise is a good exercise that relaxes eye muscles.
2. Palming (covering the eyes with your palms) and splashing the eyes with cold water help freshen up the eyes and should be practiced periodically.
3. One should not read under dim light.
4. Food rich in vitamin A is beneficial for the eyes.
5. Watching television for long hours should be avoided as it can cause eye strain. Similarly, one should take a break every few minutes while working on a computer.
6. It is advisable to go for an eye checkup every two years.

FACT FILE

Myopia or near-sightedness is a condition in which distant objects appear blurred. the opposite of this condition is hypermetropia or far-sightedness, in which nearby objects appar blurred. Both conditions arise due to an imperfection in the eye.

ACTIVITY

Aim: To find out the sensitivity of the skin to touch.

Materials required: A quill feather.

Procedure: Hold the feather by its quill and stroke different parts of the body with its tip. You can try out the tip of the fingers, different parts of the face such as nose, forehead, cheek, lip, and pinna, the neck, shoulder and different areas on the hands. Record your observations in a tabular form under two heads; 'most sensitive to touch' and 'least sensitive to touch'.

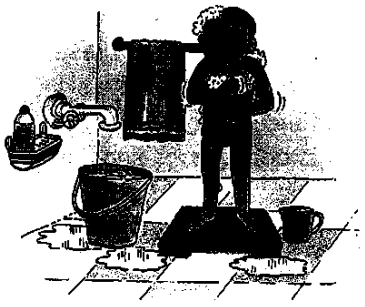


Fig. 3.6 Regular bathing keeps skin clean

Fig. 3.7 Fingernails should be trimmed regularly

Fig. 3.8 One should drink plenty of water

Ears

1. The ears have a self-cleaning mechanism and, under normal circumstances, do not require cleaning. Inserting sharp objects inside the ear can cause serious damage to the eardrum.
2. After going for a swim, the ears must be dried and the excess water shaken out.
3. Ears should be protected from extreme cold or heat, as also from prolonged exposure to loud noises.

Nose

1. Nostrils must be cleaned daily to remove mucous and dirt trapped in the hairs lining the nasal cavity.
2. While sneezing or coughing, nose and mouth should be covered with a handkerchief to prevent the spread of germs.

Tongue

The surface of the tongue may be cleaned gently with the help of a tongue cleaner while brushing teeth.

Skin

1. Regular bathing with a mild soap helps in keeping the skin clean (Fig. 3.6).
2. Fingernails should be trimmed at regular intervals to keep them free of dirt which may become a breeding ground for germs (Fig. 3.7).
3. Overexposure to harmful ultraviolet rays of the sun should be avoided.
4. Acne or pimples should not be squeezed. It will only spread the infection.
5. One should drink plenty of water to keep the skin hydrated (Fig. 3.8).

RESPONSE TO INTERNAL STIMULI

Our sense organs are designed to pick up external stimuli such as sound and smell originating in the environment. A stimulus (*plural* stimuli) is any change in the internal or external environment of an organism which provokes a response from the organism. Just as an organism is exposed to the world outside, the cells within the body are exposed to an internal environment. The body has internal receptors at strategic points to ensure the

well being of its cells, tissues, organs, and organ systems. Let us examine how the body responds to internal stimuli such as hunger, fear, growth, and development.

Hunger The brain plays an important role in appetite control. The blood glucose level is the critical factor that provides the internal stimulus—the normal being 0.1%. Experiments have revealed the existence of special 'eating-control centres' in the brain. How do these control centres decide whether to send a command 'eat' or a command 'do not eat'? Glucose circulating in the blood is a very sensitive indicator of the hour-by-hour nutritional state of the body. Shortly after a meal, glucose concentration in the blood tends to increase. Long after a meal, blood glucose levels tend to fall. A decrease or increase in the blood glucose level provides the requisite internal stimulus to the eating-control centres in the brain.

Fear Fear triggers the secretion of a chemical messenger called *adrenalin*. It is adrenalin that produces the so-called 'alarm reactions' (e.g., rise in blood pressure) that come into play in emergency or danger.

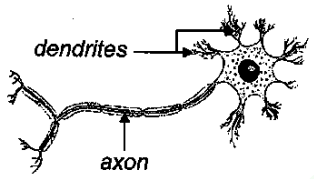
Growth and development A bean seed grows and develops into a bean plant and a maize grain grows and develops into a maize plant. *A bean seed can never grow and develop into a maize plant, nor does a maize grain grow up to become a bean plant.* What provides a seed (or an egg) the stimulus to grow and develop to become a specific organism? The starting point in the development and growth of each of them is a zygote. Zygote is formed by the fusion of the male gamete and the female gamete derived from the male parent and the female parent, respectively. Chromosomes are thread-like structures that carry hereditary units called *genes*. Genes have all the information necessary to direct the growth and development of the zygote in such a way as to transform it into a specific organism. In other words, growth and development in organisms occur in response to the internal stimuli triggered by the genes inherited from the parents.

COORDINATION

For the survival of the organism, the body has to respond correctly to the various stimuli it receives, both internal and external. A stimulus is any change in the internal or external environment of an organism which provokes a response from the organism.

TECH FILE

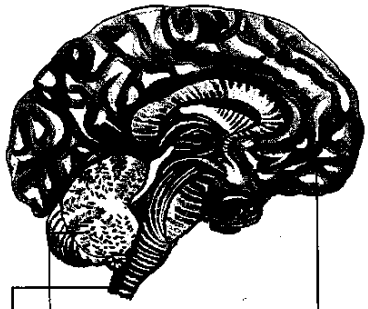
The structural and functional unit of the nervous system is the neuron. Neurons can receive stimuli, conduct impulses, and discharge them. Each neuron has a cell body with a central nucleus and two types of fibres called *dendrites* and *axons*. Dendrites are short processes that carry impulses towards the cell body while the single long axon carries an impulse away from the cell body.



FACT FILE

Information travels at different speeds within neurons. Messages move at as slow a speed as 0.5 m/sec, or as fast as 120 m/sec. Every person has more than 75 km of nerves in their body.

Brain
can be divided into three regions



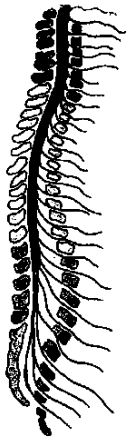
***Cerebrum**, the largest region, is responsible for memory, intelligence, learning, and logic.*

***Cerebellum**, located below the cerebrum, helps in muscle coordination and in maintaining the balance of the body.*

***Medulla**, or the brain stem, controls involuntary actions such as heartbeat and breathing.*

is attached to

Spinal cord



The spinal cord is made of nerve tissue and is protected by the backbone. It is involved in the transfer of information between the brain and the rest of the body.

There are two body systems that coordinate the response: nervous system and endocrine system.

NERVOUS SYSTEM: VOLUNTARY AND REFLEX ACTIONS

The nervous system has three parts: the central nervous system, the peripheral nervous system, and the autonomic nervous system.

Central nervous system This part consists of brain and spinal cord. Parts of the brain and their functions are listed alongside.

Peripheral nervous system This part consists of all nerves directly originating from the brain and the spinal cord. Based on their origin, these nerves can be classified as *cranial nerves* and *spinal nerves.* Cranial nerves originate from the brain; spinal nerves originate from the spinal cord.

Impulses can pass along nerve fibres only in one direction. Nerves that carry stimuli from the organ to either the brain or the spinal cord are called *sensory nerves.* Nerves that carry the command from the brain to the concerned organ are called *motor nerves.*

The central nervous system and the peripheral nervous system are involved in responses that are under our conscious control (e.g., speaking and writing).

*Actions that are under our conscious control are termed **voluntary actions.***

Autonomic nervous system Autonomic nervous system controls actions that are not under our conscious control (i.e., *involuntary*) (e.g., heartbeat and digestion). Such actions are called *reflex actions.*

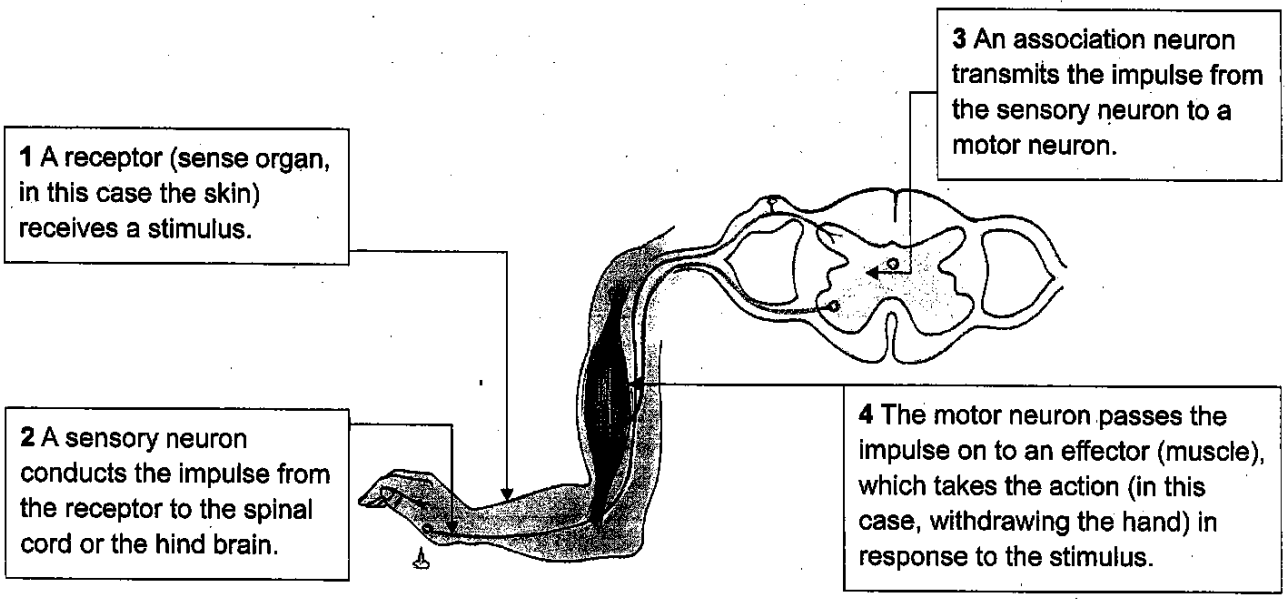
*Involuntary actions in response to external or internal stimuli are termed **reflex actions.***

If you accidentally pick up a very hot object, you drop it immediately. If you smell your favourite dish, your mouth waters. These actions are examples of reflex actions, as they involve no deliberate effort on your part. Reflex actions occur in a split second. *The path through which a stimulus passes during a reflex action is called a **reflex arc.*** The reflex arc involves the following three nerve cells (neurons):

sensory neuron, which carries impulses towards the brain or spinal cord;
interneuron (or association neuron), which connects sensory and motor neurons; and
motor neuron, which carries impulses from the brain or spinal cord to the muscle receptors.

FACT FILE

The sperm whale has the heaviest brain at 9.2 kg. In contrast, the human brain weighs only 1.3 to 1.4 kg.



ENDOCRINE SYSTEM

The endocrine system is a system of glands (and a few organs) that controls and coordinates a number of vital processes in the human body. The coordinating action of the nervous system is fast due to the transmission of electrical impulses. The endocrine system, on the other hand, uses chemicals to regulate slow processes (in general) such as growth, digestion, and reproduction.

The endocrine glands pour their chemicals directly into the blood stream and are, therefore, called *ductless glands*. Figure 3.9 illustrates the position of these glands and organs in the body.

The chemicals secreted by these glands and organs are called hormones. ***Hormones** are defined as chemical substances secreted directly into the bloodstream by the endocrine glands and organs of the body.*

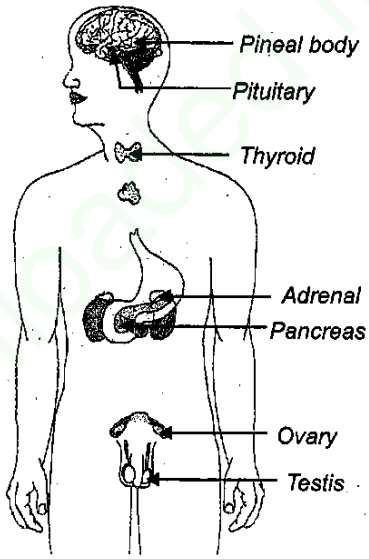


***Fig. 3.9** Major endocrine glands*

Table 3.1 provides a summary of endocrine glands and organs and their secretions.

Table 3.1 *Endocrine glands: location and secretions*

Endocrine gland	Location	Hormone	Function
Hypothalamus	Lower central part of the brain	Multiple hormones	Controls the pituitary Stimulates or suppresses hormone secretions from the pituitary
Pituitary	Base of the brain, below the hypothalamus	Multiple hormones including pituitary hormone, growth hormone, and anti-diuretic hormone (ADH)	Controls the functioning of other endocrine glands. Hence, also called the master gland. Growth hormone promotes growth of bones and tissues. ADH controls water absorption in the kidneys.
Thyroid	Front of the lower neck	Thyroxine	Controls metabolism, promotes protein synthesis
Parathyroid glands	Back of the thyroid gland	Parathormone (PTH)	Controls blood calcium levels
Adrenal glands	One on top of each kidney	Epinephrine or Adrenaline Corticosteroids	Increases blood pressure, heart rate in times of stress. Controls metabolism, immune system, sexual development and function.
Pineal body	Middle of the brain	Melatonin	Controls the wake-sleep cycle
Pancreas	Beneath the stomach	Glucagon and Insulin	Both together ensure a steady blood sugar level. Glucagon increases blood sugar while insulin decreases it.
Testes	Pelvic region	Testosterone	Development of male secondary sex characteristics
Ovaries	Pelvic region	Oestrogen Progesterone	Development of female secondary sex characteristics Controls the menstrual cycle

Let us learn in greater detail about the most important of these hormones.

Pituitary Hormone

The pituitary hormone is secreted by the pituitary gland, which is located at the base of the brain. It is called the master gland because it controls the functions of the other glands of the endocrine system. The pituitary gland is, in turn, controlled by the hypothalamus. It is attached to the hypothalamus by nerve fibres. The pituitary gland doesn't secrete just one hormone but a group of them.

Functions: Some important hormones secreted by the pituitary gland are the growth hormone, ACTH or adrenocorticotropic hormone (which controls the secretion of hormones from the adrenal glands), and TSH or thyroid stimulating hormone (which controls the secretion of hormones from the thyroid gland).

FACT FILE

Goitre is a condition caused due to abnormally enlarged thyroid gland. Deficiency of iodine in the diet is the most common cause of goitre.

Thyroxine

Thyroxine is secreted by the thyroid gland, which is located below the larynx (voice box) and is wrapped around the trachea.

Functions: Thyroxine is important for the functioning of every cell in the body. It influences the breakdown of food and the release of energy. It promotes protein synthesis and is, therefore, essential for normal growth and development.

Insulin

Insulin is secreted by the pancreas, which is a fish-shaped grayish-pink organ present behind the stomach.

Function: Insulin is required by body cells to remove and use glucose from the blood. Using glucose, the cells produce the energy they need to carry out their functions. If the pancreas is unable to produce enough insulin, or if the cells of the body are unable to utilize the insulin produced, blood sugar levels rise and cause many complications. This condition is called *diabetes mellitus.*

Adrenalin

Adrenalin is secreted by a pair of triangle-shaped adrenal glands, which are located one on the top of each kidney.

Function: Each adrenal gland is made up of two parts: an inner *medulla* and an outer *cortex*. The medulla secretes *epinephrine* or *adrenaline*, which increases blood pressure and heart rate when the body experiences stress, as we had discussed earlier in the chapter. The cortex produces *corticosteroids* that regulate salt and water balance in the body, the body's metabolism, it's response to stress, the functioning of the immune system, and sexual development and function.

KEYWORDS

Retina The innermost light-sensitive layer of the eye.
Rods A type of retinal cells that are sensitive to dim light
Cones A type of retinal cells that are sensitive to colour and bright light
Tympanum The membrane at the end of the auditory canal that picks up sound waves
Cochlea Spirally coiled tube containing organs of hearing
Voluntary action An action that is under our conscious control
Reflex action Involuntary action in response to a stimulus
Endocrine glands Ductless glands that introduce their secretions directly into the blood.
Adrenalin The emergency hormone released by the adrenal medulla

SUMMARY

- The sense organs enable us to communicate with the world around us; they have receptors that pick up various kinds of stimuli.
- The eye is responsible for vision.
- The ear performs a double function of hearing and maintenance of balance.
- The nose is the organ of smell and has sensory epithelium with hair-like cilia on its cells that pick up stimuli by chemicals dissolved in the mucous lining.
- The sense organ of taste is the tongue. The tongue is made up of about 10,000 taste buds containing groups of sensory cells with hair-like cilia that pick up stimuli by molecules of food dissolved in saliva.
- Situated at different levels in the skin are different types of receptors such as touch receptors, pressure receptors, pain receptors' and temperature receptors.
- All sense organs require proper care.
- The functions of the body are coordinated by the nervous and endocrine systems; the first bringing about nervous coordination, while the second bringing about chemical coordination.
- Voluntary actions originate in the brain and are under conscious control.
- Reflex actions are involuntary actions caused by external or internal stimulations, over which there is no conscious control.
- A reflex action involves a reflex arc that consists of a receptor, a sensory neuron, an association neuron, a motor neuron and an effector—usually a muscle or a gland.
- The autonomic nervous system controls and coordinates the involuntary functions of the body.
- The anterior lobe of the pituitary—master gland of the endocrine system—controls all other endocrine glands scattered in the body.

EXERCISES

I. Review questions

A. Fill in the blanks

1. The central nervous system consists of ..... (glands/brain) and spinal cord.
2. Colour-sensitive cells in the retina are called ..... (rods/cones).
3. ..... (Ossicles/Semicircular canals) in the ear help us in maintaining our balance.
4. Adrenal glands are situated just above the ..... (brain/kidneys).
5. Insulin is secreted by the ..... (thyroid gland/pancreas).

B. Tick the correct answer

1. Regulates the amount of light entering the eye:
   (a) lens (b) choroid (c) cornea (d) pupil
2. The outer layer of skin:
   (a) dermis (b) epidermis (c) sclera (d) cornea
3. Largest region of the brain:
   (a) hypothalamus (b) cerebellum (c) cerebrum (d) medulla
4. Neuron that carries impulses towards the brain or spinal cord:
   (a) spinal neuron (b) motor neuron (c) sensory neuron (d) motor neuron
5. The master gland:
   (a) adrenal (b) pituitary (c) thyroid (d) brain

C. Correct the statements that are false

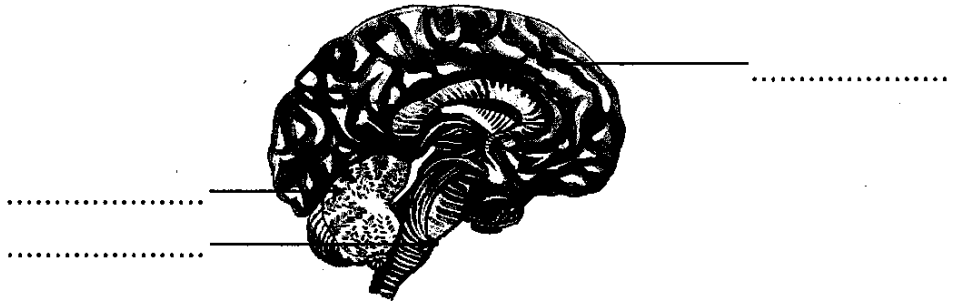
1. The spinal cord is not involved in reflex actions.
2. The spinal cord is protected by the backbone.
3. Insulin is secreted by the pancreas.
4. Adrenalin is secreted by the pituitary gland.
5. Oestrogen is secreted by the thyroid gland.

B. Answer the following

1. What is the importance of the sense organs?
2. Describe the structure of the human eye with the help of a labelled diagram.
3. Draw a diagram of the human tongue, showing the locations of different taste receptors.
4. List any three ways in which we can take care of our eyes.
5. How does the body respond to (a) hunger and (b) fear?
6. Name the three parts of the nervous system.
7. What are reflex actions? Which part of the nervous system is involved in reflex actions?
8. What is a reflex arc? Name the three kinds of nerve cells involved in a reflex arc.
9. What are hormones? Name the hormones secreted by the thyroid gland and testes.
10. Where are adrenal glands located? Name the hormones secreted by the adrenal glands.

II. Skill-based questions

E. Insert the missing labels in the following diagram:



F. Arrange the following in the correct sequence:

1. A sensory neuron conducts the impulse from the receptor to the spinal cord or the hind brain. .....
2. A receptor (sense) receives a stimulus.....
3. The motor neuron passes the impulse on to an effector (muscle), which takes the action in response to the stimulus.....
4. An association neuron transmits the impulse from the sensory neuron to a motor neuron. .....

III. Fun Time

Unscramble the following words (Hint: You must have come across these terms in this chapter.)

CREASPAN **ROIDYTH** **UTIPYRATI** **MUYTHS**

PROJECT IDEAS

- Students can make a model of the brain using modeling clay. They can use different colours to indicate each region of the brain.
- Students can make a chart on endocrine glands.

TEACHER'S NOTES

- Students get an opportunity to have a working knowledge of the sense organs in their own bodies—relating what they learn in theory to actual working situations, making the study more meaningful. This aspect may be stressed and used to the maximum.
- Nervous coordination and the action of the emergency hormone could also be studied with reference to personal experiences.
- A commonly held misconception is that the brain is firm and grey in colour. The living brain is however soft, jelly-like, and deep red.

Website References

http://www.bbc.co.uk/schools/gcsebitesize/biology/humansasorganisms/4nervoussystemrev4.shtml [animation] (accessed 29 May 07)