17

COORDINATION AND CONTROL : THE NERVOUS AND ENDOCRINE SYSTEMS

Every organism performs movements and a number of other tasks for its survival. Besides, several other actions are continuously occurring inside the body that need to be properly timed and coordinated. All this is the outcome of two organ systems – the nervous and the endocrine (hormonal) systems.

OBJECTIVES

After completing this lesson, you will be able to :

- *describe the functions of the nervous system and list its subdivisions;*
- *list, draw and label the major parts of the human brain and spinal cord and explain their functions;*
- *describe the nervous system of cockroach*
- *explain the structure of a neuron, a nerve and describe the conduction of impulse through a nerve fibre and across the synapse;*
- *define reflex action and draw the components of the reflex arc;*
- *list various sensory receptors in human body and describe the structure and functioning of the sense organs–eye, ear, nose, tongue and skin;*
- *distinguish between exocrine and endocrine glands;*
- *list various endocrine glands and locate their position in human body;*
- *identify properties of hormones and mention their nature and manner of functioning;*
- *differentiate between hormones and pheromones;*
- *name the various hormones secreted by pituitary, thyroid, parathyroid, thymus, adrenals, pancreas and reproductive organs in humans and mention their functions;*
- *relate the hormonal imbalance with hormone related disorders in humans;*
- *state the effects of over functioning (hyperactivity) and hypoactivity (underfunctioning) of pituitary and thyroid;*
- *explain the feedback mechanism of hormonal control.*

17.1 FUNCTIONS OF THE NERVOUS SYSTEM

The major functions of the nervous system in humans are as follows:

(i) It keeps us informed about the outside world through the sense organs.

(ii) It enables us to remember, think and to reason out.

(iii) It controls all voluntary muscular activities like running, speaking etc.

(iv) It regulates several involuntary activities such as breathing, beating of the heart, movement of food through the food canal, etc.

Thus, the nervous system makes our body parts work together in proper coordination, as one single integrated unit.

Some basic terms

Before you learn about the various aspects of the nervous system, get familiar with the following related terms.

Stimulus : an agent or a sudden change of the external or the internal environment that results in a change in the activities of the organism.

Impulse : a wave of electrical disturbance that travels accross the nerve cell and its fibre.

Response : a change in the activity of the organism caused due to stimulus.

Receptors : The nerve cells which on receiving the stimulus, set up wave of impulses towards the central nervous system (brain and spinal cord).

Effectors : muscles or glands, which on receiving the impulse from the brain or spinal cord contract or secrete substances.

Nerve : A bundle of axons (nerve fibres) of separate neurons connecting the central nervous system with other parts of the body.

Sensory (afferent) nerve or the cell : bringing the impulse from the receptor (sensory organ) to the main nervous system.

Motor (efferent) nerve or the cell : Carrying the impulse from the main nervous system towards a muscle or a gland.

17.1.1 Nervous System in Animals

Various activities of an animal's body are controlled and coordinated through two systems viz. the nervous system and the endocrine system. We will discuss the nervous system of cockroach here. A detailed account of the nervous system in humans is given in your text book lesson 16: module 2: Book l. Recall that the nervous system basically consists of two parts:

(i) Central nervous system

(ii) Peripheral nervous system

The nervous system of cockroach also follows the same basic plan and consists of:

(i) Central nervous system

(ii) Peripheral nervous system

(iii) Sympathetic or visceral nervous system

Central Nervous System

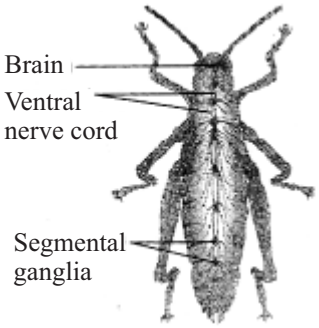
It consists of **brain** or **supra-oesophageal ganglion** that lies above the oesophagus in the head. A **sub-oesophageal ganglion** lies below the oesophagus and is formed. The brain gives off a pair of short and stout **circumoesophageal connectives** that meet the sub-oesophageal ganglion. A double ventral **nerve cord** extends from the sub-oesophageal ganglion. It bears three thoracic and six abdominal ganglia (See figure below).

Peripheral Nervous System

It consists of nerves which are given off from the ganglia so as to innervate all the parts of the body (See the figure).

Sympathetic Nervous System

It consists of frontal ganglion and a visceral ganglion. Various nerves are given are given off from the visceral ganglion.



Nervous System of Cockroach

(a) **Central Nervous System (CNS),** consisting of brain and spinal cord. It is the site of information processing (receiving information and responding to it).

(b) **Peripheral Nervous System (PNS),** consisting of all the nerves entering and leaving the brain and the spinal cord.

Further division of these two components is shown in Fig. 17.1.

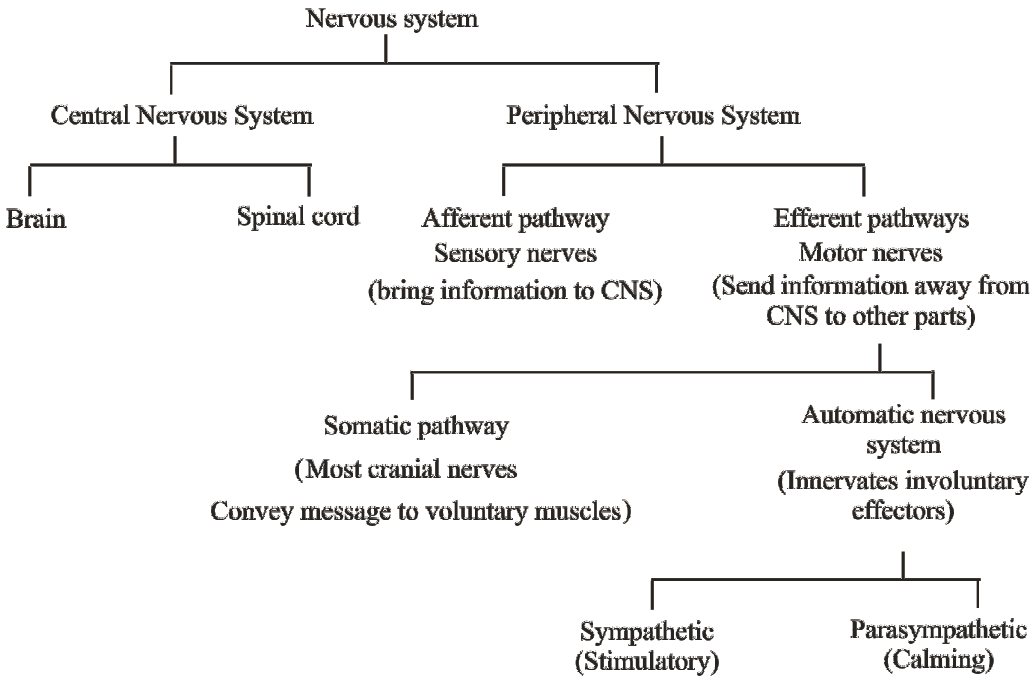


Fig 17.1 The basic components of nervous system

17.4 NERVOUS SYSTEM OF HUMANS

The central nervous system of humans includes a highly developed brains and spiral card (Fig. 17.1). Peripheral Nervous system is made of nervous as shown in Fig. 17.1.

17.4.1 The Brain

The brain is a very delicate organ lodged inside the cranium of the skull (Fig.17.2a) It is protected by three coverings, the **meninges** (meninx: membrane): an outer tough **duramater** (dura: tough; mater: mother), a thin delicate web-like middle **arachnoid** (arachne: spider), and the innermost highly vascular **piamater** (pia: tender) richly supplied with blood vessels. The space between the membranes is filled with a fluid called **cerebrospinal fluid**. There are cavities inside the brain, which are also filled with the same fluid.

The brain consists of three main regions:

(i) ***forebrain*** consisting of cerebrum and diencephalon,

(ii) ***midbrain*** a small tubular part between the fore and the hindbrain,

(iii) ***hindbrain*** consists of cerebellum, pons, and medulla oblongata.

The individual parts of the brain are described below:

(a) **Cerebrum.** This is the largest part of the brain, divided into two (the right and the left) parts called **cerebral hemispheres**. Their outer surface is highly convoluted with ridges and grooves. Each hemisphere is hollow internally and the walls have two (an inner and an outer) regions. The outer region (cerebral cortex) contains cell bodies of the nerve cells and being grayish in colour it is called ***gray matter***. The inner region is composed of whitish axon fibres and is called the ***white matte***r. **Corpus callosum** is a sheet of cris-cross nerve fibres connecting the two cerebral hemispheres (Fig. 17.2b). Left side of the cerebrum controls the right side of the body and vice-versa.

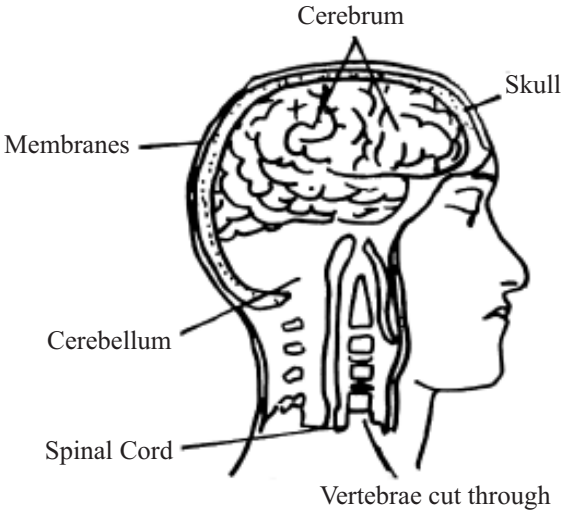


Fig. 17.2 (a) Brain lodged inside cranium

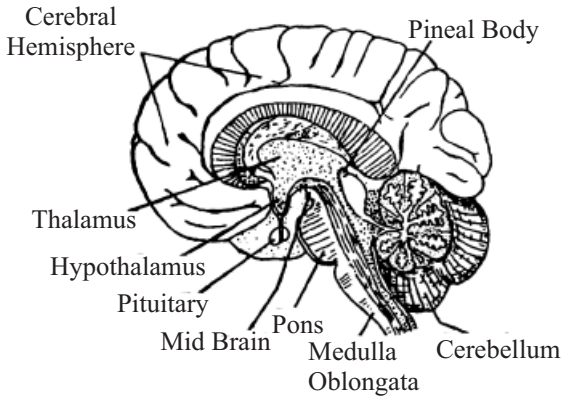


Fig. 17.2 (b) brain in median section.

The **cerebral cortex** has three main functions:

(i) It controls and initiates voluntary muscle contractions.

(ii) It receives and processes information form the sense organs, like eyes, ear, nose etc.

(iii) It carries out mental activities of thinking, reasoning, planning, memorizing etc.

(b) **Diencephalon.** This is the part of the forebrain lying below the cerebrum. It consists of the following two parts;

1. **Thalamus.** This is an egg shaped mass of gray matter, located in the centre below the cerebrum. It is the relay centre for sensory impulses (e.g. pain and pleasure) going to the cerebrum.

2. **Hypothalamus.** This is a region of the brain located below thalamus. It controls motivated behavior such as eating, drinking and sex. It controls the secretions of pituitary gland hanging below it. It also serves as the regulation centre of body temperature and body fluids (see lesson 17).

(c) **Cerebellum.** The cerebellum is a smaller region of the brain located at the base and under the cerebrum. It has numerous furrows. It also has a cortex of gray matter. Its two main functions are.

(i) to maintain the balance of the body, and

(ii) to coordinate muscular activities.

(d) **Medulla oblongata.** This is the last part of the brain, which is connected to the spinal cord. Its functions are as follows:

(i) It is the cente for breathing, coughing, swallowing, etc.

(ii) It controls heartbeat, the movement of alimentary canal and many other involuntary actions.

In all, **12 pairs of nerves** (cranial nerves) come out of the brain, some of these are sensory, some motor and some are of mixed type.

17.4.2 The Spinal cord

The spinal cord extends form the medulla of the brain downward almost the whole length of the backbone. It is also wrapped in the same three meninges as the brain and the space between them contains the same cerebrospinal fluid. The arrangement of the white and gray mater is reversed in it i.e. white matter is outside and the gray matter inside.

Fig. 17.6 shows the general structure of the spinal cord as seen in its cross section. It also shows the manner in which the spinal nerves originate from it.

Functions of spinal cord.

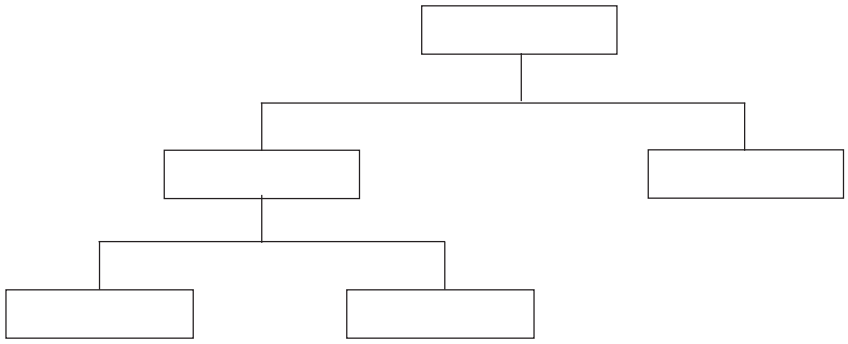
(i) Carry out reflexes below the neck,

(ii) Conducts sensory impulses from the skin and muscles to the brain,

(iii) Conducts motor responses from the brain to the trunk and limbs.

INTEXT QUESTIONS 17.1

1. With the help of a flow chart write down the basic components of the nervous system in the space given below.



2. Name the ganglia which
   (a) forms the brain
   (b) lies below the oesophagus and is joined to brain.
3. Which part of nervous system of cockroach can be compared to our spinal cord though our spinal cord is dorsal and this part of nervous system of cockroach is ventral?

Notes

4. Name the main parts of the brain.

.....

5. Mention the one functions each of :

   (i) Cerebrum .....

   (ii) Cerebellum .....

   (iii) Medulla oblongata .....

   (iv) Hypothalamus .....

6. What are the

   (i) gray matter, and .....

   (ii) white matter made of? .....

7. Name the fluid in the cavities of the brain.

.....

17.4 PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system consists of all nerves arising from the brain and the spinal cord. Overall, it consists of two kinds of pathways: the afferent (receiving) sensory pathways and efferent (carrying aways) motor pathways.

A. The **afferent (receiving/sensory) pathways** are included in two kinds of nerves.

- Purely sensory nerves, for example the cranial nerves received from the eyes, ears, nose, etc.
- Mixed cranial nerves like the fifth (facial nerve) which contains sensory fibres bringing sensations from the face but it also contains motor fibres which carry impulses away to the jaw muscles.

B. The **efferent (sending) pathway** may be subdivided into somatic and autonomic nervous systems.

(i) **The somatic nervous system** controls the voluntary muscles. It includes most **cranial nerves** as well as the motor nerve fibres of the **spinal nerves**. Both these convey message from the CNS to the **voluntary muscles**.

(ii) **Autonomic nervous system** (ANS). This innervates the involuntary muscles and the glands. It consists of a pair of chains of ganglia and nerves on either sides of the backbone (Fig. 17.3) This system is essentially a motor system, which regulates the involuntary actions of the internal organs. It consists of two parts: (a) Sympathetic nervous system and (b) parasympathetic nervous system. (Fig. 17.3).

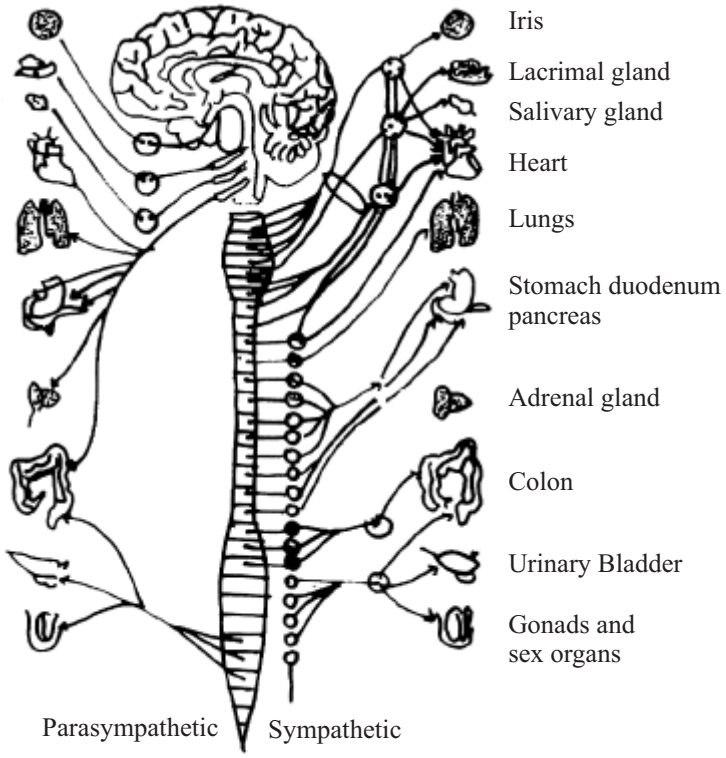


Fig. 17.3 Autonomic nervous system - sympathetic and parasympathetic

Sympathetic nervous system prepares the body for facing emergency situations and the **parasympathetic nervous system** reestablishes the normal conditions once the emergency is over.

The opposite effects of the two subdivisions of the autonomic nervous system on the different organs are listed below in the table 17.1.

Table 17.1 Effects of autonomic nervous system

Organ	Effect of Sympathetic Activity	Effect of Parasympathetic activity
1. Eye pupil	Dilated	Constricted
2. Heart beat	Speeded up	Slowed down
3. Blood vessels		
a. on skin	Constricted	Dilated
b. on muscles	Dilated	No effect
4. Bronchioles	Dilated	Constricted
5. Urinary bladder	Muscles relaxed	Muscles contract (feeling of urination)
	Sphincter contracted	Sphincter relaxed
6. Sweat secretion	Increased	No effect

7. Blood sugar	Increased	No effect
8. Salivary secretion	Stops	Increased
9. Tear glands	Activated	Slowed down
10. Erector muscles of skin hair	Stimulated (hair raised)	Relaxed (hair flattened)
11. Adrenal glands	Increased secretion of Adrenalin	No effect
12. Intestine	Peristalsis decreased	Peristalsis increased
13. Stomach glands	Decreased secretion	Increased secretion

The autonomic nervous system is strongly influenced by emotions such as grief, anger, fear, sexual stimulation, etc.

INTEXT QUESTIONS 17.2

1. What are the two subdivisions of the autonomic nervous system?

   .....

2. Name the specific subdivisions of the autonomic nervous system concerned with the following:

   (i) Slowing down heart beat .....

   (ii) Increasing salivary secretion.....

   (iii) Dilatation of the pupil .....

   (iv) Increasing intestinal peristalsis .....

   (v) Muscle contraction of the urinary bladder giving the feeling the need for urination. .....

3. Why is the peripheral nervous system called so?

   .....

4. State the alternative terms for sensory and motor nerves.

   .....

17.5 NEURON – THE STRUCTURAL AND FUNCTIONAL UNIT OF NERVOUS SYSTEM (FIG. 17.4)

You have already studied about the nerve cell. This is to refresh your memory for relating the structure of the neuron with the conduction of nerve impulse.

- The **cell body** contains nucleus and cell organelles in the cytoplasm.

- **Dendrites** (short branching processes) extend out from the cell body. They bring signals (impulses) from the receptor or from the axon endings of another neuron. There may be as many as 200 dendrites in a single neuron allowing as many connections with the axon endings of other neurons.
- A long **nerve fibre or axon** carries the impulse from the cell body towards its terminal branches which may either pass on the impulse to another neuron, or into a muscle or gland to bring about the required action. Synapse is the point of communication between one nerve cell and another or between nerve cell and a muscle.
- A sheath of fatty material (myelin) often covers the axon, and such nerve fibres are called medullated or myelinated fibres.

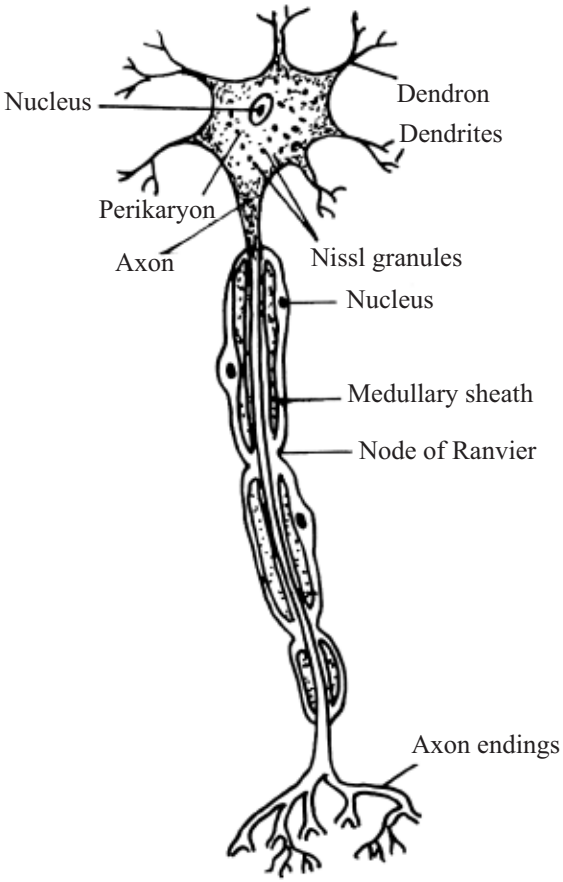


Fig. 17.4 The nerve cell

17.6 CONDUCTION OF NERVE IMPULSE ALONG THE NEURON AND OVER THE SYNAPSE

The conduction of nerve impulse through the nerve fibre is electrical in nature and the one through the synapse is chemical in nature.

A. Along the neuron–Electrical Signalling

The transmission (moving from one end to another) of the nerve impulse through the nerve fibre is electrochemical. It is not simply a flow of electrons through an electric wire but it travels as a wave of **depolarization** (Fig. 17.5). Read the following to understand depolasis atom.

In normal resting condition the outside of the nerve fibre carries positive (+) charge. In this condition nerve fibre is said to be polarized. The polarization is due to the presence of more Na^+ ions outside the cell membrane. Such state is maintained due to the sodium ions being continuously pumped out by means of the **sodium potassium pump** and operated by **active transport** using ATP for energy.

> **Sodium potassium pump** is a carrier protein on the plasma membrane which transports sodium and potassium ions across the membrane. Normally ions move from the region of their high concentration to the region of their low concentration.

The changes when a stimulus arrives at the nerve fibre are as follows:

- The axon membrane at that spot becomes more permeable to Na^+ ions, which move inward and bring about **depolarization** or localised change of charge from positive to negative (see diagram) on that spot.
- This point of depolarization itself becomes the stimulus for the adjoining area of the membrane, which in turn becomes depolarized.
- Meanwhile the previous area becomes repolarized due to active movement of the sodium ions to the outside of the membrane by means of what is called 'sodium pump'.
- And now the fibre is ready for the next wave of depolarization.

Thus a nerve impulse is a self- propagating wave of depolarization and repolarization

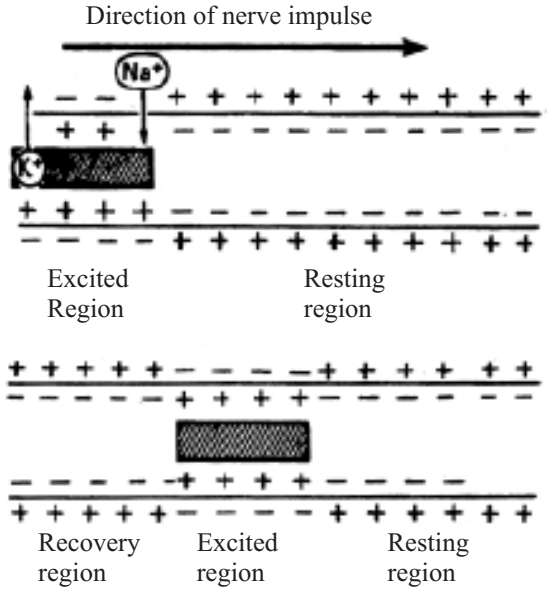


Fig. 17.5 Conduction of nerve impulse.

B. Over the Synapse – Chemical Signalling

The impulse travelling through a nerve fibre may reach either its destination. (muscle or gland) for action or the dendrites of another neuron for further transmission. The meeting place is called **synapse**. The transmission over a synapse is a chemical process. As the impulse reaches the terminal end of the axon, the following events occur :

– a chemical acetylcholine is released by the end of the axon.
– acetylcholine stimulates the next neuron to start the new impulse.
– acteylcholine is soon broken down there to make the synapse ready for the next transmission.

In case the axon endings are branched and in contact with the dendrites of other neurons the impulse will travel through all of them.

'**All or none**' **principle.** If the stimulus is strong enough (with a minimum threshold) to produce the impulse, the impulse will set up and travel at its own speed. Threshold is the minimum strength of a stimulus that can initiate an impulse. ***Increasing the intensity of the stimulus cannot raise the speed of transmission***.

17.7 REFLEX ACTION

Reflex action is an automatic, quick and involuntary action in the body brought about by a stimulus. For example,

- You instantaneously withdraw your hand on accidentally touching a hot plate or a sharp thorn.
- Watering (salivation) of the mouth takes place on seeing or just smelling a familiar tasty food.

Two types of reflexes – simple and conditioned

The two examples of reflex action given above are basically different. The first one is inborn or natural, which did not require previous learning. Such reflexes are called **simple reflexes**.

The other example is the outcome of repeated experience. Here the brain actually remembers the taste of food and works in an unconscious manner- such reflexes are called **conditioned reflexes**.

Some other examples of reflexes are as follows:

(A) Simple Reflex

- **Quick closing of eyelids** on noticing an object suddenly approaching the eye.
- **Coughing** when the food swallowed enters the windpipe instead of the food pipe.
- **Narrowing of the eye pupil** in strong light.
- If the foot of sleeping person is tickled, it is **jerked away.**

(B) Conditioned Reflexes

- **Applying brakes** in your vehicle (car or bicycle) on noticing someone suddenly coming in front of it.

- **Tying shoe laces** while talking to someone, not knowing whether you are first putting the left lace over the right or the vice versa.
- **A dog runs away** if it notices you kneeling down as if you are picking up a stone for striking.
- **Standing up on** seeing the teacher entering the classroom.

Mechanism of Reflex Action

Some reflexes are brought about through the brain (cerebral reflexes) such as the closing of the eyelids due to approaching objects while other are brought about through the spinal cord (spinal reflexes). The pathway in a simple spinal reflex action is represented in the diagram below (Fig.17.6).

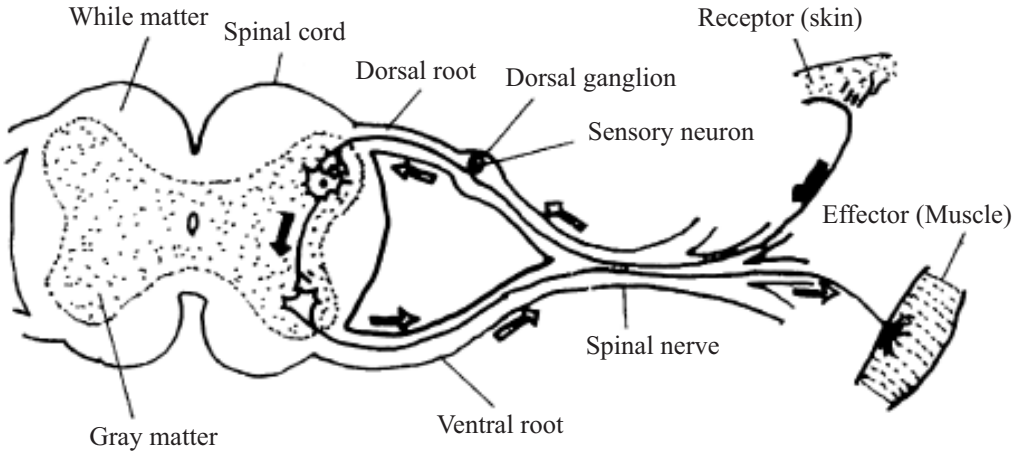


Fig. 17.6 Nerve pathways in a simple reflex action

In this, there are five necessary parts:

The stimulus (prick, heat etc.) → receptor in the sensory organ → the afferent (sensory) nerve fibre running through the dorsal root of the spinal nerve bringing the impulse into the spinal cord → a (motor) neuron sending out the command through its efferent fibre in the ventral root of the spinal nerve → a muscle or the gland.

Mostly there occur an **intermediate neuron** between the axon ending of the afferent fibre and the motor neuron inside the spinal cord.

INTEXT QUESTIONS 17.3

1. Given below are a few examples of reflexes. Write against each, the category of reflex, whether simple or conditioned.

   (i) Knee jerk .....

(ii) Salivation on seeing a favorite dish .....

(iii) Tying of shoe laces while talking .....

(iv) Closing of eyelids if a strong beam of light is flashed across .....

(vi) Mistaking a coiled rope as snake if you happen to step on it in darkness .....

17.8 SENSORY RECEPTORS (THE SENSE ORGANS)

Sense organs are the organs through which we sense or detect changes in the external environment. Each sense organ has special sensory cells, which receive the stimuli and transmit the impulses produced through the concerned nerve to the brain or the spinal cord. The brain sorts out the impulses, interprets them and transmits message for the required response. In human there are typically five sense receptors, eyes for seeing, ears for hearing, nose for smelling, tongue for taste and skin for sensing touch, pain, heat, etc.

17.8.1 The Eye (the sense of vision)

The eye is nearly spherical in shape, bulging a little in front, and is able to rotate freely in the bony socket. It is a hollow ball containing several structures inside (Fig.17.7).

The wall of the eyeball is made up of three layers: the sclera, choroid and retina.

- **Sclera** is the outermost tough white layer. In front it is continued as the transparent **cornea**.
- **Choroid** is the middle layer. It is composed of connective tissue having a dense network of blood vessels. Its inner surface is dark brown or black. This prevents reflection, which would otherwise interfere with the clarity of the image.

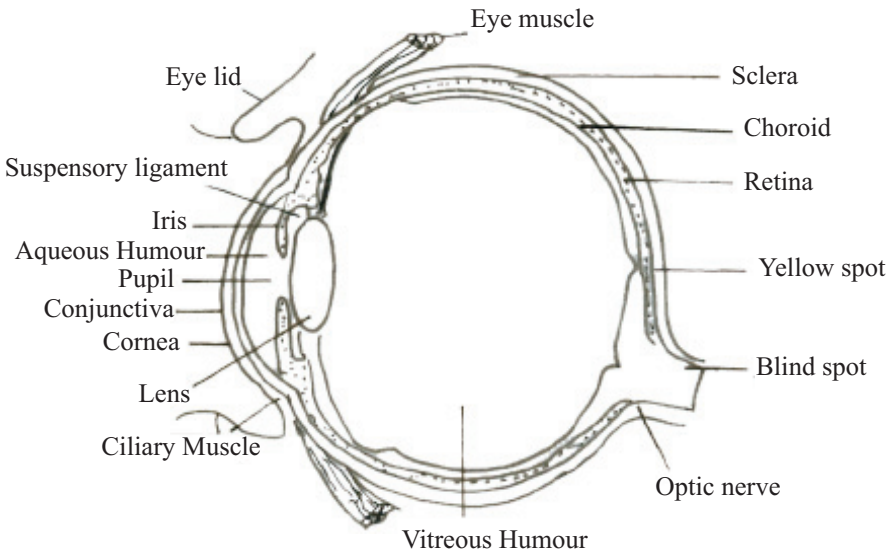


Fig. 17.7 Vertical section of the human eye

- **Retina** is the innermost sensitive layer. It contains two kinds of sensory cells– the **rods** (sensitive to dim light) and **cones** (sensitive to bright light and colours).
  - **Yellow spot** lying at the visual axis is the place of best vision in the normal eye. It contains maximum number of sensory cells and particularly the cone. The rest of the retina has fewer cones and more rods.
  - **Blind spot** is the point where the nerve fibres (axons) from all the sensitive cells of the retina converge to form the optic nerve which connects the eye to the brain. There are no sensory cells at the blind spot and any image formed here is not perceived.

The parts of the eye

Internally the eye is divided into two main chambers separated by the lens.

- **Aqueous chamber** is the front part containing a watery fluid (**aqueous humour**) and **vitreous chamber** is the back part containing a thick jelly like glassy substance (**vitreous humour**, *vitro* : glass). The aqueous humour keeps the lens moist and protects it from physical shocks. The vitreous humour helps in maintaining the shape of the eyeball and protects the retina.
- The **lens** is biconvex in shape and semi-solid. It is composed of soft gelatinous tissue. It is held in position by suspensory ligament, which attaches it to the muscular **ciliary body**. The shape of the lens is influenced by the amount of tension in the suspensory ligament.
- **Iris** is a sort of circular curtain in front of the lens. It is black, brown or blue. The colour of the eye is the colour of its iris. It contains two kinds of muscles : **circular muscles** for narrowing the pupil, and **radiating muscles** for dilating it. The size of the pupil is adjusted involuntarily to control the amount of light entering the eye. Can you think of the situations when the pupil gets narrower and when it becomes wider?

How Do We See

- **Transmission of light :** Reflected light rays from the object enter the eyes through the transparent structures of the eye i.e. conjucativa, cornea, aqueous humour, lens and vitreous humour.
- **Formation of image**. The curvature of the cornea bends the rays to some extent and the lens bends them further to form an image on the retina.
- **Nature of image**. The image is inverted and real.
- **Production of nerve impulse and its transmission**. The light energy of the image produces chemical changes in the sensory cells (rods and cones). These changes produce nerve impulses, which travel through the optic nerve and reach the brain.
- **Perception.** The brain interprets the image in many ways; e.g. it sees the object vertical although the actual image formed is inverted.

- **Accomodation (focusing)**. Focusing the image on retina is called **accommodation**. Changing the curvature of the elastic lens brings about accommodation.
  - **For distant vision :** The lens is more flattened or thinner; this is the normal condition of the lens, which is kept stretched by the suspensory ligaments.
  - **For near vision :** The ciliary muscles which are circular, contract and tend to reduce the circumference of the eyeball there. This releases the tension on the suspensory ligament and the lens becomes thicker (more rounded) on account of its own elasticity.

> A normal eye is constantly accommodating while walking, playing or just looking around.

- **Binocular vision**. In all primates including humans, both eyes are placed forward. Each eye views at a slightly different angle. The images from the two eyes are perceived overlapped inside the brain giving the impression of depth (3-dimensional/stereoscopic vision).

Three Common defects of the eye

1. **Near sightedness (Myopia).** Nearby objects are clearly seen but not the distant ones by those suffering from myopia because the image of the object is formed in front of the retina. This can be corrected by using concave lens (worn in frames (spectacles) or as contact lenses).
2. **Long sightedness (Hypermetropia).** Distant objects are clearly seen but not the nearby because the image of the object is formed behind the retina. This can be corrected by convex lens (worn in frames as spectacles or as contact lenses).
3. **Cataract (opacity of the lens).** The lens usually loses its transparency and turns opaque with age. Such a lens can be surgically removed and replaced by an intra-ocular lens.

INTEXT QUESTIONS 17.4

1. State the function of the following parts of the eye:
   (i) Iris .....
   (ii) Ciliary muscles .....
   (iii) Pupil .....
   (iv) Vitreous humour .....
   (v) Retina .....

Notes

2. Name the following:
   (i) Area of sharp vision in the eye .....
   (ii) The kind of lens used for correcting near-sightedness .....
   (iii) The condition in which the lens of the eye turns opaque .....
   (iv) The capacity of eye to focus objects at different distances .....

17.8.2 The Ear-Sense of Hearing and Balance

The ear serves two sensory functions: hearing and maintaining balance of the body. The ear has three main parts – external ear, middle ear, and internal ear (Fig. 17.8)

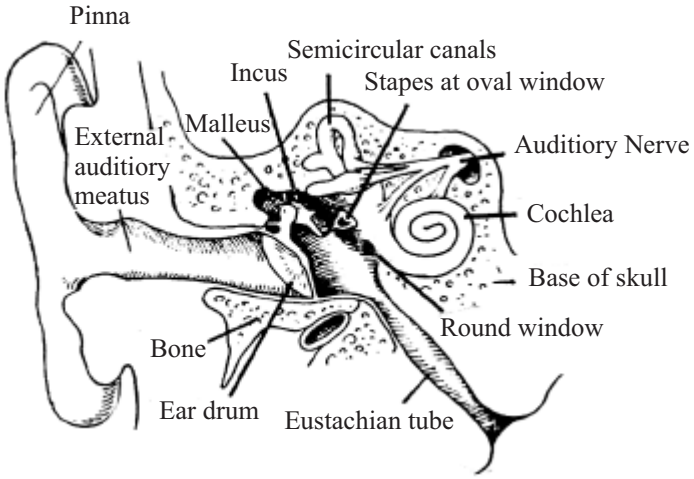


Fig. 17.8 The human ear.

The **external ear** consists of the following :

– an outwardly projecting ear to be called **pinna** supported by cartilage. It directs the sound waves inwards.

– The **auditory canal** through which the sound waves travel up to the ear drum (tympanic membrane)

The **middle ear** consists of the following:

- An air-filled tympanic cavity
- The **tympanum** or ear drum
- Three tiny bones-**malleus** (hammer) connected to the ear drum, incus (anvil) in between and **stapes** (stirrup) forming a contact with the oval window of the internal ear.
- **Eustachian tube** connects the tympanic cavity with pharynx. It equalizes the pressure on both sides of the eardrum or tympanum :

The **internal ear** contains two main parts:

(a) **Cochlea** – It is a long coiled structure which looks like the coils of the shell of a snail. It has two and a half turns. The inner winding cavity of the cochlea is divided into three parallel tubes of canals separated by membranes. The canals are filled with a fluid called endolymph. The middle canal possesses sensory cells (organ of corti) for hearing.

(b) **Vestibule** – is concerned with physical balance of the body. It consists of three **semicircular canals** arranged at right angles to each other and a part joining the cochlea and differentiated into a **utriculus** and a **sacculus**. One end of each semicircular canal is widened to form an **ampulla,** which contains sensory cells, and the nerve fibres from them continue into auditory nerve.

Mechanism of hearing

- The sound waves enter the auditory canal and cause the eardrum to vibrate
- The vibrations of the eardrum are transferred to malleus, to incus, and then to stapes. Stapes transfers the vibrations through oval window into the cochlea.
- These vibrations move the fluid in the cochlea. The organ of corti catches the movement of the fluid and transfers it to the auditory nerve that carries the impulses to the brain

Perception of body balance

Static balance due to gravity – Any bending or change in the body posture causes the fluid inside the semicircular canals to move. The semi circular canals are arranged in different planes. The sensory hairs in the ampulla of the canal pick up these movements and the impulses are transmitted through the auditory nerve.

Balance during motion – Utriculus and sacculus perceive dynamic equilibrium (while the body is in motion). Fine particles of calcium carbonate present in the endolymph press on the sensory hairs whenever the body is in some motion. The impulses are carried through the auditory nerve.

17.8.3 Tongue and Nose (Sense of taste and smell)

The tongue perceives the taste and the nose perceives the smell. The perception depend upon the nature of chemical substance coming in contact with the sensory cells. For taste there is a direct contact of the substance with the sensory cells located in the taste buds on the tongue. For smell, the molecules of the chemical are carried inward by the air inhaled and they stimulate the sensory epithelium of the nose.

17.8.4 Skin (Touch and some other miscellaneous senses)

There are a variety of nerve endings in the skin. Some of these are concerned with touch (gentle pressure), some with deep pressure and others with cold, heat and pain.

The sense of hunger is due to receptors in the stomach wall. The sense of thirst is due to stimulation of nerves in the pharynx. And the sense of fatigue is located in the muscles.

INTEXT QUESTIONS 17.5

1. Which part of the ear is involved when:
   (i) a gymnast performs various balancing feats. .....
   (ii) you hear a song. .....