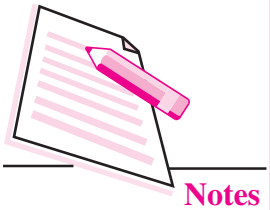

Notes

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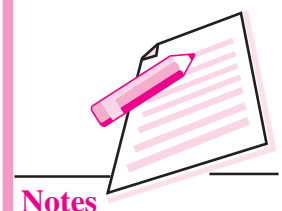
COORDINATION AND CONTROL : THE NERVOUS AND ENDOCRINE SYSTEMS

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 1. 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

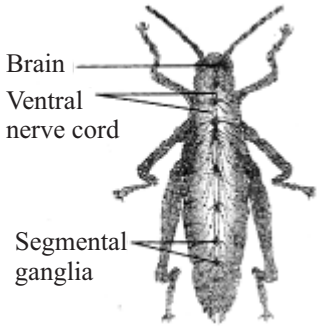
It consists of **brain** or **supra-oesophageal ganglion** that lies above the oesophagus in the head. A **sub-oesophageal ganglion** lies below the oesophagus and is formed. The brain gives off a pair of short and stout **circumoesophageal connectives** that meet the sub-oesophageal ganglion. A double 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.

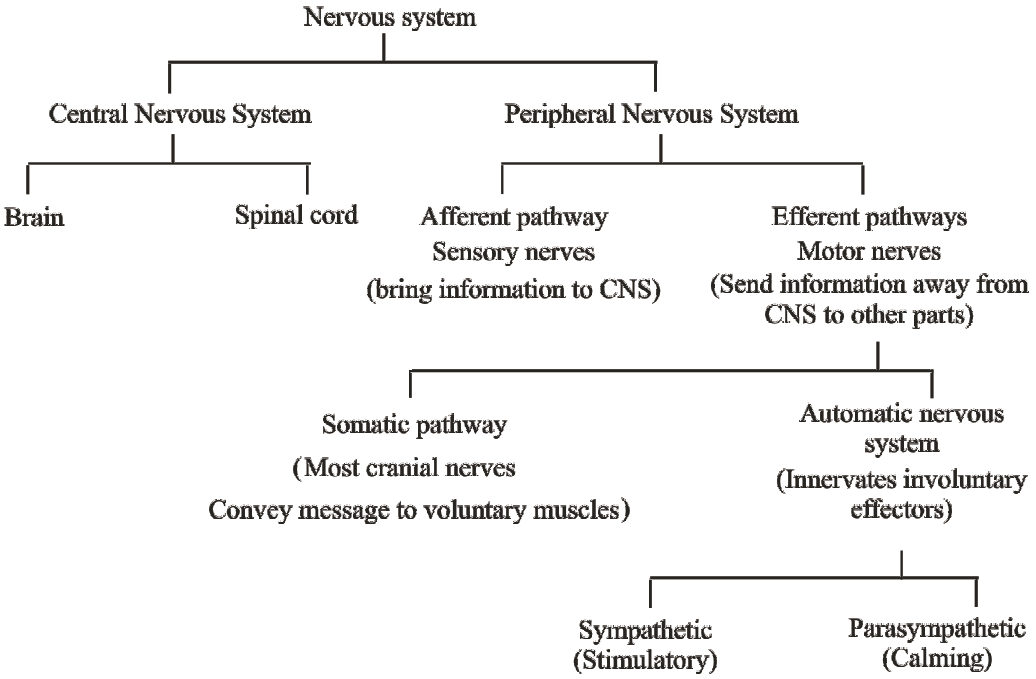
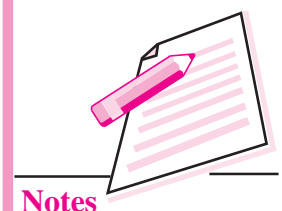


Fig 17.1 The basic components of nervous system



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.

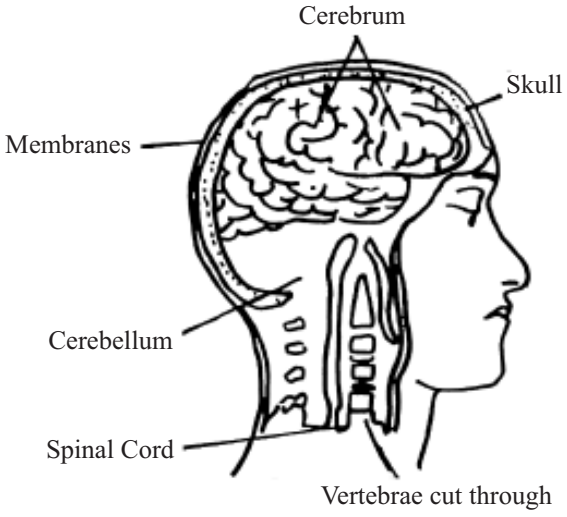


Fig. 17.2 (a) Brain lodged inside cranium

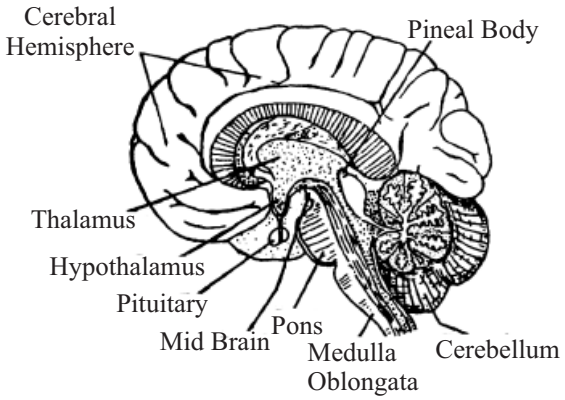


Fig. 17.2 (b) brain in median section.

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.

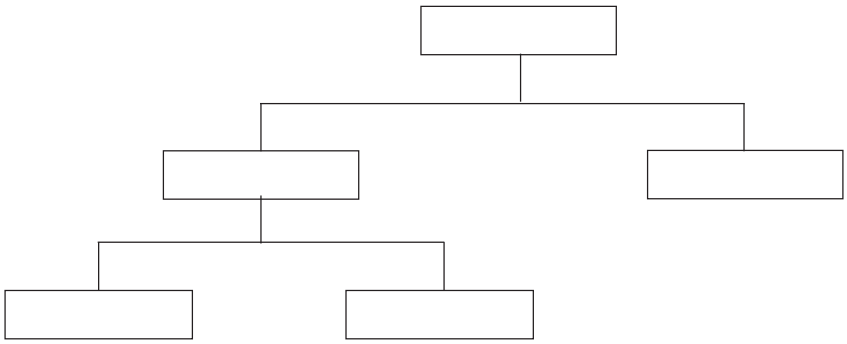
(i) Carry out reflexes below the neck,

(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?

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).

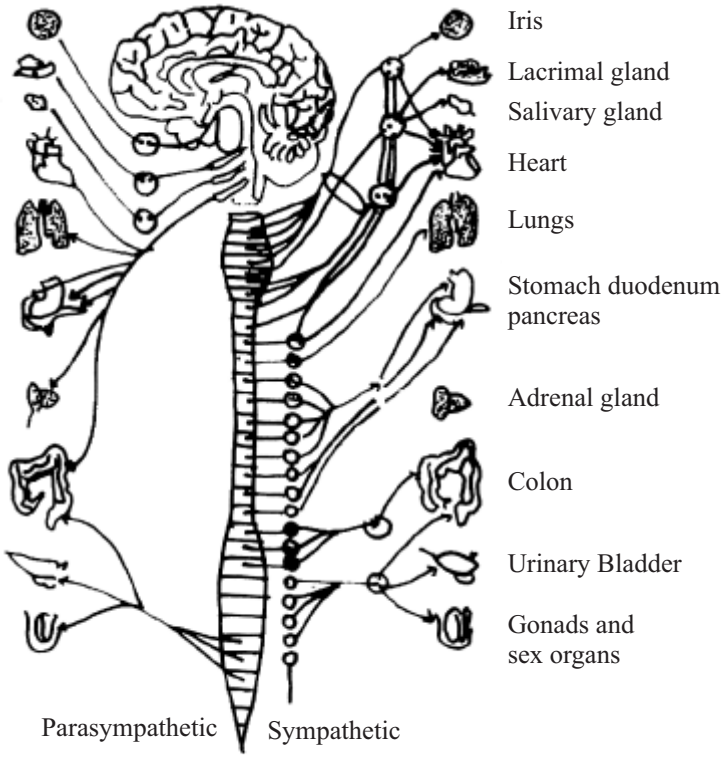


Fig. 17.3 Autonomic nervous system - sympathetic and parasympathetic

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.

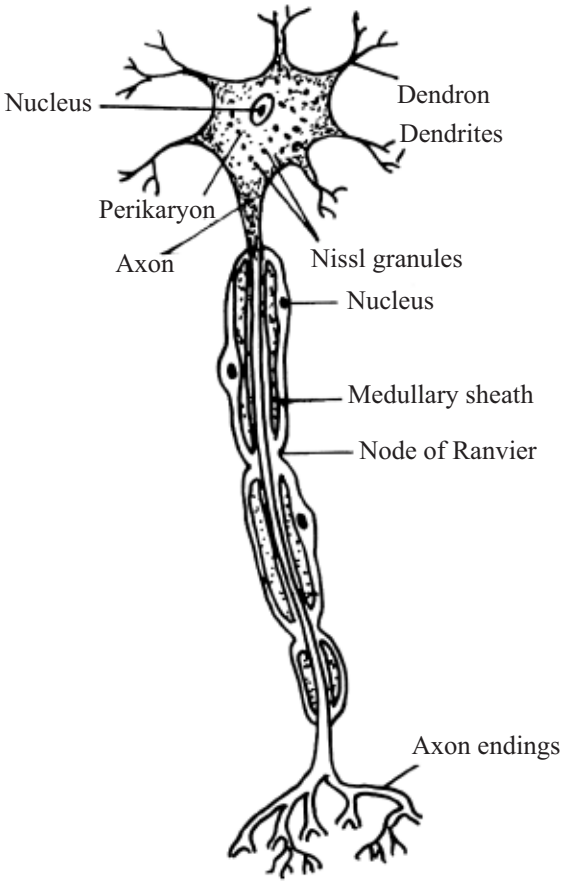


Fig. 17.4 The nerve cell

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

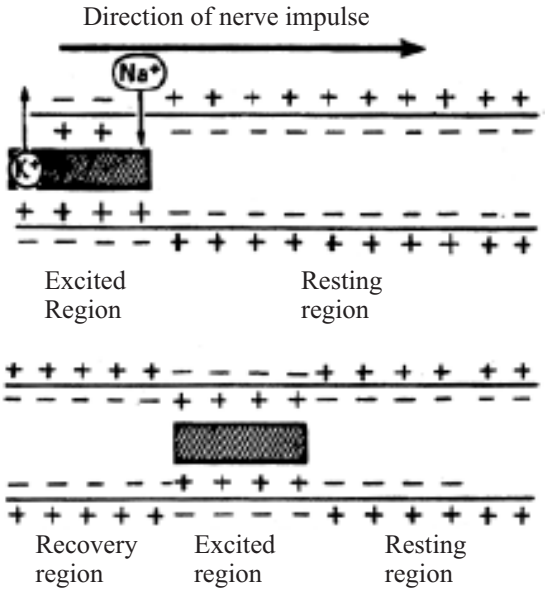


Fig. 17.5 Conduction of nerve impulse.

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).

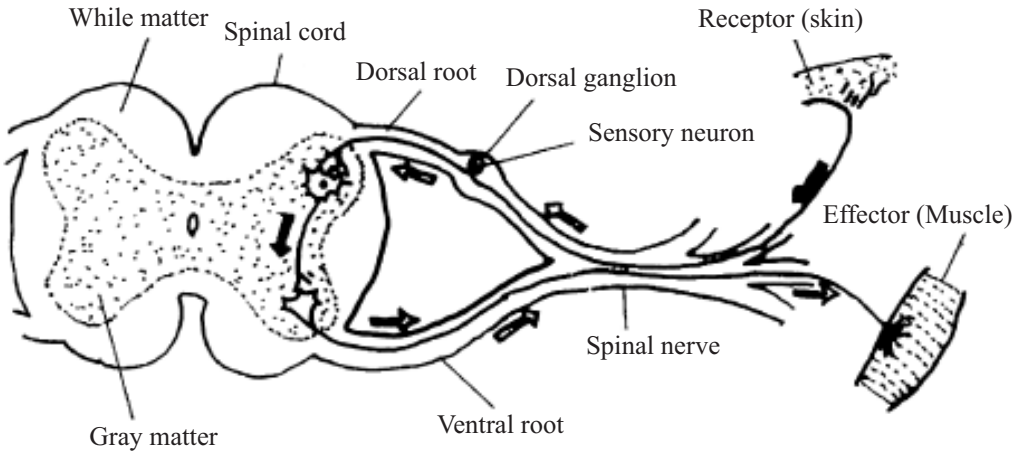


Fig. 17.6 Nerve pathways in a simple reflex action

In this, there are five necessary parts:

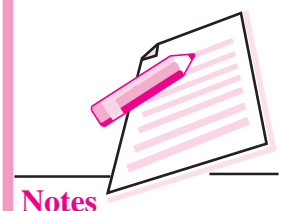
The stimulus (prick, heat etc.) → receptor in the sensory organ → the afferent (sensory) nerve fibre running through the dorsal root of the spinal nerve bringing the impulse into the spinal cord → a (motor) neuron sending out the command through its efferent fibre in the ventral root of the spinal nerve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

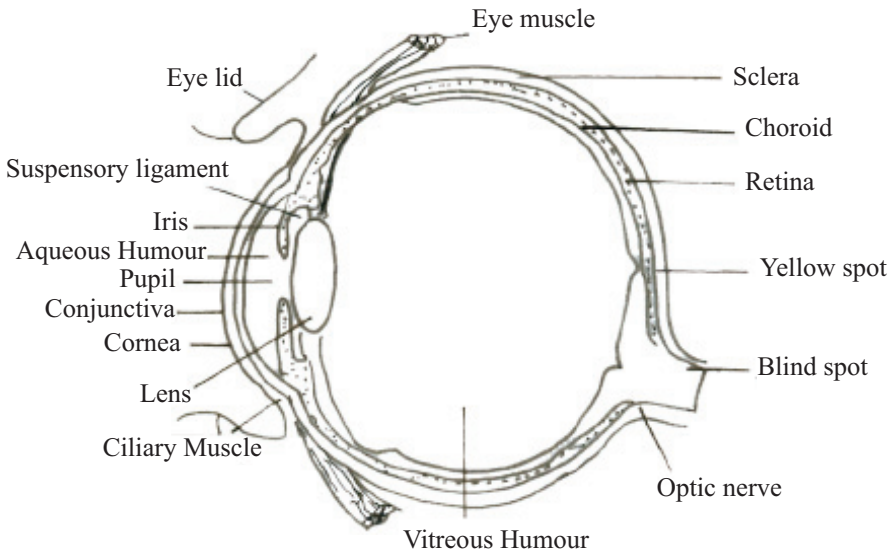


Fig. 17.7 Vertical section of the human eye

- **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 .....

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)

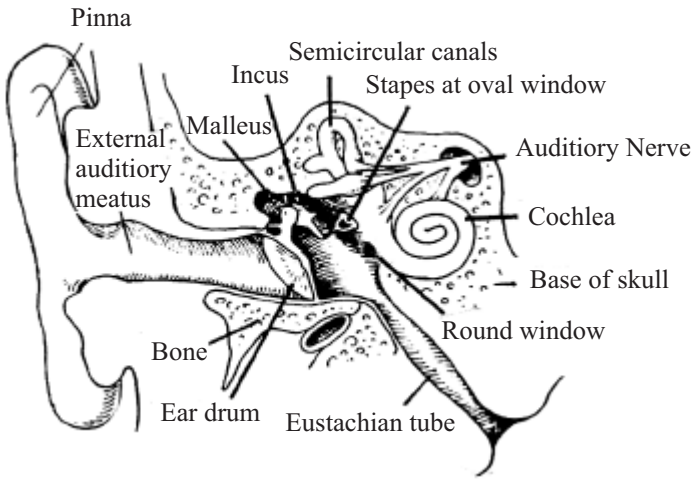


Fig. 17.8 The human ear.

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

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

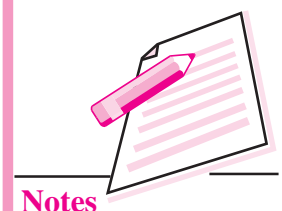
– The **auditory canal** through which the sound waves travel up to the ear drum (tympanic membrane)

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. .....

2. Name the following :

(i) The part into which the sound waves are directed by the ear pinna.

.....

(ii) The kind of balance with which the semi-circular canals are concerned.

.....

(iii) Any two sensations felt through free nerve endings in the skin.

.....

17.9 COORDINATION THROUGH HORMONES—THE ENDOCRINE SYSTEM

Hormones are secretions from specific cells or glands in the body called endoerine glands Harmones are carried by blood to target organs. Their effect is produced in one or more specific parts only. Most hormones are secreted by special glands called the endocrine glands. These are also called ductless glands because their secretions are poured directly into the blood and not through ducts. Certain hormones are produced by other glands or body parts also, for example, the stomach and the duodenum.

17.9.1 Nature and Function of Hormones

- Hormones are secreted from their source directly into the blood.
- Blood carries the hormone to the **target cells** which respond to it.
- Hormones **regulate** the physiological processes.
- They are produced in **very small quantities** and are **biologically very active**. For example, adrenaline is active even at a concentration of 1 in 300 million parts.
- Their **excess** and **deficiency**, both, cause serious disorders.
- Chemically, the hormones may be water-soluble **proteins (peptides), glycoproteins** and **amines** or lipid-soluble **steroids**.
- The extra hormones are not stored in the body and are excreted out.

17.9.2 Hormone Secretors — the Endocrine Glands

In humans there are more than a dozen tissues and organs that produce hormones. Most of these are shown in Fig. 17.8. These can be listed under two categories

(a) **Exclusively endocrine** : the **pituitary,** the **thyroid,** the **parathyroid, thymus** and the **adrenals.**

(b) **Partially endocrine** : The **pancreas, gastric and duodenal epithelium,** the **gonads** (testis in males and ovary in females) and **placenta** in females.

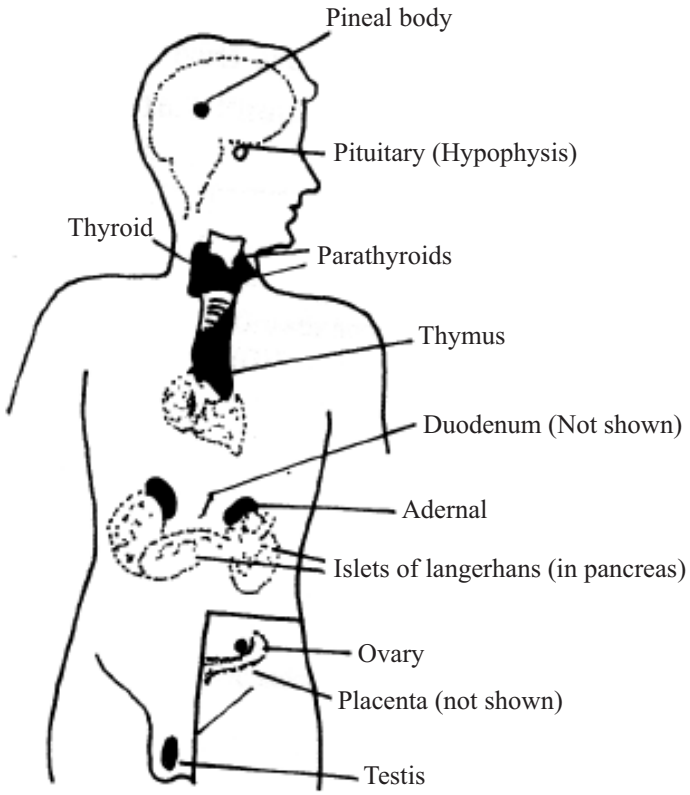


Fig. 17.8 Location of principal endocrine glands in the human body

1. Pituitary — the master gland

The pituitary gland (also called hypophysis) (Fig. 17.9) is a small projection (about the size of a pea) which hangs from the base of the mid-brain. It is connected to the hypothalamus of the brain by the pituitary stalk. The hypothalamus, although a part of the brain, also secretes some hormones.

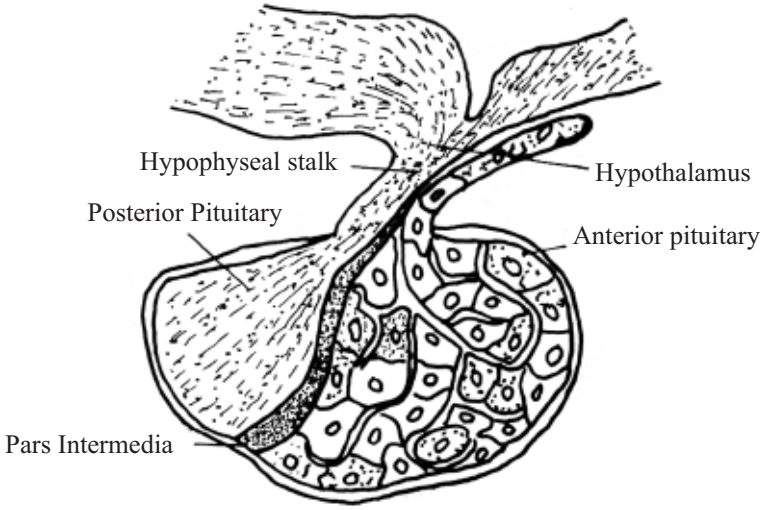


Fig. 17.9 Pitutary gland

The pituitary controls most other endocrine glands. It has two distinct parts: the **anterior pituitary** and the **posterior pituitary**. Various hormones produced from these two parts and their actions are listed below in Table 17.2.

Table 17.2 Pituitary hormones, their action and abnormalities due to its oversecretion or undersecretion

Source	Hormones	Action and abnormalities produced
Anterior lobe of pituitary	Growth hormone (GH), also known as somatotropic hormone (STH)	Promotes growth of whole body, particularly of the skeleton. Undersecretion in childhood lead to Dwarfism; oversecretion in childhood causes gigantism and in adult, acromegaly.
	Tropic hormones (stimulate other endocrine glands)	1. Thyroid stimulating hormone (TSH) stimulates thyroid. 2. Adrenocorticotropic hormone (ACTH) stimulates adrenal cortex.
	Gonadotropic hormones	3. Follicle stimulating hormone (FSH) stimulates egg formation in females and sperm formation in males. 4. Luteinizing hormone (LH) stimulates ovulation and the formation of corpus luteum which produces the female hormone progesterone and LH stimulates testis to produce the male hormone testosterone. 5. Prolactin stimulates milk production.
Posterior lobe of pituitary	Antidiuretic hormone (ADH) or vasopressin	Increases absorption of water from the kidney tubules (osmoregulation). Its deficiency causes **diabetes insipidus**.
	Oxytocin	Stimulates contractions of the uterus during childbirth.

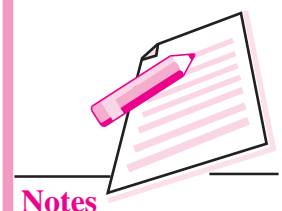
2. Thyroid

Thyroid is a bilobed structure situated in the front region of the neck (Fig. 17.10). It secretes two hormones—**thyroxine** and **calcitonin.**

Thyroxine regulates basal metabolism i.e. the rate of cellular oxidation resulting in heat production. Controls growth and development, ossification of the bones, body temperature, mental development, etc.

Undersecretion of thyroxine (hypothyroidism) produces three conditions

- Simple **goitre.** Enlargement of thyroid visible as a swelling in the neck. It is caused due to iodine deficiency in food as iodine is needed for production of thyroid hormones.
- **Cretinism.** Poor body growth (dwarfism) and mental retardation
- **Myxoedema.** Swelling of the face and hands. General sluggishness.



Oversecretion of thyroxine (hyperthyroidism) produces exophthalmic goitre. This condition causes marked increase in the metabolic rate, rapid heart beat, shortness of breath and the eyes protrude out together with goitre in the neck.

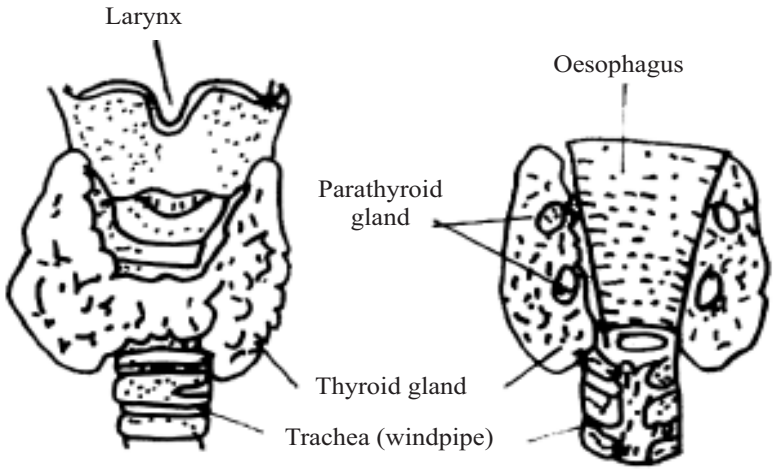


Fig. 17.10 The thyroid gland

Calcitonin. It regulates the calcium and phosphate levels in the blood. If the calcium level in blood is high more calcitonin is secreted and the calcium ions are moved from the blood to the bones making them harder. The reverse happens when the calcium level in the blood is low making the bones soft.

3. Parathyroids

These are two small pairs of glands wholly or partially embedded in the thyroid gland. Their secretion **parathormone** raises blood calcium level by stimulating release of calcium from bones.

4. Thymus

It is located at the base of neck. It produces some hormones involved in maturation of T lymphocytes. It begins to atrophy after puberty.

5. Adrenals

The adrenals (ad: adjacent, renal; kidney) are a pair of glands situated like caps one above each kidney. Each adrenal consists of two parts: a central **medulla** and a peripheral **cortex**.

The **adrenal medulla** secretes adrenaline which,

- increases heart beat accompanied by an increase in the blood pressure.
- increases blood supply to the muscles while decreasing blood supply to the visceral organs.
- releases more glucose into the blood from the liver.

The **adrenal cortex** secretes two categories of hormones: **glucocorticoids** and **mineralocorticoids**.

(a) **Glucocorticoids** e.g. **cortisone**

- In response to stress it raises blood glucose through action of the liver including deamination of amino acids. During starvation and prolonged fasting the required glucose is partly provided through this hormone.
- It adapts the body to stresses such as extreme heat or cold, burns, infections, etc.
- Some of the cortical hormones behave like sex hormones.
  - **Overgrowth of adrenal cortex in young children** causes premature sexual maturity.
  - **Overgrowth of adrenal cortex in mature females** results in the development of male characters such as beard and deep voice.
  - **Overgrowth of adrenal cortex in mature males** results in the development of some feminine characters such as enlargement of breasts.

(b) **Mineralocorticoids** e.g. **aldosterone**

This hormone is concerned with water retention. It increases reabsorption of sodium and chloride ions in kidneys. Read the role of aldosteronl in increasing blood volume and blood pressure in increasing blood volume and blood pressure in lesson 14 (14.3.6)

6. Pancreas

Pancreas is an endocrine as well as an exocrine gland. It has special groups of cells called **Islets of Langerhans**, which consists of three kinds of cells – *alpha cells* producing the harmone glucagon, *beta cells* producing harmone *insulin* and *gamma* cells producing harmone **somatostatin**.

(i) **Glucagon.** It stimulates breakdown of glycogen to glucose in the liver, leading to rise in the blood sugar level.

(ii) **Insulin**. It performs two principal tasks;

- Promotes glucose utilization by the body cells.
- Stimulates deposition of extra glucose in the blood as glycogen in the liver.

Gluccagon and insulin have oppsite functions.

Non-secretion or under secretion of insulin causes **diabetes mellitus** (***hyperglycemia***, meaning 'more than normal sugar in blood'.

A diabetic person,

- has higher glucose in blood;
- excretes a great deal of urine loaded with sugar;
- feels thirsty because of loss of water through too much urination;
- loses weight and becomes weak. In some cases, the patient even loses the eyesight.

Oversecretion of insulin causes **hypoglycemia** or low blood sugar. The brain may enter a state of coma if the level of sugar in blood becomes too low.

(iii) **Somatostatin** also called Growth Hormone-Inhibiting Hormone (GHIH) inhibits secretion of insulin as well as glucagon.

7. Gonads (testis and ovary)

Testes in males possess two kinds of cells : the sperm-producing germinal cells and the hormone-producing interstitial cells. The hormones produced are called androgens and the commonest one among them is **testosterone**.

The **testosterone** stimulates the development of the male characters during which the body at **puberty** starts developing facial hair**,** and their voice cracks and deepens.

Ovaries in females produce two kinds of hormones—**estrogen** and **progesterone**. **Estrogen** is secreted from the follicles of the ovary and stimulates the development of breasts and fat deposition on the hip in a mature woman. Estrogen prepares the wall of the uterus for receiving the fertilized egg.

Progesterone is secreted by the corpus luteum (follicle left after the release of ovum). It brings about the final changes in the uterus for the retention and growth of the foetus during pregnancy.

8. Placenta

Placenta of a pregnant woman produces certain hormones. One such hormone is **human chorionic gonadotropin** (HCG), which maintains the activity of corpus luteum in secreting progesterone continuously, when a women becomes pregnant.

9. Hormones from stomach and intestine

(i) **Gastrin** is the hormone secreted by the mucus membrane of the pyloric end of the stomach. It stimulates the gastric glands to secrete gastric juice.

(ii) **Secretin** is the hormone secreted by the inner lining of the duodenum. It stimulates the production of pancreatic juice while the hormone **cholecystokinin** stimulates release of bile from gall bladder.

17.10 THE FEEDBACK MECHANISM (CONTROL OF HORMONAL SECRETION)

The amount of hormone released by an endocrine gland is determined by the body's need for the particular hormone at any given time. The product of the target tissue exerts an effect on the respective endocrine gland. This effect may be positive ('*secrete more*') or negative ('*secrete no more*' or '*slow down*'). This can be explained by taking the example of thyroid gland.

Feed back mechanism of thyroid activity (Fig. 17.11). Hypothalamus releases a hormone TSH-RH (TSH- Releasing Hormone) which instructs the anterior pituitary to release TSH (thyroid stimulating hormone). The TSH stimulates thyroid to release thyroxine. If the level of thyroxine in blood increases, the pituitary stops the release of TSH. When the level of thyroxine falls in the blood, the thyroid gets stimulated

to secrete more of it. In feedback mechanism the starting point of an activity receives back the information whether to continue or increase, or to slow down or even stop.

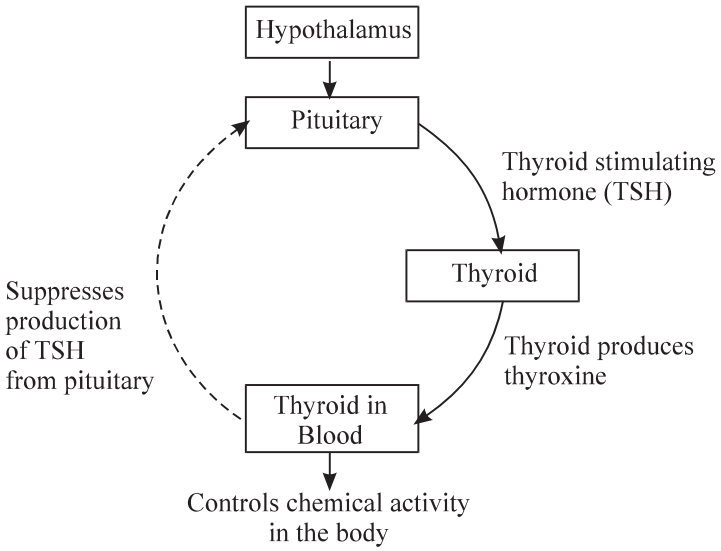


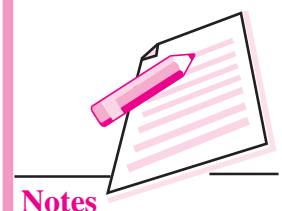
Fig. 17.11 Feed back mechanism in hormone action
(solid line = stimulation; broken line = suppression/inhibition)

17.11 COMPARISON OF HORMONAL AND NERVOUS COORDINATION

The table 17.2 below lists a few major differences between these two different kinds of control and regulating mechanisms.

Table 17.2 difference between hormonal and nervous control

Property	Hormonal control	Nervous control
1. Nature of signal	All hormones are chemical signal	Nerve impulses are electrical signals. Chemical signalling takes place at synapses
2. Speed of signal	Slow	Rapid. Between 0.7 metres per second and 120 metres per second
3. Effect in the body	General effect. The hormones can influence cells in many different parts of the body.	Localized effect – affects only the particular muscle or the gland



4. Effect on growth	Can affect growth	Cannot affect growth
5. Capacity for modification	Cannot be modified by learning from previous experience	Can be modified by learning from previous experiences
6. Duration of effect	Short term or long lasting.	Short – lived

17.12 PHEROMONES—THE CHEMICAL MESSENGERS AT SOCIAL LEVEL

Pheromones are the secretions given out by **an individual** into the environment, which bring about a specific response **in other members of the same species**. Some of the examples of the pheromones are as follows:

- **Common ants march on the floor or walls in a trail** on an invisible path laid down by a secretion from their bodies. It helps them to reach the destination one after another, as well as to return correctly to their own nest.
- **When disturbed honey bees give out an alarm pheromone** from their sting at the back and mandibles in the mouth. This alerts the inmates of the hive to face the attack.
- Females of a particular moth gives out a scent which can attract a male from as much distance as 3-4 kilometers.
- Introduction of a male mouse into a group of female mice shortens oestrus cycle (cycle of development of eggs in the ovary and ovulation).
- Introduction of a **strange male mouse** of a different strain disturbs to the extent that the **newly pregnant females abort their foetuses**. The source of pheromone of the strange male mouse is in its urine.

INTEXT QUESTIONS 17.6

1. Name the following

   (i) The organ in the neck on the trachea close to which thyroid is located

   .....

   (ii) The condition caused due to oversecretion of thyroxin

   .....

   (iii) The hormone concerned with facing dangers

   .....

(iv) The condition of passing much glucose in the urine

.....

(v) The source gland of ADH

.....

2. What are pheromones?

.....

WHAT YOU HAVE LEARNT

- The coordination of body activities inside the body of an organism is brought about by two systems- the nervous and the endocrine systems.
- The nervous system is composed of the central nervous system (brain and spinal cord) and the peripheral nervous system (cranial and spinal nerves and the autonomic nervous system).
- The autonomic nervous system consists of a pair of chain of ganglia by the side of spinal cord. It is largely concerned with the normal functioning of the visceral organs.
- The nervous system of cockroach is made of brain or cerepral gangha, suboeso phaegeal ganglion, thoracic ganglia gangha and six abdominal ganglia from which nerves come out.
- Cerebrum is the largest part of the brain and is the seat of intelligence.
- Cerebellum is the centre of balance.
- Medulla oblongata controls breathing and heart beat.
- Spinal cord is the centre for simple reflexes.
- The sensitive layer of the eye is the retina which is composed of rods (sensitive to dim light) and cones (sensitive to bright light and for colour vision).
- The internal ear performs two tasks perception of sound by the cochlea and that of disturbance in body balance by the semicircular canals, utriculus and sacculus.
- The nose perceives chemical stimuli by the chemicals carried by the air and the tongue by direct contact with them.
- Skin possesses receptors for touch, pain, heat cold etc.
- Chemical coordination is brought about by hormones produced by the ductless glands, that are carried by the blood and which act on the target cells or organs away from their source.
- There is a close link between the nervous and the endocrine systems, shown by the way in which the pituitary gland interacts with the hypothalamus of the brain.

- Our endocrine glands include the pituitary, thyroid, parathyroid, thymus adrenals, pancreas, gonads and placenta.
- The pituitary controls and regulates the activities of almost all other endocrine glands.
- The undersecretion as well as the oversecretion of the hormones, both produce ill effects.
- Hormone levels are generally controlled by feed back mechanism.
- Pheromones are secretions released outside in the enviroment, which produce response in other individuals of the same species.

TERMINAL QUESTIONS

1. Name the two divisions of the nervous system?
2. What is gray matter?
3. Name the chemical involved in the transmission of nerve impulse across a synapse.
4. Give two examples of sensory nerves.
5. Name the respective areas of the retina concerned with best vision and no vision.
6. What is the role of the eustachian tube in the ear?
7. Name the hormone and its source glands, whose deficiency leads to diabetes insipidus.
8. What are pheromones?
9. Name and explain the event that happens immediately when a nerve fibre gets stimulated?
10. Are the endocrine glands and the ductless glands one and the same thing? Give one example.
11. Describe any one example of condition reflex in the humans.
12. List the functions of medulla oblongata.
13. Differentiate between sympathetic and parasympathetic nervous systems.
14. What are the two principal tasks of insulin?
15. Explain the following terms: (i) synapse (ii) stimulus and (iii) impulse
16. Draw a diagram to show the arrangement of the bones inside the middle ear.
17. Write short notes on the following :
    (i) myopia
    (ii) taste buds
    (iii) accommodation of the eye

18. How do sympathetic and parasympathetic nervous systems act differently on (i) pupil of the eye, and (ii) urinary bladder?

19. Draw a labelled diagram of the cross section of the spinal cord and the nervous pathway of a simple reflex concerned with it.

20. Explain the role of ciliary muscles in our eyes

21. Taking the example of thyroxine secretion, explain what is meant by feedback mechanism?

ANSWERS TO INTEXT QUESTIONS

17.1

1. FIg. 16.1, page 337
2. (a) supraoesophageal ganglion (b) sub oesophageal ganglion
3. Ventral nerve cord
4. Cerebrum, cerebellum, medulla oblongata, thalamus and hypothalamus
5. (i) Cerebrum–intelligence/thinking/reasoning/memory;
   (ii) Cerebellum– balance/muscular coordination
   (iii) Medulla oblongata–involuntary actions
   (iv) Hypothalamus–homeostasis
6. Gray matter–composed of neuron cell bodies
   White matter–composed of axon fibres
7. Cerebrospinal fluid

17.2

1. Sympathetic nervous system and parasympathetic nervous system
2. (i) parasympathetic nervous system
   (ii) parasympathetic nervous system
   (iii) sympathetic nervous system
   (iv) parasympathetic nervous system
   (v) parasympathetic nervous system
3. because it connects the periphery (surface) of the body
4. sensory = afferent, motor = efferent

17.3 1. (i) simple (ii) conditioned (iii) conditioned
(iv) simple (v) conditioned

17.4 1. (i) contracts and dilates pupil
(ii) helps in near vision/contracts to make lens thicker
(iii) controls amount of light entering the eye
(iv) maintains shape of the eye ball and protects retina
(v) produces nerve impulses into the optic nerve

2. (i) yellow spot (ii) concave lens
(iii) cataract (iv) accommodation

17.5 1. (i) vestibule (ii) cochlea

2. (i) auditory meateus
(ii) static balance
(iii) touch/pressure/warmth/cold/ ….

17.6 1. (i) larynx, (ii) cretinism, (iii) adrenaline (iv) diabetes mellitus,
(v) posterior pituitary

2. Pheromone is a secretion from one individual that is given out into the environment and which elicits a response in other members of the same species.