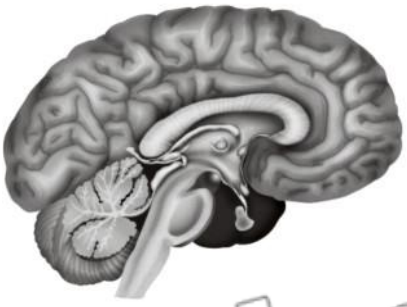


Chapter 17
Coordination and Control

17.1 COORDINATION

Definition

Coordination may be defined as the integration, organization, regulation and control in the composition and function of the complex multicellular animals.

OR

Working together of different parts to perform a specific function with timing and efficiency is called coordination.

Need and Advantage

All organisms show certain common characteristics one of them is to respond to stimuli. These stimuli may be internal or external at;

- Molecular level
- Sub-cellular level
- Cellular level
- Organismic level

The activities of different body parts in response to these stimuli must be coordinated. The coordination makes possible this integration of functions essentials in organismic behaviour. The coordination is must for any organism to survive.

Coordination in Unicellular Organisms

In unicellular organisms, coordination exists between various cellular processes and they respond to changes in their environment such as temperature, light intensity, concentration of various chemicals and even to electric current.

Coordination in Multicellular Organisms

In multicellular organisms, in spite of division of labour among cell, yet every cell can respond to changes in its immediate vicinity.

Coordination in Human

Most highly developed organisms e.g. humans are unable to detect and unable to respond to various changes or stimuli in environment. For example

(i) We are unaware about presence of bacteria on surface of our body but some of our internal body cells do respond and produce chemicals or phagocytose them to destroy them.

(ii) Similarly, our body cells can respond to different radiations, which cannot be detected by our eyes except for the visible light.

17.2 COORDINATION IN PLANTS

Responses of Plants

Plants respond to stimuli in two different ways

(1) Regulating their growth and development in appropriate ways.

(2) Controlling their body functions through plant hormones or growth hormones.

17.2.1 CONTROL THROUGH HORMONES

Plants' behaviour is fundamentally different from animals as they are sessile while animals are motile.

Most of the plant behaviour involves variations in growth rates or changes in turgidity.

In plants, control of these activities is solely by hormones.

Different features of hormonal control in plants are as follows.

i) It is a slow process.

ii) There is delay between release, arrival at the target cells and action of hormones in the body.

iii) Response is not immediate.

However, all the activities of plants from growth to fruit production and ripening are under the control of plant hormones.

Examples of Responses in Plants

Different examples of responses shown by plants are as follows.

17.2.2 PLANT MOVEMENTS

Plants do not show locomotion but movements of plant organs are possible and are modified according to the nature and intensity of external stimuli. There are two main kinds of plant movements i.e. turgor and growth movements or autonomic movement and paratonic movements.

17.2.3 RESPONSES TO ENVIRONMENTAL STRESSES IN PLANTS

Major requirements of plants are water, light, carbon dioxide and various nutrients. Absence or short supply of any of these factors in environment may exert environmental stress on plants.

Absence of Light

If plants are grown without light, they become extremely long and fail to form chlorophyll. They are said to be ***etiolated***.

Mineral Deficiency

Many plants, which cannot prepare chlorophyll due to mineral deficiency, develop yellowish hue. This condition is called ***chlorosis***. This usually arises from short supply of mineral nutrients in the soil.

17.2.4 DEFENSE AGAINST PATHOGENS IN PLANTS

Plants protect themselves from different infections and developmental abnormalities.

Callus

If plants are wounded, they develop masses of amorphous material with very poor differentiation known as ***callus***.

Plant Tumors

Plant tumors and plant cancers arise and spread through the plant as an amorphous invasion of surrounding well-differentiated tissues.

Galls

Galls are growing areas on plants that are induced by parasites and usually highly organized growth galls are tumors induced by bacteria. They are usually less differentiated than other types of galls. Others are usually well differentiated tissues.

17.2.5 BIOLOGICAL CLOCKS AND CIRCADIAN RHYTHMS

Definition

Such behavioural activities in living organisms, which occur at regular intervals, are called biorhythms or biological rhythms.

Types

There are two types of biorhythms.

a) Circadian Rhythms

Definition

Latin word 'circa' = about and 'dies' = day.

Biorhythms, which occur showing periodicity of about 24-hours (one day) are called circadian or diurnal rhythms.

Example

Changes in flowers and leaves with day and night.

b) Circannual Rhythm

Definition

If biorhythms are less than or about 365 days, then they are called circannual rhythms.

Example

Germination, flowering and fruiting along different seasons.

Synchronization with Environment

The organisms come across environmental changes that are cyclical in nature such as days, tides and seasons etc. many organisms maintain internal rhythm or clock, to predict the onset of the periodic changes and to keep them prepared for these changes.

Causes of Biorhythms

Biorhythms may be the result of following.

i) These may be direct response of various changes in external stimuli (exogenous).

ii) There may be internal changes (endogenous) stimulating biorhythms.

iii) Exogenous and endogenous may be in synchronicity.

Work of Ervin Bunning

Ervin Bunning of University of Tubingen Germany has shown that exposure of fruit fly Drosophila to constant conditions for 15 consecutive generations fail to eliminate the essentially 24 hr rhythm. Thus, he proved that basic period of clock is innate.

QUESTIONS RELATED TO ABOVE ARTICLE

What do you mean by biological rhythm? Explain its different types. Also discuss the causes of these rhythms.

Describe the defense against pathogen in plants.

17.2.6. PLANT HORMONES

Some of the special substances produced by the plants and influence the growth and plant responses to various stimuli are called plant hormones.

Some of the important plant hormones are described below.

17.2.6. a. Auxins

These are indole acetic acid (IAA) or their variants.

Functions

i) In stem, they promote **cell enlargement** in region behind apex. It promotes cell division in cambium.

ii) In **root**, they promote **growth** at low concentration while inhibit growth at higher concentration e.g. during geotropism. They promote growth of roots from cuttings and calluses.

iii) They promote **bud initiation** in shoots but sometimes antagonistic to cytokinins and is inhibitory.

iv) They promote **apical dominance** and **fruit growth**. It can sometime induce parthenocarpy.

v) They cause delay in **leaf senescence** (aging) in a few species.

vi) They inhibit abscission.

Commercial Applications

Discovery of IAA led to the synthesis of wide range of compounds by chemists. The synthetic auxins are economical than IAA to produce and often more active because plants generally do not have necessary enzymes to break them down.

Synthetic auxins	
NAA (Naphthalene acetic acid) Indole Propionic Acid	Stimulates fruiting help natural fruit set. Sometimes causes fruit setting in absence of pollination (parthenocarpy)
2,4 D (2,4 Dichloro phenoxy acetic acid)	Selective weed killer Kills broad leaved species (dicots). Used in cereal crops and lawns to eliminate weeds. Inhibits sprouting of potatoes. Prevents premature fruit drop (retards abscission)

17.2.6. b. Gibberellins

These are produced commercially from fungal cultures. *(Gibberella fujikuroi)*

Functions

i) They promote **cell enlargement** and **cell division** in apical meristem and cambium in presence of auxins.

ii) They promote **bolting** of some rosette plants.

iii) They promote **bud initiation** in shoots of chrysanthemum callus.

iv) They promote **leaf growth** and fruit growth and may induce parthenocarpy.

v) In **apical dominance**, they enhance action of auxins.

vi) They break bud and **seed dormancy**.

vii) Sometimes, they act as **substitute for red light**. Thus, **promote flowering** in **long-day plants**, while **inhibit** in **short day** plants.

viii) They cause **delay in leaf senescence** in a few species.

Commercial Applications

- ***GA*** promotes fruit setting e.g. in tangerines and pears, used for growing seedless grapes (parthenocarpy) and also for increase in berry size.
- ***GA_3*** is used in brewing industry to stimulate α-amylase production in barley and this promotes malting.
- They are also used to delay ripening and improving storage life of bananas and grape fruits.

17.2.6. c. Cytokinins

Functions

i) They promote **stem growth** by cell division in apical meristem and cambium.
ii) They inhibit primary **root growth**.
iii) They promote lateral root growth.
iv) They promote **bud initiation** and leaf growth.
v) They promote **fruit growth** but can rarely induce parthenocarpy.
vi) They promote lateral bud growth and also break bud dormancy.
vii) They cause delay in **leaf senescence**.
viii) They promote **stomatal opening**.

Commercial Applications

- They are commercially used to delay aging of fresh leaf crops e.g. cabbage and lettuce.
- They are used for keeping flowers fresh.
- They are also used to break dormancy of some seeds.

17.2.6. d. Abscisic Acid

Functions

i) It **inhibits stem and root growth** mostly during physiological stress e.g. drought, waterlogging etc.
ii) It promotes bud and seed **dormancy**.
iii) It promotes **flowering in short day** plants and inhibits in long day plants (antagonistic to gibberellins).
iv) Sometimes it promotes **leaf senescence**.
v) It promotes **abscission**.
vi) It promotes **closing of stomata** under conditions of water stress (wilting).

Commercial Applications

It is usually sprayed on tree crops to regulate fruit drop at the end of the season. This removes the need for picking over a large time-span.

17.2.6. e. Ethene

Functions

i) It inhibits stem growth mostly during physiological stress.
ii) It **inhibits root growth**.
iii) It breaks **dormancy** of bud.
iv) It promotes flowering in pineapple.
v) It promotes **fruit ripening**.

Commercial Applications

- It is used to induce flowering in pineapple.
- It is used for ripening of tomatoes and citrus fruit.

The commercial compound ethephon breaks down to release ethene in plants and thus is used in rubber plant to stimulate the flow of latex.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain the role of auxins in plants.
Describe role of Abscisic Acid and Ethane in plant growth.
(Compare the characteristics and commercial applications of Gibberellins and Abscisic acid
Describe the functions and commercial applications of cytokinins. (FSD 2019)
Describe the functions of "abscisic acid" growth hormone in plants. (GRW 2017, GRW 2021)
Describe any four functions of Gibberellins. (RWP 2019, SGD 2021)
Describe role and commercial applications of Auxins. (RWP 2021)
Suggest the various commercial application applications of auxins & gibberellins. (RWP 2022)

17.3 COORDINATION IN ANIMALS

In higher animals, coordination is brought about by nervous and endocrine systems. Thus, we classify it in two types.

1) Nervous coordination
2) Chemical coordination

17.3.1 NERVOUS COORDINATION

In the nervous co-ordination involves specialized cells or neurons linked together directly or via the central nervous system, to from network that connects the cell or organs which receive stimuli (receptors) and those which carry out actions or responses (effectors).

Principle of Nervous Coordination

Three steps are involved in nervous mechanism.

i) Reception of stimuli by receptors.
ii) Conduction of stimuli by neurons
iii) Response to stimuli by effectors.

Element

The elements of nervous system which help in coordination are

1) Receptors
2) Neurons
3) Effectors

Any external or internal environmental change in environment is called ***stimulus***.

Reaction to stimulus is called ***response***.

17.3.1.1 Receptors

Definition

The structures which detect stimuli in external or internal environment of the animal are called receptors.

The neuron fibres and cell bodies can be excited by small electric shocks, mechanical, chemical, light and temperature stimuli.

The receptors may be

- A cell
- Neuron ending
- Receptor organ

Receptors are classified as follows

a) Chemoreceptors

Such type of receptors, which detect chemical stimuli are called chemoreceptors.

These are for smell, taste and for blood CO_2, oxygen, glucose, amino acids and fatty acids (receptors in the hypothalamus).

b) Mechanoreceptors

Such type of receptors, which detect mechanical stimuli are called mechanoreceptors.

These detect stimuli of touch (free nerve endings + expanded tip ending, stray endings), pressure, hearing and equilibrium.

c) Photoreceptors

Such type of receptors which detect stimuli of light are called photoreceptors.

These are also called as electromagnetic receptors. Examples are eyes, rods and cones.

d) Thermoreceptors

These detect stimuli of cold and warmth. These are free nerve endings.

e) Nociceptors

These are undifferentiated nerve ending, which produce the sensation of pain.

Modalities of Sensation

Each type of the principal type of sensation that we experience – pain, touch, sight, sound and so forth are called modalities of sensations.

Receptors detect different type of stimuli, but they transmit all of them in form of same nerve impulse. Different modalities of sensation as follows

(1) Each receptor organ is specialized to receive a particular type of stimulus and is carried to a particular area of brain.

(2) Each nerve tract terminates at a specific point in the CNS, which determines the type of sensation. For example, touch is differentiated by touch area and vision by visual cortex of brain.

QUESTIONS RELATED TO ABOVE ARTICLE

What are receptors? Classify and explain each class.

What are receptors? Discuss their types.

(GRW 2019, FSD 2021, DGK 2022)

17.3.1.1. a. Working of Sensory Receptors with Special Reference to Skin

In skin there are at least 3 different types of sensory endings for detection of five different type of stimuli i.e. touch, pressure, heat, cold and pain.

These three receptors are as

1) Hair End Organs

These are situated at the base of hairs, hear end organs and receive ***touch*** stimuli.

2) Meissner's Corpuscles

These are encapsulated nerve endings, which lie in papillae extending into the ridges of fingertips. The corpuscles consist of spiral and much twisted endings each of which end in a knob.

These are ***touch*** receptors.

3) Pacinian Corpuscles

These are encapsulated neuron endings situated quite deep in body, mostly in limbs.

These detect ***deep pressure*** and ***vibration***.

Vibration of ground by terrestrial vertebrates is detected by receptors in joints.

Abundance of Receptors

Relative abundance of various types of receptors differs greatly.

- Pain receptors are nearly 27 times more abundant than cold receptors.
- Cold receptors are nearly 10 times more abundant than heat or temperature receptors.

Distribution of Receptors

Receptors are not equally distributed evenly over the entire surface of the body. For example

Touch receptors are much more numerous in the finger tips than in the skin of the back.

Transmission of Stimulus

Stimulus is transmitted in form of nerve impulse.

More intensive stimulus is transmitted in form of repeated impulses or by involving more fibers.

Pathway of Nerve Impulse

Stimulus from skin receptors is passed to the motor neurons via inter or associative neurons, which are present in brain via spinal cord. Motor neurons carry impulse to effectors i.e. muscles or glands.

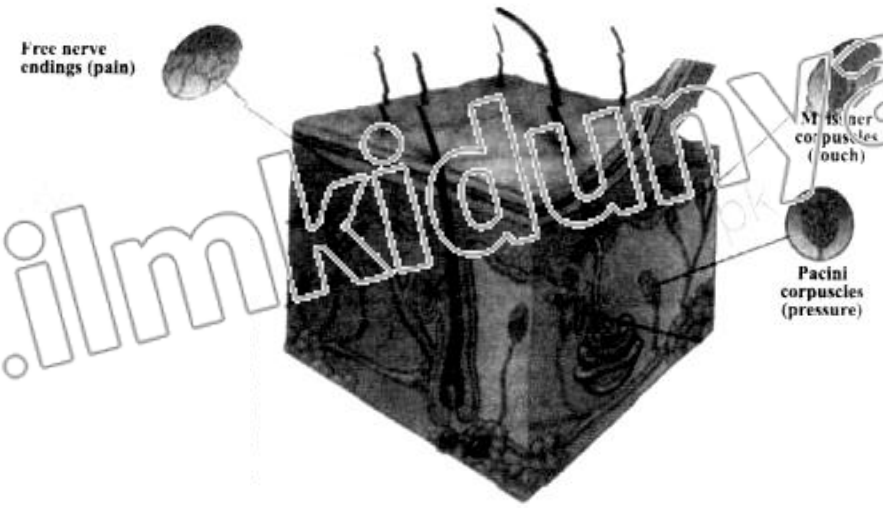


Fig 17.1 Sensory receptors of the skin. The sensations of touch pressure, heat, cold and pain are detected by modified sensory neurons having naked nerve endings (touch and pain receptors) or specialized cellular corpuscles (pressure, hot and cold receptors).

QUESTIONS RELATED TO ABOVE ARTICLE

Discuss working of sensory receptors with special reference of skin.

17.3.1.2 Neurons

Definition

Neuron is the chief structural and functional unit of nervous system.

In higher animals, ***Neuroglia*** are also associated with neurons. They form nearly half of the nervous system. They play vital role as;

- Nutrition of neurons.
- Protection of neurons by myelin sheath.

Structure of a Neuron

There are three important structural components of a neuron.

i) Cell body
ii) Cell processes
iii) Myelin sheath

i) Cell Body

Cell body or soma is the main nutritional part of the cell and is concerned with the biosynthesis of materials necessary for the growth and maintenance of the neuron.

It is the part of neuron containing nucleus and various organelles in the cytoplasm.

Nissls granules, which are groups of ribosomes associated with rough endoplasmic reticulum and Golgi apparatus are present in the cell body.

If the cell body of neuron remains intact, it can regenerate axonal and dendrite fibers; but neurons once mature do not divide any further.

ii) Cell Processes

These are protoplasmic processes arising from cell body. There are two types of cell processes or fibers.

- Those, which carry message towards cell body, are called ***dendrites***. If single it is called dendron.
- Those, which carry message away from cell body, are called ***axons***. Axoplasm (cytoplasm of axon) contains microtubules, neurofibrils, rough endoplasmic reticulum and mitochondria are present throughout the axoplasm (cytoplasm of axon) of the neuron.

iii) Myelin Sheath

Cell processes of neurons are surrounded by a layer of myelin sheath made by Schwann cells.

Types of Neurons

Neurons are classified functionally into three types. These are

a) Sensory neuron
b) Motor neuron
c) Associative neuron

a) Sensory Neuron

Neurons, which carry messages from receptors to CNS are called sensory neurons.

b) Motor Neurons

Neurons, which carry messages away from CNS to effectors are called motor neurons.

c) Associative Neurons

Such neurons, which act as link between sensory and motor neurons and present at level of CNS are called associative or intermediate neurons.

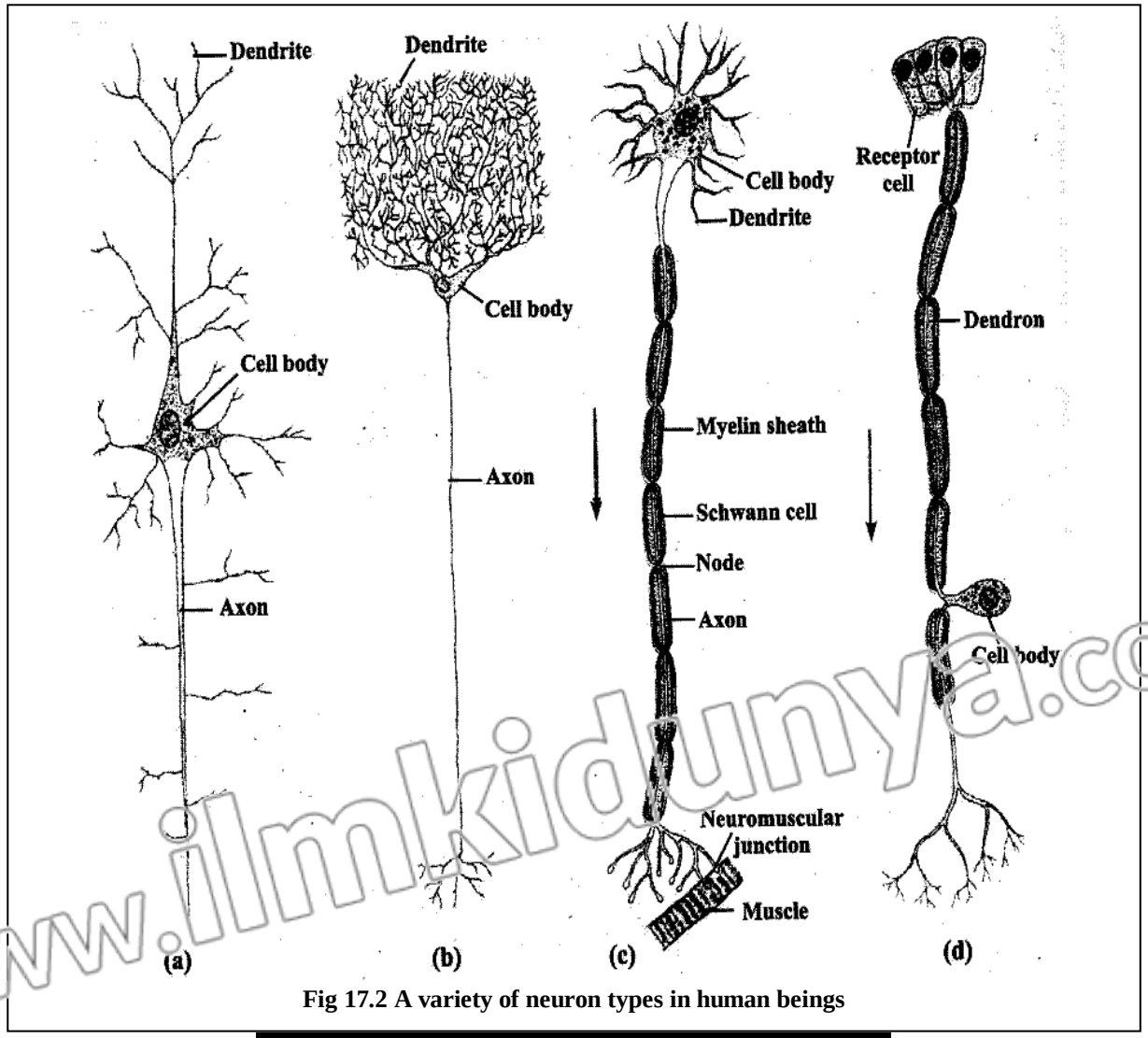


Fig 17.2 A variety of neuron types in human beings

QUESTIONS RELATED TO ABOVE ARTICLE

What is neuron? Explain its types and structure in detail.

What are neurons? Explain their different types with the help of diagrams. (FSD 2021)

17.3.1.3 Effectors

Definition

These are the structures, which respond when they are stimulated by impulse coming via motor neuron.

Examples

The principal effectors are

- ***Glands***, which respond by secreting
- ***Muscles***, which respond by contracting.

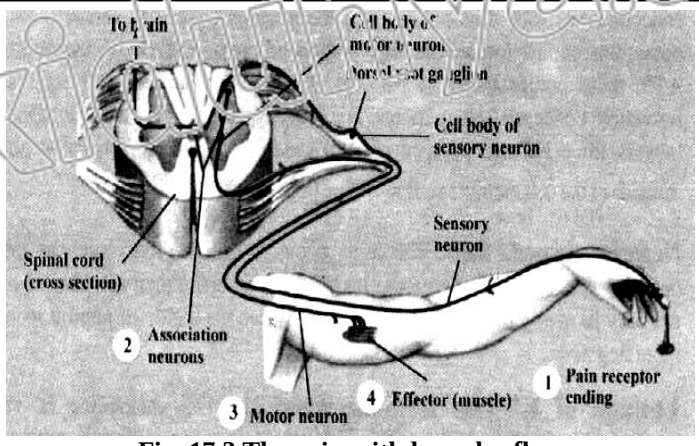


Fig. 17.3 The pain-withdrawal reflex

17.3.2 Reflex Arc

Definition

Reflex arc is pathway of passage of impulse during a reflex action.

Reflex Action

Reflex action is a type of involuntary action. It may be monosynaptic or polysynaptic.

The direction of stimulus is from receptors to sensory neuron to associative neuron and then through motor neuron to the effectors.

QUESTIONS RELATED TO ABOVE ARTICLE

What is reflex arc? Describe the flow of information through the nervous system.

Explain how reflex action prevent the body damage during emergency? (FSD 2022)

17.3.3 Nerve Impulse

Definition

Nerve impulse is a wave of electrochemical changes, which travel along the length of neuron involving chemical reactions and movement of ions across the cell membrane.

Electrical Potential

Electrical potential is a measure of the capacity to do electrical work. It represents a type of stored energy which is manifested during separation of charges across a barrier.

In case of membrane potential, charges are positive and negative ions while charge separating barrier is cell membrane.

Membrane Potential

The electrical potential across a cell membrane is called membrane potential.

Membrane potential may be resting or action.

- **Resting membrane potential** is during non-conducting stage. Its value is - 0.07 volts (-70 milli volts)
- **Active membrane potential** is during conducting stage. Its value is + 0.05 volts (+ 50 millivolts).

Factors Involved

Major factors involved in this context are

1) Sodium & Potassium Ions

They are most important. Sodium ions are 10 times higher in concentration outside than inside the membrane surface, whereas potassium ions are 20 times more concentrated inside than outside.

2) Negative Organic Ions

The large negative ions, organic ions (proteins, organic acids etc) are much more inside the membrane than outside, where they are only in negligible concentrations. This makes inside of neuron membrane more negative.

3) Sodium Gates & Sodium-Potassium Pumps

- Sodium gates are involved in transport of sodium from outside to inside under concentration gradient.
- Sodium-potassium pumps are driven by splitting of ATP. These pumps transport Na^+ out and K^+ into the cell, both against their respective concentration gradients. For every two K^+ that are actively transported inward, three Na^+ are pumped out so inside becomes more negative than the outside of the cell membrane of neurons.

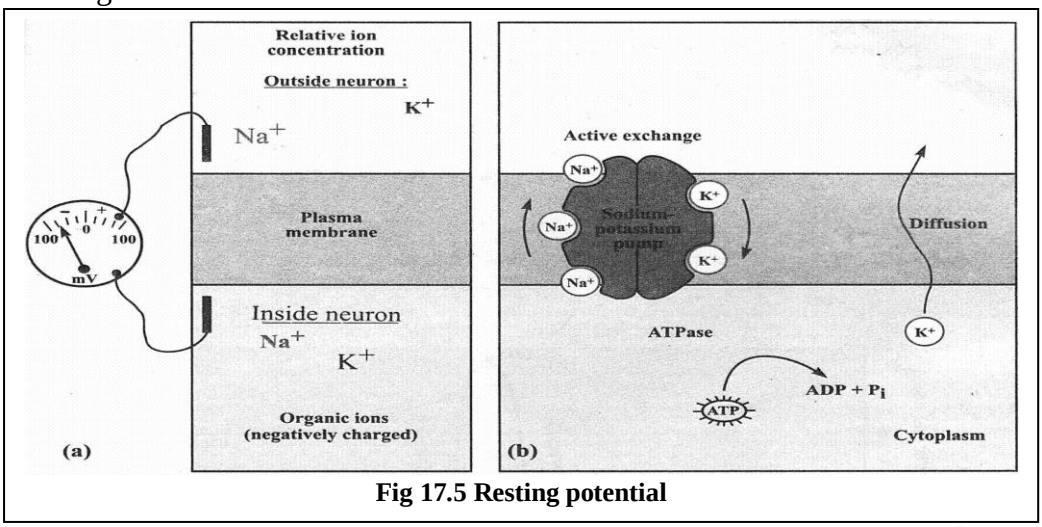


Fig 17.5 Resting potential

Initiation of Nerve Impulse

A nerve impulse is initiated by an appropriate stimulus (called ***threshold stimulus***) applied at one end of the neuron and it results in remarkable localized change in the resting membrane potential. It disappears for a brief instant and is replaced by a new potential called active membrane potential which is in the form of nerve impulse.

During this state, the inner membrane surface becomes more positive than the outside. This change is so brief (for perhaps a millisecond) that only a portion of the neuron is in the active membrane potential state.

Conduction of Nerve Impulse

1. **Na^+ and K^+ Ions Movement**

The passage of nerve impulse is associated with increase in permeability of Na^+ ions moving inward upsetting the potential momentarily, making the inside more positive than outside. This movement is through sodium gate. Some K^+ moves out.

The inner side of the cell membrane becomes positive and outer negative. In this way neuron conducts nerve impulse.

2. Charges are Reversed

The inner side of the cell membrane has excess of positive ions (thus positive charge) at its internal surface, and the outer surface becomes more negative.

3. Passage of Nerve Impulse

During active membrane potential, the neuron conducts the impulse in the form of nerve impulse.

4. Membrane Potentials

Active membrane potential of +0.05 volts (+50 mv) exists.

Restoration of Resting Potential

Soon after passage of the impulse, the resting membrane potential is restored by the movement of a small number of ions especially K^+ moving out. This neuron is now ready to conduct another impulse.

General Features

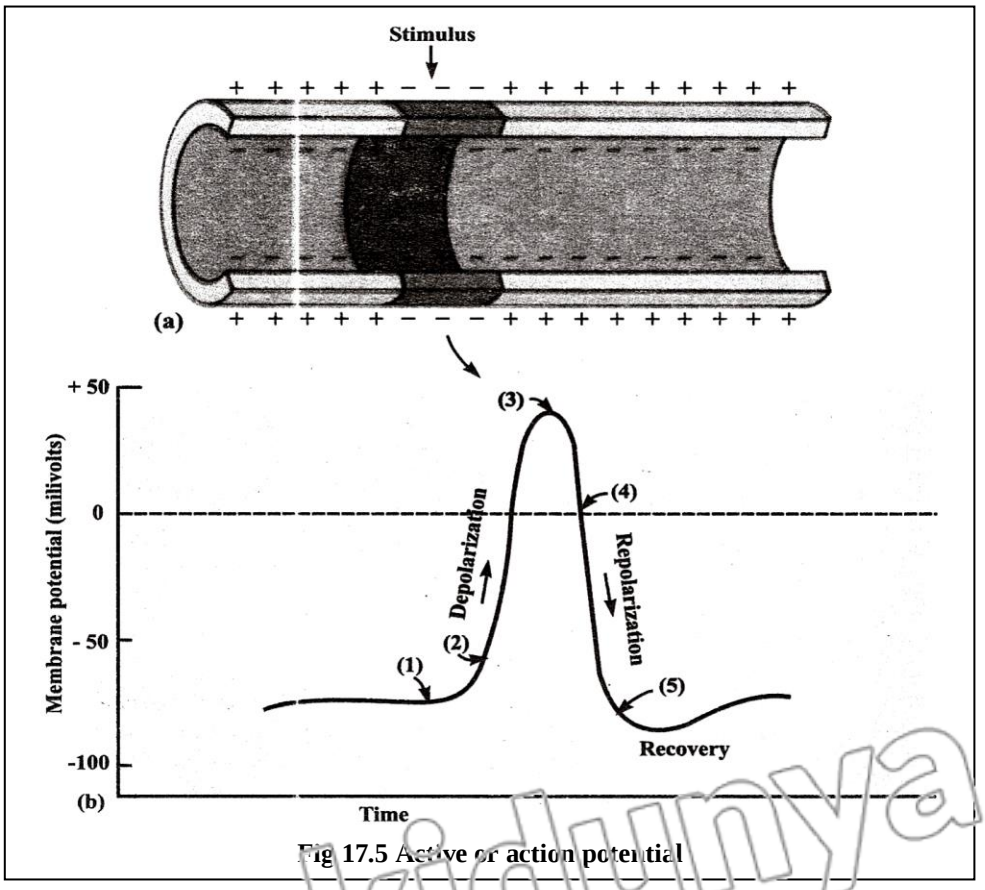


Fig 17.5 Active or action potential

- The normal speed of nerve impulse in humans is 100 meters per second but maximum speed recorded is 120 meters per second.
- In myelinated neurons, the impulse jumps from node to node (Node of Ranvier). This is called ***saltatory impulse***.

QUESTIONS RELATED TO ABOVE ARTICLE

What is resting membrane potential? How is resting membrane potential maintained across neurolema? (LHR 2021)

Define Nerve impulse. How the action potential is initiated and conducted? (MTN 2021)

Define nerve impulse. Explain the mechanism involved by labeled diagram. (Exercise Question iii)

17.3.4 Synapse

Definition

Consecutive neurons are so arranged that axon endings of one neuron are connected to the dendrites of next neuron and do not have cytoplasmic connections between two neurons but there are some microscopic gaps between them.

These microscopic gaps between two consecutive neurons are called synapses.

A single neuron may form synapses with many incoming fibres of different neurons.

Conditions for Passage of Nerve Impulse through Synapse (Communication)

- A single nerve impulse does not necessarily get across the synapse. It may take two or three impulses arriving in rapid succession or perhaps simultaneously from two or more fibers to start an impulse in the next neuron.
- The action potential cannot jump from one neuron to the next in line, rather the message is transmitted across synapse in the form of chemical messenger called neurotransmitters.

Neurotransmitters

Neurotransmitters are chemicals, which are released at the axon ending of the neurons at synapse. Out of various transmitters, most important are acetylcholine, adrenaline, nor-epinephrine, serotonin and dopamine.

- ***Acetylcholine*** is the main transmitter for synapses that lie outside the central nervous system.
- ***Others*** are mostly involved in synaptic transmission within the brain and spinal cord.

Mechanism of Transmission through Synapse

i) When an impulse reaches a synaptic knob, synaptic vesicles within fuse with the pre-synaptic membrane.

ii) These vesicles cause release of neurotransmitter molecules into the synaptic cleft.

iii) Neurotransmitter molecules bind to the receptors on post-synaptic membrane, causing changes in its permeability.

iv) Change in permeability causes initiation of nerve impulse in post-synaptic neuron.

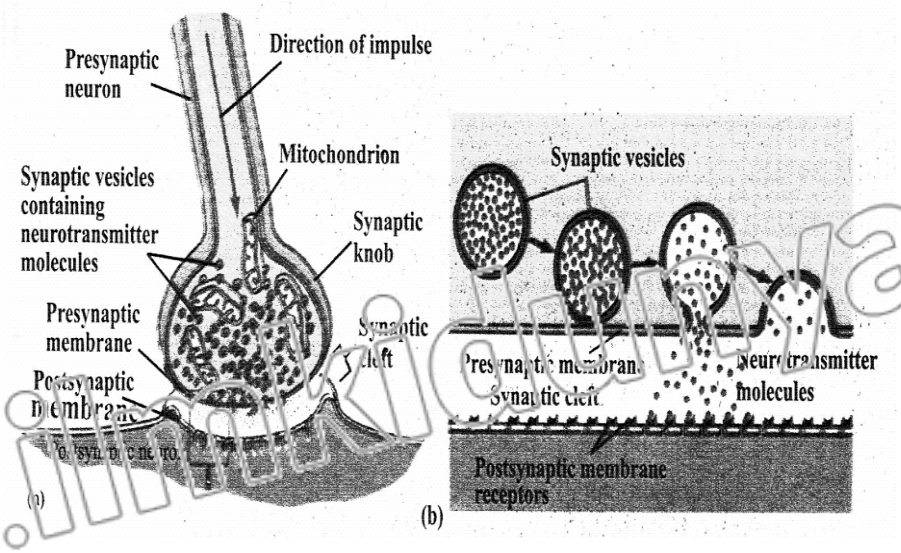


Fig 17.6 Communication across a synapse

QUESTIONS RELATED TO ABOVE ARTICLE

Give a detailed account of synapse.

What is Synapse? Diagrammatically mention how nerve impulse passes through a synapse? (BWP 2021)

17.3.5 Evolution of Nervous System

Basic Designs of Nervous System

There are two basic designs of nervous system in the animal kingdom.

i) A diffused nervous system e.g. as in Cnidarians (hydra, jelly fish etc).

ii) A centralized nervous system e.g. as present in platyhelminthes to chordates including humans.

- Nervous system design is highly co-related with the animal's life style.
- From evolutionary point of view, diffuse type is primitive while centralized type is latest.

17.3.5. a Nervous System of Hydra as an Example of Diffuse Type

Introduction

Hydra, a cnidarian, is a small animal, which is sedentary in its life style. Prey and other dangers are equally likely to come from any direction.

Characteristics of Nervous System

i) There is no head, so no centralized nervous system i.e. no brain and nerve cords etc.

ii) However, a cluster of neuron cell bodies forming ganglia can be seen here and there.

iii) Its nervous system consists of a network of neurons present between ectoderm and endoderm.

iv) Neurons are so arranged in a network that we cannot distinguish between their different functional types i.e. sensory, associative and motor neurons.

v) There are no specialized sense organs in hydra.

Mechanism of Nervous Response

When an appropriate stimulus is given to hydra, almost whole body of hydra responds as a unit. However, tentacles are more responsive and react to the stimulus instantaneously.

17.3.5. b Nervous System of Planaria as an Example of Centralized Type

Introduction

Planaria, belonging to phylum platyhelminthes, has somewhat better developed centralized nervous system as compared to hydra.

Characteristics of Nervous System

i) There is bilobed mass composed of two ganglia. This acts as 'brain' or a centralized collection of neurons. It receives and sends impulses from and to different parts of the body.

ii) There are definite nerves i.e. longitudinal and lateral.

iii) There is differentiation of neurons into sensory, associative and motor neurons. In it most of the neurons are associated with brain and longitudinal nerves.

- Sensory neurons carry messages to brain or nerves.
- Motor neurons carry messages from 'brain' or nerves to different parts of the body.

iv) Sense organs in form of eyes and chemoreceptors are present.

v) Receptor cells are sensitive to pressure, touch, chemical and light stimuli.

vi) In addition to superficial nerve net below epidermis, there is a deeper plexus embedded in the parenchyma.

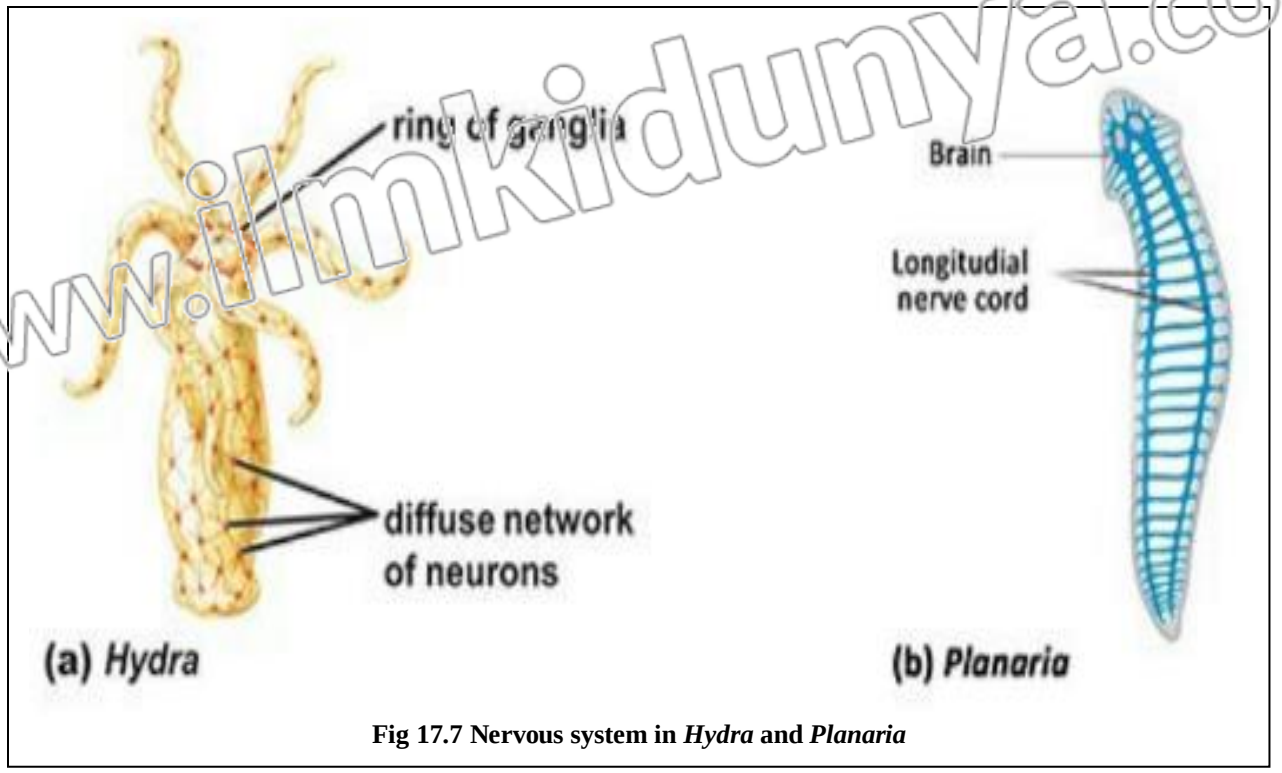


Fig 17.7 Nervous system in *Hydra* and *Planaria*

Comparison of nervous system of Hydra and Planaria

Feature	*Hydra*	*Planaria*
Nervous system	Diffused type	Centralized type
Concentration of neurons	No concentration, so no brain.	Concentration in anterior region forming 'brain'
Differentiation of neurons	No functional differentiation	Differentiation into sensory, associative and motor neurons.
Sense organs	No sense organs	Sense organs in form of eyes and chemoreceptors
Nerves	No definite nerves	Definite longitudinal and lateral nerves
Nerve net	Only superficial	Superficial and deep plexus

QUESTIONS RELATED TO ABOVE ARTICLE

Discuss the nervous system of Hydra.

Compare the nervous system of planaria with hydra. (GRW 2018, DGK 2019)

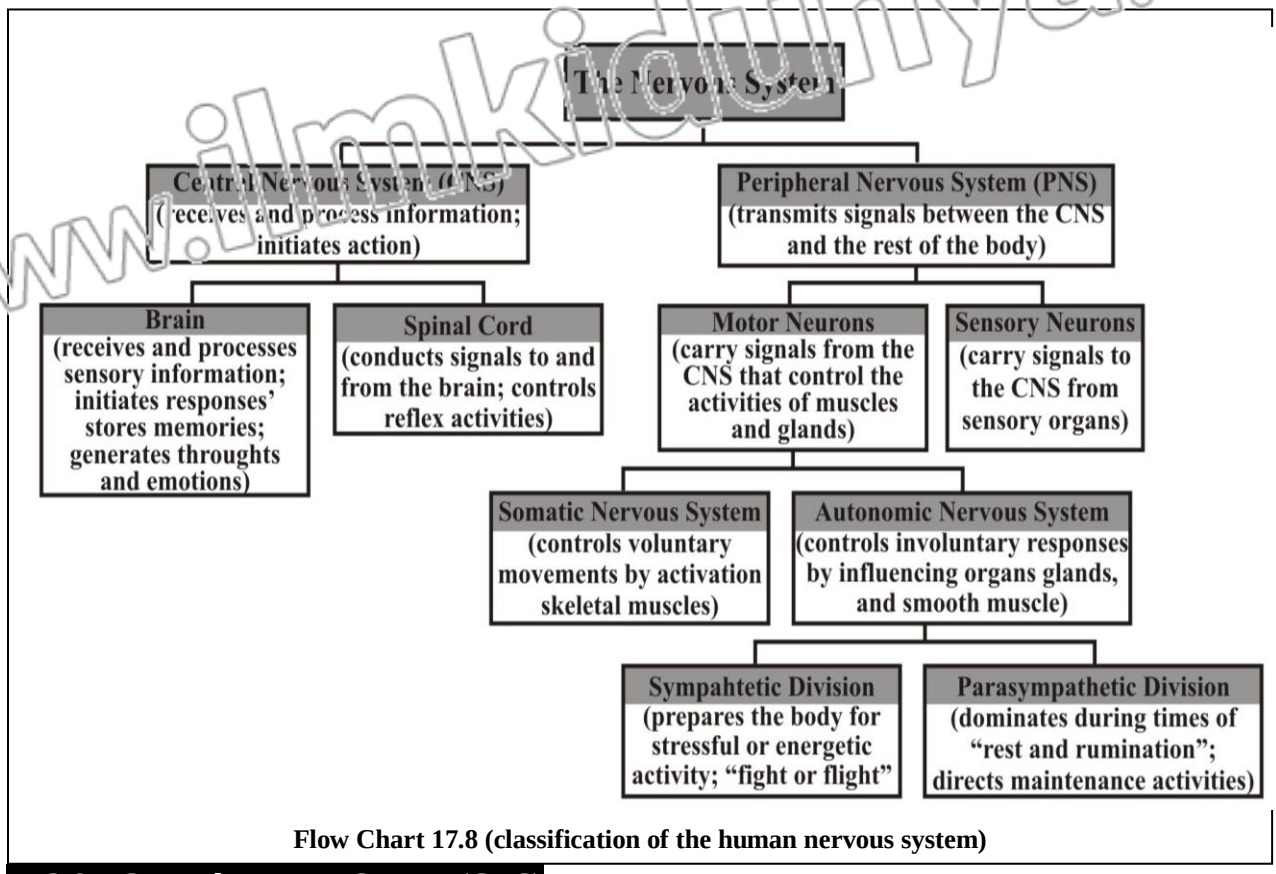
How dose diffused type of nervous system differ from central nervous system. List the difference by taking example of one animal with diffused nervous system and other with central nervous system. (SGD 2022)

How is the nervous system of *Planaria* better developed than that of *Hydra.*

(Exercise Question iv)

17.3.6 HUMAN NERVOUS SYSTEM

Human nervous system is a type of centralized nervous system. Its classification in different subdivisions and different functions performed by these subdivisions are given in flow chart.



Flow Chart 17.8 (classification of the human nervous system)

17.3.6.1 Central Nervous System (CNS)

The CNS consists of brain and spinal cord.

- Both brain and spinal cord are hollow.
- Spinal cord has central canal.
- Brain has many cavities (ventricles) filled by CSF present between the triple layers of meninges.

Protection to CNS

Brain and spinal cord are protected in three ways

i) Cranium & Vertebral Column

- Cranium, which is part of skull, protects the brain and neural arches.
- Vertebrae of vertebral column protect the spinal cord.

ii) Meninges

There are three protective layers below cranium and spinal cord, which are collectively called as meninges.

iii) Cerebrospinal Fluid (CSF)

Between layers of meninges cerebrospinal fluid is present. It is similar in composition to blood plasma.

Major functions, which are performed by CSF are;

- It bathes the neurons of brain and spinal cord.
- It cushions against the bumps and jolts.

17.3.6.1. a. Brain

Brain is part of CNS present in cranium.

Division of Brain

The brain can be divided into three parts;

A) Forebrain
B) Midbrain
C) Hindbrain

A) Forebrain

Forebrain is further divided into three functional parts. These are;

a) The thalamus
b) The limbic system
c) The cerebrum

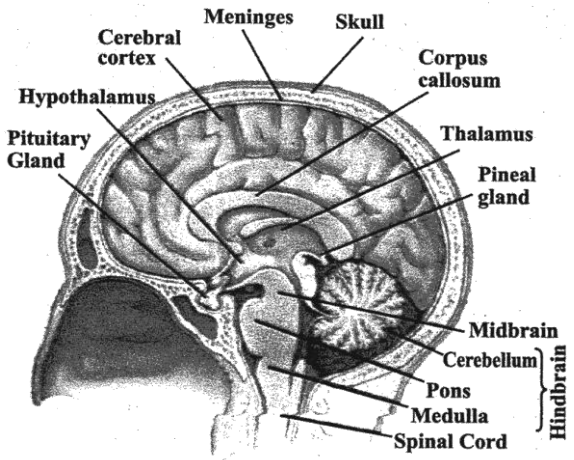


Fig 17.9 The human brain

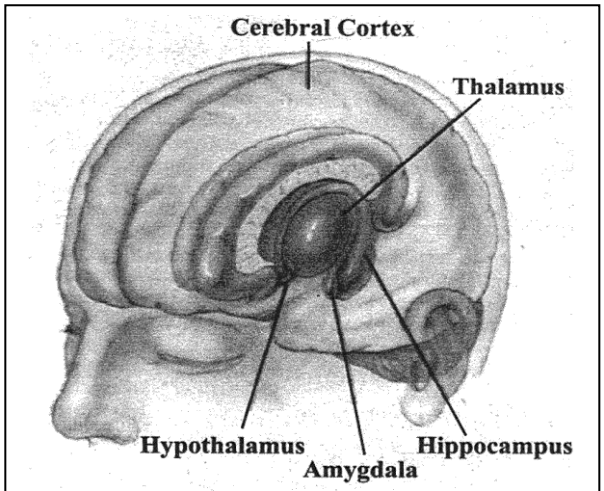


Fig 17.10 The limbic system and thalamus

a) The Thalamus

Thalamus acts as ***relay station***.

Functions

i) It receives sensory input from auditory and visual pathways. It also receives sensory information from skin and other internal body parts.
ii) Then it carries these informations to the limbic system and cerebrum.

b) The Limbic System

The limbic system is located in an arc between the thalamus and cerebrum.

Functions

i) It works together to produce our most basic and primitive emotions, drives and behaviors including fear, rage, tranquility, hunger, thirst, pleasure and sexual responses.
ii) Some portion of limbic system is also important in the formation of memories.

Parts of Limbic System

Limbic system consists of three parts.

i) Hypothalamus

The hypothalamus through its hormone production and neural connections acts as a major coordinating centre controlling body temperature, hunger, the menstrual cycle, water balance, the sleep-wake cycle etc.

ii) Amygdala

In the amygdala, cluster of neurons produce sensations of pleasure, punishment or sexual arousal when stimulated. It is also involved in the feelings of fear and rage.

iii) Hippocampus

It plays an important role in the formation of long-term memory and thus is required for learning.

c) Cerebrum

It is the largest part of brain.

Structure

- It is divided into two halves called ***cerebral hemispheres***. These are right and left hemispheres. The left cerebral hemisphere controls right side of the body and right cerebral hemisphere controls the left side of the body.
- Two halves of cerebrum communicate with each other by means of a large band of axons called ***corpus callosum***.
- Cerebrum consists of tens of billions of neurons.
- Outer part of cerebrum is called ***cerebral cortex***. It forms folds called convolutions, which greatly increase its surface area.

Functions

Cerebrum receives sensory informations, processes it, stores some in memory for future and also produces voluntary movements. Its major functions are summarized as follows.

i) Cerebral cortex contains primary sensory areas where signals originating in sensory organ such as eyes and ears are received and converted into subjective impressions such as light and sound.

ii) Nearby association areas of sensory areas interpret sensory information.

iii) Cerebral cortex is also involved in speech and also receives and interprets sensations of touch from all parts of body.

iv) Cerebral cortex is also a center for sending impulses to voluntary muscles controlling movements.

v) It is also involved in intelligence, reasoning and judgment.

B) Midbrain

It is reduced in humans. Its important component is reticular formation.

Function

It contains auditory relay station.

It also contains centre that controls reflex movements of eyes.

Reticular formation is a relay centre connecting hindbrain with the forebrain. It is very important in screening the input information before they reach higher brain center.

C) Hindbrain

It includes three parts.

a) Medulla

b) Pons

c) Cerebellum

a) Medulla

Medulla is the lowermost part of hindbrain.

Function

It controls several automatic functions such as breathing, heart rate, blood pressure and swallowing.

b) Pons

It acts as bridge.

Function

It is made up of certain neurons. It appears to influence transitions between sleep and wakefulness and also influences rate and pattern of breathing.

c) Cerebellum

It is second largest part of brain. It is best developed in birds, which engage in the complex activity of flight.

Function

- It is important in coordinating movements of the body.
- It guides smooth and accurate motions and maintains body position.
- It is also involved in the learning and memory storage for behaviors.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain structure and function of forebrain in man. (LHR 2019)

Describe the structure and functions of different parts of human brain. (Exercise Question v)

17.3.6.1. b. Spinal Cord

Medulla oblongata narrows down into an oval-shaped hollow cylinder, the spinal cord, running through the vertebral column.

Structure

Spinal cord is made up of a very large number of neurons. Their cell bodies and fibres are arranged in a definite pattern.

In cross-section, the spinal cord shows an inner butterfly shaped grey matter, containing a central canal, and the outer portion composed of white matter.

- ***Gray matter*** consists of cell bodies and non-myelinated nerve fibers or tracts.
- ***White matter*** is made up of myelinated nerve fibres or tracts.

Functions

- It serves as pathway for conduction of impulses to and from different parts of the body and brain.
- It is center for many reflexes. It mostly controls reflexes of trunk.

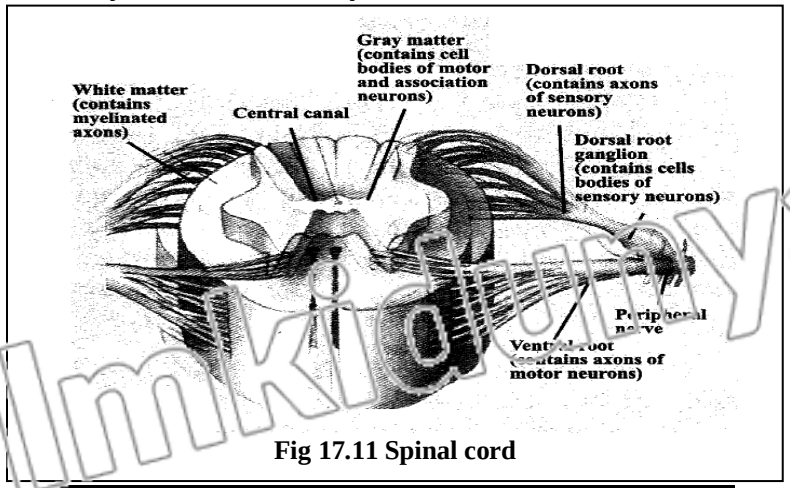


Fig 17.11 Spinal cord

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the structure and function of spinal cord.

17.3.6.2 Peripheral Nervous System (PNS)

Definition

Such type of nervous system, which connects different body parts with central nervous system, is called peripheral nervous system.

Components

Peripheral nervous system mainly consists of sensory and motor neurons in form of nerves. Alongwith nerves, ganglia are also associated with it.

- ***Nerves*** are the bundles of axons or dendrites, bounded by connective tissue.
- ***Ganglia*** are the concentrations of cell bodies of neurons outside the CNS.

Classification of Nerves

Nerves are mainly classified on two bases:

1) On Base of Function/Direction of conduction of impulse

According to this classification, nerves are divided into three types.

i) Sensory Nerves

Such nerves, which carry sensations from sense organs to CNS are called sensory nerves.

ii) Motor Nerves

Such nerves, which carry motor messages from CNS to effectors are called motor nerves.

iii) Mixed Nerves

Such nerves, which contain both sensory and motor neurons and carry both type of messages are called mixed nerves.

2) On Base of Location / Link with Brain or spiral cord

According to this classification, there are two types of nerves.

i) Cranial Nerves

Such nerves, which are originated from brain are called cranial or cerebral nerves.

- There are ***12 pairs*** of cranial nerves in humans.
- They may be ***sensory, motor or mixed***.

ii) Spinal Nerves

Such nerves, which are originated from spinal cord are called spinal nerves.

- There are ***31 pairs*** of spinal nerves in humans.
- All are ***mixed***.

CLASSIFICATION OF PNS

Peripheral nervous system (motor neurons) is further classified into somatic and autonomic nervous system.

1) Somatic Nervous System

Somatic nervous system constituted by motor neurons, controls voluntary movements of skeletal muscles of body under conscious control of body.

2) Autonomic Nervous System

Autonomic nervous system, constituted by motor neurons, controls involuntary responses by influencing organs, glands and smooth muscles

It is further divided into sympathetic and parasympathetic systems.

i) Sympathetic System

Most ganglion fibres of the sympathetic system arise from the middle portion of the spinal cord and terminate at ganglia near cord.

This system is important in emergency situations and is associated with 'fight or flight'.

This system

- Accelerates heart rate
- Dilates the pupil
- Inhibits digestive tract
- Accelerates breathing rate

ii) Parasympathetic System

A few cranial nerves (including vagus nerve) together with nerves from bottom portion of spinal cord form parasympathetic nervous system.

It promotes all the internal response, which are associated with the relaxed state of.

- Contracts pupils
- Promotes digestion of food
- Retards heart beat
- Normalizes breathing rate and blood flow

QUESTIONS RELATED TO ABOVE ARTICLE

What is peripheral nervous system? Explain its various components

Discuss peripheral nervous system of man. (LHR 2018)

17.3.7 Nervous Disorders

Following are some of the common disorders of nervous system in humans.

1) Parkinson's Disease

Definition

It is a nervous disorder, characterized by involuntary tremors, diminished motor power and rigidity.

Cause

Disease is believed to be caused by cell death in a brain area that produces dopamine. The disease may result from head trauma.

Features of Disease

- The mental faculties during this disease are not affected.
- Onset of disease is usually in age of 50's and 60's.
- Disease is slowly progressive; thus the patient may live for many years.

Treatment

- ***L-dopa*** is one of effective drugs available for treatment of Parkinson's disease.
- A naturally occurring protein called Glial cell-lined Derived Neurotrophic Factor (***GDNF***). It has been successfully applied on laboratory rats and monkeys and has been shown to boost uptake of dopamine.

2) Epilepsy

Definition

It is one of the convulsive disorders of nerves, which are characterized by abrupt transient symptoms of motor, sensory, psychic or autonomic nature, frequently associated with changes in consciousness.

Cause

i) These changes are believed to be secondary to sudden transient alterations in brain functions associated with excessive rapid electric discharges in gray matter.

ii) In some patients, emotional disturbances play a significant trigger role.

iii) Alcohol aggravates epilepsy.

Feature

- The onset of epilepsy is usually before age 30.
- Later age onset suggests organic disease.

Treatment

- Anticonvulsant drugs are used.
- Persons suffering from epilepsy should avoid alcohol.

3) Alzheimer's Disease

Definition

It is characterized by decline in brain function similar to those diseases that cause dementia (memory loss).

It was first described by Alois Alzheimer in 1907.

Cause

i) In some people, there is genetic predisposition so running in families.

ii) High level of aluminum may contribute to the onset of this disease.

iii) Age may also be considered as an important cause in decline of brain function.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain different types of Nervous disorders

17.3.8 Effect of Drugs on Coordination

Action of Nicotine

Nicotine affects the post-synaptic membrane in CNS and PNS. It mimics the action of acetylcholine on nicotine receptors, thus acts as stimulant of nerve impulse. It causes

- increase in heart beat rate
- increased blood pressure
- increased digestive tract mobility
- vomiting and diarrhea
- water retention by kidneys

17.4 CHEMICAL COORDINATION

Endocrine System

This system consists of some ***20*** endocrine glands in humans.

Such glands, which do not have ducts and pour their secretions in blood are called ductless or endocrine glands.

These glands produce secretions called hormones.

17.4.1 Hormones

Definition

Hormone is a Greek word meaning 'exciting or setting in motion'.

Hormones are organic compounds of varying structural complexity produced by glands.

Feature

i) They are poured directly into blood and transported to respective target tissues.

ii) They do not initiate new biochemical reactions, instead either stimulate or inhibit an already occurring function.

iii) Hormones may also control some long term changes such as rate of growth, rate of metabolic activity and sexual maturity.

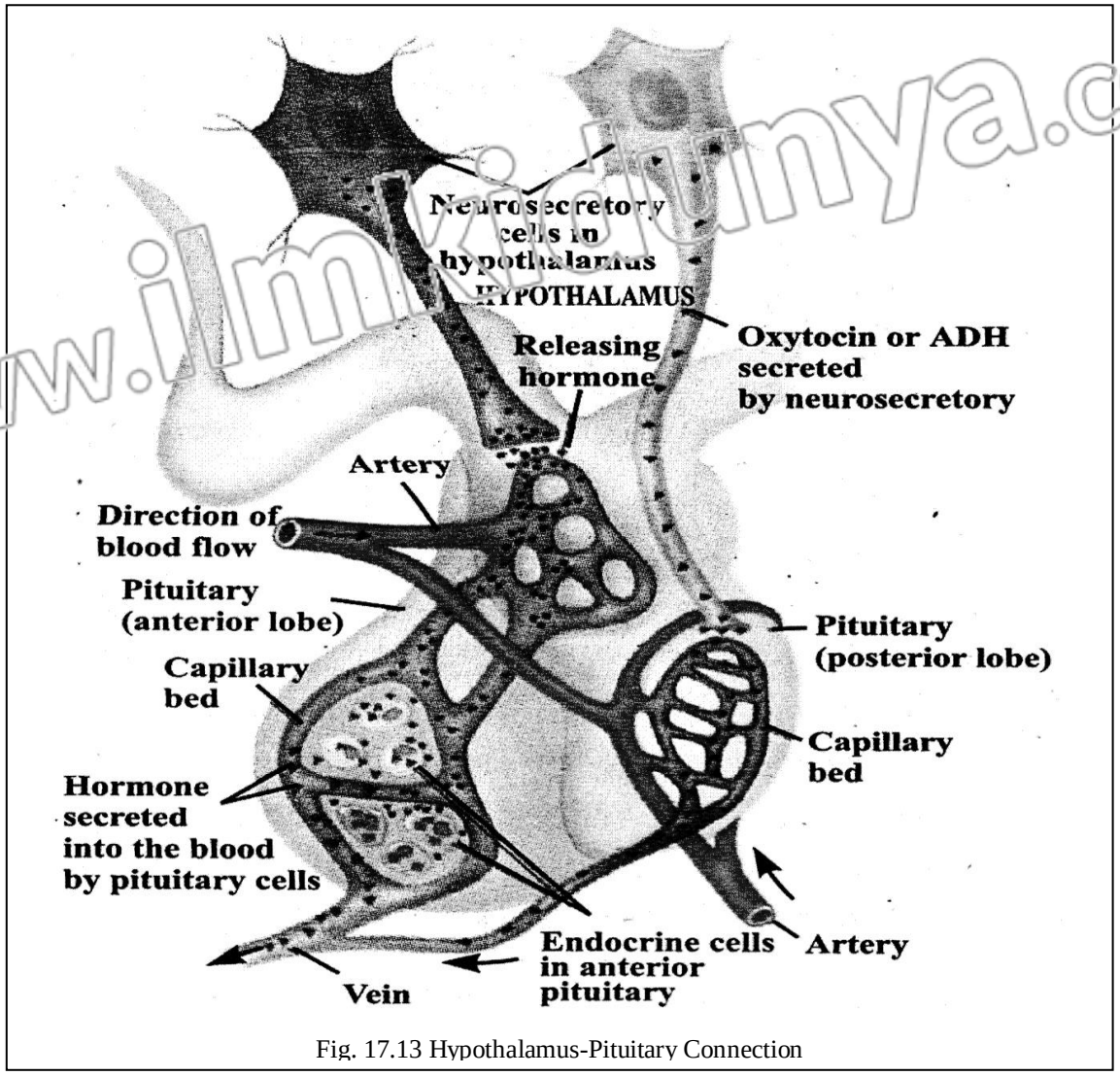


Fig. 17.13 Hypothalamus-Pituitary Connection

Chemical Composition of Hormone

Chemically hormones may be of following four types

i) ***Proteins*** e.g. insulin and glucagon.
ii) ***Amino acids & derivatives*** e.g. thyroxine, epinephrine and nor-epinephrine.
iii) ***Polypeptide*** e.g. vasopressin or antidiuretic hormone and oxytocin.
iv) ***Steroids*** e.g. estrogen, testosterone and cortisone.

QUESTIONS RELATED TO ABOVE ARTICLE

What are hormones? How are they classified? (BWP 2019)

17.4.2 Endocrine Glands of Mammals

17.4.2. a. Hypothalamus

Introduction

It is part of forebrain. Here sensory stimuli of nervous system are converted into hormonal responses.

Function

It is believed that oxytocin and ADH are produced in hypothalamus and travel down the nerves to the posterior lobe of pituitary to be stored.

They are released from their storage after receiving nerve impulses from the hypothalamus.

17.4.2. b. The Pituitary Gland

Introduction

In man, the pituitary gland or ***hypophysis cerebri*** is an ovoid structure about ***0.5 gm*** in the adult and is connected to brain through a short stalk called ***infundibulum***.

Lobes of Pituitary

Pituitary gland is divided into three lobes.

A) Anterior lobe
B) Median lobe
C) Posterior lobe

A) Anterior lobe

Anterior lobe is often referred as ***master gland*** because in addition to producing primary hormones, it also produces the tropic hormones, which control the secretions of other endocrine glands.

Different hormones produced by anterior lobe are as follows.

1) Somatotropin (STH)

Control of Production

It is secreted under stimulation of somatotropin releasing factor (SRF) from hypothalamus. This factor is secreted throughout life.

Function

This hormone controls growth of individual. When growth has mostly ceased after adolescence, the hormone continues to promote protein synthesis throughout body.

Abnormal Secretions of Hormone

- ***Over secretion*** of this hormone during early life leads to ***gigantism*** resulting in abnormal development of hands, feet and jaws etc (condition known as ***acromegaly***).
- ***Under secretion*** of somatotrophin results ***dwarfism*** as well as other symptoms associated with lack of thyroid and adrenal hormone.

2) Thyroid Stimulating Hormone (TSH)

Control of Production

Secretion of TSH is controlled by thyrotrophin releasing factor (TRF) from hypothalamus, which is itself controlled by levels of thyroxin in the blood.

In the presence of low levels of thyroxin, there is increasing production of TSH and vice versa.

Function

It is secreted throughout life but particularly reaches high levels during periods of rapid growth and development.

It acts directly on the cells of the thyroid gland increasing both their number and their secretory activity.

3) Adrenocorticotrophic Hormone – Cotricotrophic Hormone (ACTH)

Control of Production

Release of ACTH is controlled by corticotrophin releasing factor (CRF) from hypothalamus, which is itself controlled by steroid levels in the blood and by direct nervous stimulation of the hypothalamus as a result of stress e.g. cold, heat, pain, fright, infections.

Function

It controls hormones secreted from cortex of adrenal gland.

Abnormal Secretion

Abnormal secretion of ACTH causes disturbance of normal adrenal functions.

5) Gonadotrophic Hormones

These hormones are related with gonads.

These are

a) Follicle stimulating hormone (FSH)

b) Luteinizing hormone (LH)

c) Prolactin

a) Follicle Stimulating Hormone (FSH)

It shares a common hypothalamic releasing factor alongwith LH.

- FSH in females stimulates follicle development and secretion of estrogen from the ovaries.
- FSH in males stimulates development of germinal epithelium of the testis and sperm production.

b) Luteinizing Hormone (LH)

It also called interstitial cell stimulating hormone (ICSH) in male.

As described above it shares common hypothalamic releasing factor alongwith FSH.

- LH works with FSH to stimulate estrogen secretion and rupture of mature follicles to release egg or ovum.
- It also causes lutenisation ('lit'= 'turning yellow') of mature follicles.
- It acts synergistically with prolactin to maintain the corpus luteum and stimulates progesterone secretion.
- ICSH in male stimulates the interstitial cells of testis to secrete testosterone.

c) Prolactin

It is sometimes inappropriately called luteotrophic hormone (LTH).

Prolactin is continuously produced from pituitary and is inhibited by prolactin inhibiting factor (PIF).

- It acts alongwith LH in maintaining and stimulating production of progesterone.
- It stimulates milk production.

B) Median lobe

Median lobe secretes following hormone.

Melanophore Stimulating Hormone (MSH)

Control of Production

Its inhibition of secretion is controlled by hypothalamus.

External light governs its secretion.

Function

It stimulates melanocytes in skin to produce brown pigment, melanin, which gives colour to skin.

Abnormal Secretion

- Pregnancy stimulates over secretion and thus darkening of skin.
- Excess amount is also secreted in Addison's disease, one of the symptoms of which is darkening of skin.

C) Posterior lobe

Posterior lobe of pituitary gland secretes the following hormones.

1) Antidiuretic Hormone (ADH)

It is also called as ***vasopressin***.

Control of Production

It is mostly secreted in response to decrease in blood pressure, blood volume and osmotic pressure of blood detected by osmoreceptors in hypothalamus.

External sensory stimuli also influence hypothalamic neurosecretory cells to secrete ADH.

Function

It controls level of water in body by affecting reabsorption of water at level of kidneys.

Abnormal Secretion

- Increased levels cause increased water reabsorption in distal parts of nephrons.
- A lack of this hormone produces ***diabetes insipidus***, characterized by production of large quantities of dilute urine and great thirst.

2) Oxytocin

Control of Production

Its release is stimulated by

- Distension of cervix
- Decreased progesterone level in blood
- Neural stimuli during parturition and suckling

Function

It acts on smooth muscles particularly in uterus during childbirth and also causes milk ejection from mammary glands.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain the role of hormones produced by posterior lobe of pituitary gland. (LHR 2019)

Discuss hormones of anterior lobe of pituitary gland. (MTN 2019, MTN 2021)

Describe co – relation between G.H ACTH and Thyroxine hormones regarding growth of an individual. (MTN 2022)

How is growth affected by STH, thyroxine and adrenal hormones of human endocrine system? (SWL 2022)

Write a note on pituitary gland. (Exercise Question vi)

17.4.2. c. Thyroid Gland

Location

In mammals, it consists of two lobes situated above the larynx.

Hormones

Important hormones produced by thyroid gland are

i) Thyroxine (also called tetraiodo-thyronine or T4)

ii) Tri-iodothyronine or T3 (similar to thyroxine with three iodine atoms rather than four)

iii) Calcitonin

The thyroid is active continuously but produces higher levels of secretions during period of rapid growth and sexual maturation and in stress situations such as cold and hunger.

Thyroxine and Tri-iodothyronine

Function

i) They act on basal metabolic rate by stimulating the breakdown of glucose and release of heat and generation of ATP.

ii) They function with somatotrophin hormone to control growth.

iii) They act directly on brain cells to differentiate.

iv) In amphibians, they control process of metamorphosis. If secretion of thyroid is deficient, tadpole larvae of frog increases in size but does not metamorphose.

Abnormal Secretions

i) Over secretion

Excess thyroxine produces a condition called ***Graves' disease***.

Major cause of Graves' disease is production of an abnormal protein, which continuously stimulates the thyroid to excessive secretion.

Graves' disease is associated with;

- Exophthalmic goiter.
- Increase in basic metabolic rate.
- If prolonged may lead to cardiac failure.

ii) Under secretion

Congenital deficiency of thyroxine causes an abnormal condition called ***cretinism***. In it

- Individual fails to develop normally
- Small in size
- Coarse scanty hair
- Thick yellowish scaly skin
- Mental retardation.
- Sexual retardation

Deficiency of hormone in adult life mainly due to iodine shortage in diet, leads to ***goiter*** (swelling of neck) and ***myxedema***. It is characterized by;

- Puffiness of hands and skin
- Bodily and mental retardation

Role of Iodine

Iodine is essential for normal production of thyroxine. Table salt with iodine is recommended for this.

Calcitonin

Control of Production

- High Ca^{++} ion concentration in the blood causes stimulation of the synthesis and release of calcitonin.
- Low level of Ca^{++} ions suppresses its manufacture.

Function

It controls calcium level of blood. Calcitonin is antagonist to parathormone.

Abnormal Secretion

Excess or deficiency leads to a disturbance of calcium metabolism with its associated effects on nerve, skeleton, muscle, blood etc.

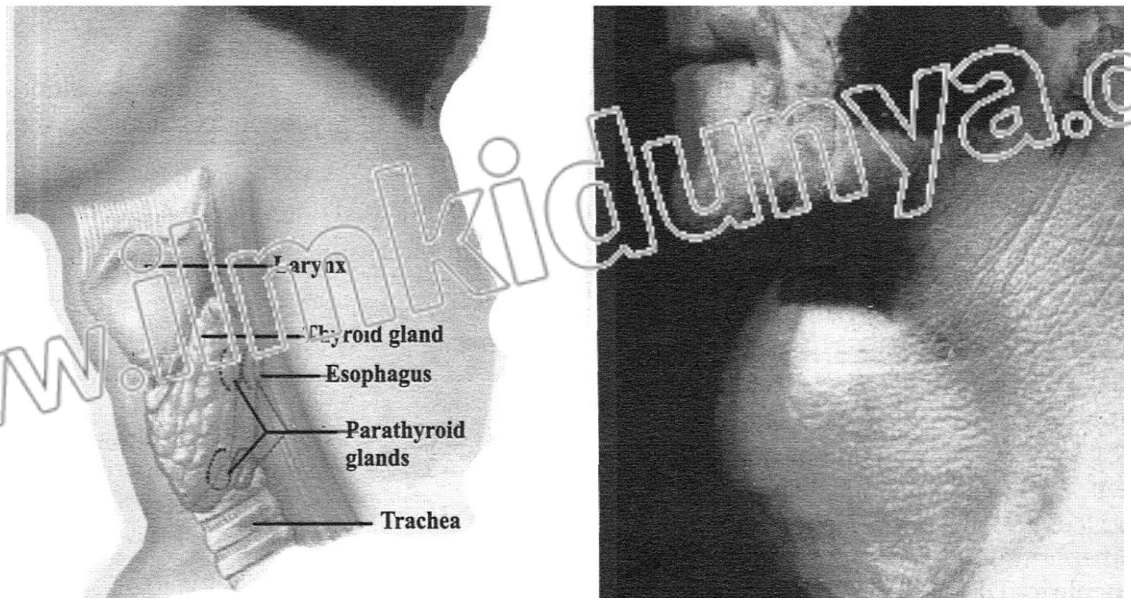


Fig 17.15 The thyroid and parathyroid glands

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the functions of thyroid gland. **(MTN 2019)**

17.4.2. d. Parathyroid

Location

These are embedded in the posterior part of the lateral lobes of the thyroid.

Hormone

These produce a hormone called ***Parathormone***.

Function

It controls calcium level in blood.

Control of Production

- Low-level blood calcium ions stimulate the parathyroid directly to increase Parathormone production.
- High-level of calcium ions in blood suppresses its release.

Abnormal Secretion

- ***Over secretion*** caused by overactivity of parathyroid gland leads to progressive demineralization of the bones similar to rickets alongwith formation of massive kidney stones.
- ***Under secretion*** due to underactivity causes a drop in blood calcium level which in turn leads to muscular tetany.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe briefly parathyroid gland.

Explain the structure and function of thyroid gland. **(LHR 2017)**

17.4.2. e. Islets of Langerhans (Pancreas)

Islets of Langerhans is endocrine part of pancreas.

Structure

Two cells of this are important in this context;

i) ***β-cells***, which are more in number and concerned with production of insulin.

ii) ***α-cells***, which are smaller in number and concerned with production of glucagon.

Control of Production

This is under control of pituitary trophic hormone (STH) and ACTH and responds directly to the level of blood glucose.

Hormones

Two important hormones are produced by Islets of Langerhans

1) Insulin
2) Glucagon

1) Insulin

Functions

It performs following functions.
It depresses blood glucose level in a variety of ways e.g. by

- Converting into glycogen
- Increasing cell utilization of glucose
- Stimulating conversion of glucose into lipids and proteins to reduce glucose level.
- Inhibiting hydrolysis of glycogen in liver and muscles

Abnormal Secretion

i) Deficiency of insulin leads to a condition called ***Diabetes Mellitus***. Symptoms of this disease are

- High level of blood glucose
- High level of sugar in urine
- Disturbance of body's osmotic equilibrium
- Derangement of nervous system
- Production of toxic fat metabolites and their removal from kidneys alongwith valuable metal cations.
- Dehydration of body.

ii) Excessive production of insulin leads to

- Increased utilization of glucose.
- Fall of glucose level in blood (hypoglycemia)
- Upset of nerve and muscle functioning.

2) Glucagon

Function

It is antagonistic to insulin and causes an increase in blood glucose level by

- Promoting breakdown of glycogen to glucose in liver and muscles.
- Increasing rate of breakdown of fats

Abnormal Secretion

Glucagon abnormalities are rare as endocrine disorders. Tumors on α cells will cause excess glucagon secretions and consequent high blood glucose levels, which in turn damages alpha cells.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the functions of Pancreas as endocrine and exocrine gland.
Describe the role of pancreas as an endocrine gland. (SGD 2019)
Discuss the role of insulin and explain how diabetes mellitus is caused? (BWP 2022)

17.4.2. f. Adrenals

A pair of adrenal glands is present, one on top of each kidney.

Structure

- Outer layer of adrenals is called adrenal cortex.
- Inner layer of adrenals is called adrenal medulla.

Medullary Hormones

Medulla produces two important hormones.

1) Adrenaline

2) Noradrenaline

Both adrenaline and Noradrenaline are produced in stress situations.

Function

i) Adrenaline dilates blood vessels in certain areas e.g. skeletal muscles and increase cardiac out put. Noradrenaline constricts blood vessels in certain areas e.g. gut. Both functions synergistically in raising blood pressure.

ii) They promote release of glucose from liver glycogen and reinforce the effects of the sympathetic system.

iii) In rare cases, they cause abnormal increase in blood pressure.

iv) It is found that rats with surgically removed adrenal medulla do not have ability to withstand stress situation like cold etc.

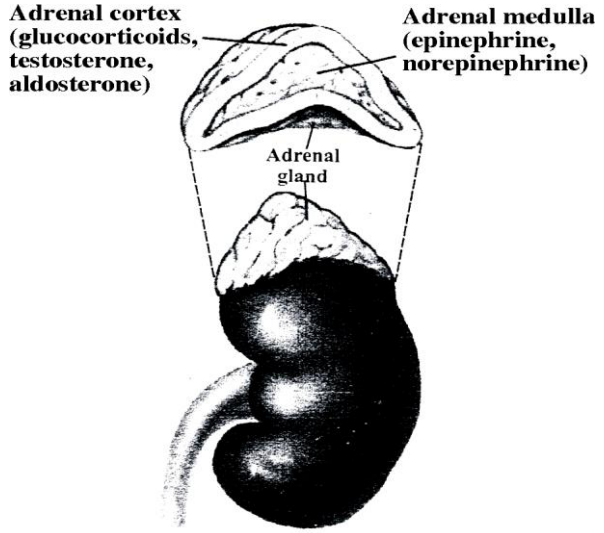


Fig: 17.16 The adrenal gland

Cortical Hormones

Adrenal cortex is active at all times but especially following shock or stress situations and infections. Important hormones secreted by adrenal cortex are

1) **Cortisol**

2) **Aldosterone**

3) **Androgens**

Cortisol and aldosterone are collectively called as ***corticosterone***, which acts both as gluco corticoid and mineralocorticoid.

1) **Cortisol**

It brings about an increase in blood glucose level mainly by its production from protein and by antagonizing the action of insulin.

2) **Aldosterone**

It is principal mineralo-corticoid and it conserves the level of Na^+ ions in the body by preventing their loss from the kidney tubules.

Abnormal Secretion

i) ***Under secretion***

Destruction of adrenal cortex such as ***in Addison's disease***, will lead to

- General metabolic disturbance
- Weakness of muscle action.
- Loss of salts.
- Loss to deal stress situations such as cold, which may lead to collapse and death.

ii) ***Over secretion***

Over secretion of adrenal cortex as ***in Cushing's disease*** leads to

- Excessive protein breakdown.
- Muscular and bone weakness.
- Disturbance in metabolism.
- High blood sugar leading to diabetes.

3) Androgens

These are produced in small amounts from adrenal glands in both male and female. Most important androgen is testosterone.

Function

Androgens cause development of secondary male characters.

Abnormal Secretion

Any tumor on inner part of adrenal cortex in female can cause excess androgens to be produced and the development of certain male characteristics. Such cases are rare.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe in detail the role of adrenal glands. **(GRW 2021)**

Describe in detail the role of adrenal glands. **(Exercise Question ii)**

17.4.2. g. Gut

Many parts of gut act as endocrine tissue. Important hormones produced from gut are as follows.

1) Gastrin

It is produced by mucosa of pyloric region of stomach.

Control of Production

It is produced under the influence of protein food in the stomach after it is partially digested.

Function

It stimulates secretion of gastric juice.

2) Secretin

It is produced from duodenum.

Control of Production

It is produced under influence of acidic food as it touches lining of duodenum.

Function

It affects

- Pancreas to produce pancreatic juice.
- Liver to produce bile.

17.4.2. h. Gonads

A) Ovary

Important hormones produced by ovary are as follows.

1) Oestrogen

2) Progesterone

1) Oestrogen

They are secreted from ripening of follicles and in many species by interstitial cells of ovary.

Control of Production

As development of follicles is initiated by FSH, thus production of oestrogen is controlled by FSH.

Functions

i) They bring about development of secondary sexual characters in female.

ii) They cause thickening of the uterine wall.

iii) They cause a sharp rise in LH output by pituitary during oestrous or menstrual cycle as a positive feedback.

iv) They also aid in healing and repair of uterine wall after menstruation.

v) They stimulate transformation of some uterine cells to glandular cells, which then produce proteinaceous secretions. These are taken up by embryo for early development.

Deficiency

Deficiency of these hormones lead to

- Sexual retardation in young.
- Sterility in adults.

2) Progesterone

It is secreted from ruptured follicle in response to LH from the pituitary.

Control of Production

It is produced under response to LH from pituitary.

Functions

It acts as major constituent of birth control pill.

i) It inhibits FSH secretion from pituitary and thus preventing any more follicles from ripening.

ii) It also affects uterus causing further thickening and vascularization of its wall.

iii) Preparation of other areas for maintaining state of pregnancy.

iv) It suppresses ovulation.

B) Testes

The testes consist of

- Many coiled seminiferous tubules where spermatozoa develop.
- Regions of interstitial cells between tubules, which produce gonadal hormones.

Hormones

Testes produce:

- Testosterone
- 17 β-hydroxy testosterone

After initiation of development of sex organs in foetus, level of these hormones rises fairly consistently until puberty. After puberty the supply of LH and testosterone remains constant.

Functions

Testosterone performs following functions.

- In foetus, it initiates the development of sex organs.
- At puberty, it brings about development of secondary sexual characters in male. It also promotes sex drive.

Affect of Castration

The castrated male fails to develop secondary sexual characteristics and his body tends more towards the form of immature female.

QUESTIONS RELATED TO ABOVE ARTICLE

What is the role of Gonads as endocrine glands?

17.4.3 Feedback Mechanism

Definition

It is a type of interaction in which a controlling mechanism is itself controlled by the products of reactions it is controlling.

Importance of Feedback Mechanisms

Feedback mechanism provides two opposing systems, which are required for proper body functioning.

- If there are accelerators, there must be inhibitors.

If one hormone in body stimulates a reaction, another hormone would be checking the same.

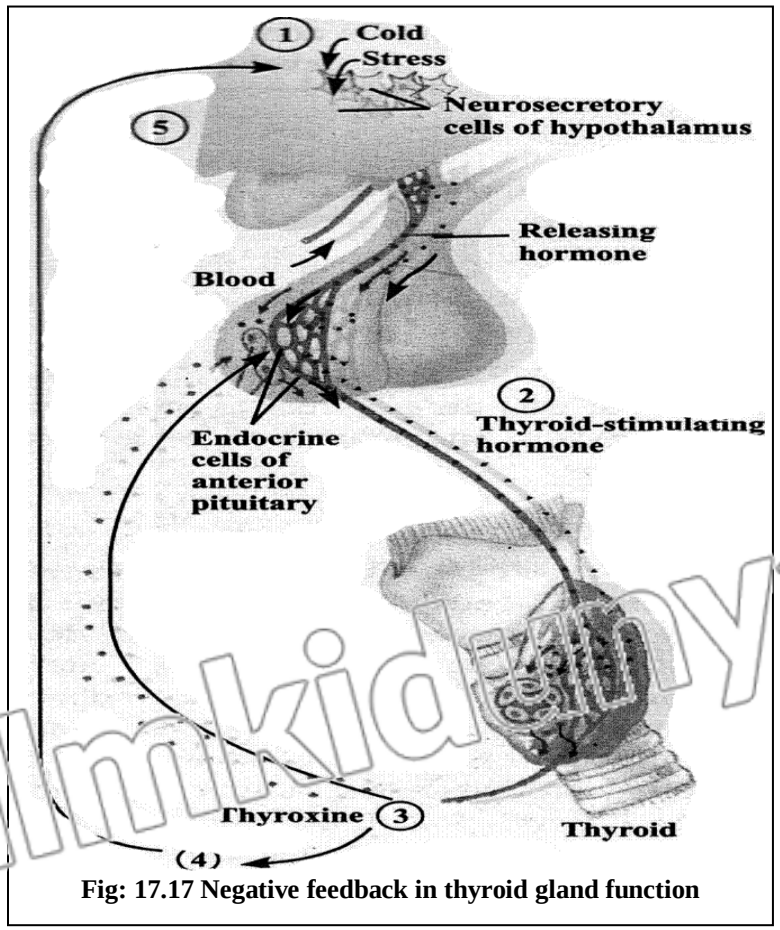


Fig: 17.17 Negative feedback in thyroid gland function

Mechanism

Concentration of secretions by glands is controlled by information, which is sent back to the source. Source adjusts its secretion according to this feedback.

Example

Pituitary and other endocrine glands are connected through feedback mechanism. It is explained with following example.

1. Low body temperature or stress stimulates neurosecretory cells of hypothalamus.
2. Releasing hormone of hypothalamus triggers release of thyroid-stimulating hormone from anterior pituitary.
3. TSH stimulates thyroid gland to release thyroxin.
4. Thyroxin causes an increase in metabolic activity of most body cells generating ATP, energy and heat.
5. Both raised body temperature and higher thyroxin levels in blood inhibit the releasing-hormone cells and TSH-producing cells.

QUESTIONS RELATED TO ABOVE ARTICLE

Write notes on the Feedback mechanism.

Explain feed-back mechanism. Give an example. (LHR 2017)

Define learning behavior, describe its various types. (BWP 2019)

Explain the steps of that mechanisms which maintains the concentration of secretions in the body. (LHR 2022)

17.4.4 Comparison of Nervous Coordination and Chemical Coordination

Similarities

1) Specific Stimuli

Both systems function in response to specific stimuli either from within the body or from the external environment.

2) Chemical Messengers

Both hormone producing cells and nerve cells (neurons) synthesize chemical messenger.

3) Extra-Cellular Release

Both release the messenger chemicals in extra-cellular spaces of the body.

5) Coordination

Both help in coordination of the body.

5) Homeostasis

Both are homeostatic in function.

Differences

Nervous Coordination	Chemical Coordination
1. Neurons (sensory, associative and motor), are the basic units of structure and function. In addition, neuroglial cells are also present, which provide nutrition and protection to neurons	**1.** Hormone producing cells and neurosecretory cells (such as those found in the hypothalamus), release hormones and are units of structure and function.
2. Chemicals produced by neuron endings act where they are produced i.e. very close to the cells they influence, commonly from less than a micrometer away. For example, acetylcholine produced by nerve endings at synapse, excites the next neuron.	**2.** Chemicals produced (the hormones or neuro hormone) are poured into and are transported by blood. These hormones affect the target cells, which are far away from where the hormones are produced. ADH is produced from posterior lobe of pituitary gland, but affects the target cells present in the nephron and collecting tubule of kidney, to control re-absorption of water
3. In this system the neurons release its neurotransmitter into one or a small group of specific cells.	**3.** The blood borne hormones bathe millions of cells indiscriminately and only a few responds to these hormones.
4. This has immediate effect or show response to a stimulus instantly.	**4.** There may have immediate effects (e.g. insulin), but mostly hormones have prolonged or delayed or delayed effects for example growth hormone.
5. This control is affected through the electrical signals that travel within the cell itself and it releases its neuro transmitters only where it reaches its target.	**5.** This control involves only chemical stimulation and the target cells are far away from them.
6. This shows faster or rapid effect. The speed of impulse in most cases is 100 meters/second; but maximum speed of nerve impulse recorded in the human beings is 120 meter/second.	**6.** It is not very rapid; but shows slow but prolonged effects.
The chemicals involved in this system (the neurotransmitters or neuro hormones) are short lived i.e. they are broken down shortly after their release. Thus, the effects of messengers sent by neurons tend to be of much shorter duration.	The hormones are the chemicals, which remain active for much longer duration within the blood; and thus, have much longer duration for their actions.

QUESTIONS RELATED TO ABOVE ARTICLE

What are the major differences between nervous system and endocrine system?

Write any four differences between nervous and chemical coordination. (LHR 2018)

17.5 BEHAVIOUR

All the activities shown by an organism during its lifetime collectively constitute its behaviour.

Major Types

There are two types of behaviour

- Innate behaviour
- Learning behaviour

17.5.1 Innate Behaviour

Definition

It is a collection of responses that are predetermined by the inheritance of specific nerves or cytoplasmic pathways in multicellular or unicellular organism.

Features

i) In this behaviour, a given stimulus always produces in variable a same response.

ii) It occurs due to built-in pathways.

iii) It is economical on nervous pathways.

iv) It does not demand on higher centers of nervous system.

Types

There are two types of innate behaviour.

1. Orientation

(i) Kinesis

It is a behaviour in which an organism changes the speed of random movements, which help them to survive in the environment.

Example

Pill pugs to reach moist area, which is required for their survival by this behaviour.

(ii) Taxes

It is a directed movement.

If it is towards stimulus, then is called positive taxis and if away from stimulus then negative taxis.

2. Reflexes & Instincts.

These are complex behaviours and include biological rhythms, territorial behaviour, courtship, mating, aggression, altruism, social hierarchies and social organizations.

17.5.2 Instincts & Learning

Definition

Darwin (1859) was the scientist, who first time proposed proper definition of instinct.

According to him

"Instinctive behaviour is a part of one's inherited structure by which the individual responses to a particular stimulus."

Sign Stimulus

A sign stimulus is a part of stimulus configuration and may be relatively simple part.

Uexkull (1934) and ***Lorenz*** (1935) thought that animals sometime respond instinctively to specific though often-complex stimuli. Such stimuli are called "sign stimuli".

For example, a male three-spined stickle back fish has a characteristic red belly when in breeding condition. This is a sign stimulus that elicits aggression in other territorial males.

Features

- Instincts equip an animal with series of response to a particular stimulus, thus enabling it to adapt to its environment.
- This response is similar in all members of a species.
- Selective responses to stimuli suggest that there must be some built-in mechanism by which sign stimuli are recognized. This mechanism is called innate releasing mechanism (IRM).
- It is usually present in those animals with short life span or no parental care.

Example

Complete behaviour of female digger wasp (*Ammophila adriaansei*) is innate. Different activities performed during its life cycle are as follows.

- It prepares a nest, catches caterpillars, kills them by sting and puts them in nest.
- Then it lays eggs on them and then closes the nest.
- After doing all this, she dies.
- The larvae after emerging from the eggs, start feeding on caterpillars killed by their mother before death and grow to digger wasp.

All this is completed within few weeks and is done by instincts of digger wasp, which may be responding to perception of caterpillar (possible sign stimulus) in different ways.

17.5.3 Learning Behaviour (Modification Through Experience)

Definition

Thorpe defined learning as "The process, which manifests itself by adaptive changes in individual behaviour as a result of experience".

Types

Thorpe classified learning behaviour into six types

1) Imprinting
2) Habituation
3) Conditioned reflex type I
4) Conditioned reflex type II
5) Latent learning
6) Insight learning

1) Imprinting

Definition

It is a behaviour shown by young bird's specially precocial birds, produced by hatching in early brief sensitive period during which they follow moving objects in their surroundings.

It is best known in birds such as geese, ducks and chickens.

Explanation

Normally first moving object encountered is mother bird. Young birds to learn her appearance and follow her. However, if its parents are absent, a young bird may imprint on other species of birds, human beings or inanimate objects.

In later life such birds will attempt to court and mate with imprinted objects in preference to adults of their own species.

2) Habituation

Definition

It is the simplest form of learning and involves modification of behaviour through a diminution (loss) of response to repeated stimuli.

Importance

Loss of response to repeated stimuli is useful in preventing a drain of energy and attention for trivial purposes.

Examples

i) A snail crawling on a sheet of glass retracts into its shell when glass is tapped. After a pause, it emerges and continues moving. A second tap causes retraction again but it emerges more quickly. Ultimately, tapping has no effect and snail ceases to respond.

ii) Rodents (squirrels, rats) respond to alarm calls by others in their group. If these calls are continued and no danger is confirmed, further calls may be ignored.

3) Conditioned Reflex Type I/ Conditioning

It is also called simple conditioning. ***Pavlov*** did first work on it.

Definition

It involves the pairing of an irrelevant stimulus with natural primary stimulus that elicits an automatic response.

Explanation

Pavlov conditioned the dogs to secrete saliva on ringing bell (artificial stimulus).

In his experiment, he used to ring the bell just before giving food to dogs. After some repetition, when only bell was rung dog responded that by secreting saliva.

Importance

It enables animals to react appropriately to environmental changes. This conditioning process removes dependence on one kind of reflex symbol for action.

4) Conditioned Reflex Type II/ Operant Conditioning

It is also called operant learning or trial and error learning. ***Thorpe*** and ***B.F.Skinner*** (Harvard psychologist) did a valuable work on it.

Definition

In it, random activities through trial and error repetition leads to achievement of a particular goal is the reward that directs random activities into behavioural patterns.

Trial and error repetitions, step by step, lead to final achievement.

Explanation

Experiments on rats and cats to run into a maze for food or to depress lever and coming out were performed. In this case, first experiment is accidental and then it is rewarded. Animal learns with latter experience.

5) Latent Learning

It was defined and explained first by ***Thorpe***.

Definition

Latent learning is the association of indifferent stimuli or situations without patent reward.

Explanation

If a rat is put in maze, it wanders about and accidentally gets food. If it is put again, it directly reaches food. It means that rat was wandering in first case, but he also learned something without reward.

6) Insight Learning

It is highest form of learning. ***Kohler*** did a valuable work on this type of learning.

Definition

It is an extreme case of behavioural modification involving the application of insight or reasoning to solve a problem in novel situation.

Explanation

If an animal can direct its behaviour to solve a problem for which it has no previous experience, then reasoning is involved. It is present in primates.

Reasoning in humans involves imagination and manipulation of concepts to produce a solution that can be applied to the situation.

Example

A chimpanzee is placed in a cage in which a choice piece fruit hangs from ceiling. Some boxes of different sizes are also placed. This chimpanzee cannot reach the fruit immediately but after a short period of head scratching, it moves largest box, piles other small boxes over it and climbs up to reach the fruits.

Comparison between Instinctive Behaviour and Learning Behaviour

FEATURE	INSTINCTIVE BEHAVIOUR	LEARNING BEHAVIOUR
Dependence	This is the type of behaviour that depends on the heredity material which the animal inherits. The animal may be born with the right responses built in the nervous system as part of its inherited structure.	This type of behaviour depends on the environmental influence but the ability to modify its behaviour depends on the heredity material.
Experience	It has no obvious influence.	It has an obvious influence.
Origin	It depends on selection operating during the history of species so that it helps in adaptability of the organism in the environment.	It depends on selection operating during the history of the individual (during one's life time) so as to help organism in adaptability in the environment.
Relation with life span	Instincts can equip an animal with a series of responses. It is advantageous for animals with short life spans and with little or no parental care.	It can equip an animal with a set of adaptive responses to its environment. It is advantageous for those animals which have long life spans and have parental care.
Evolution	It evolves slowly in species.	It evolves during the life cycle of the individual but ability of learning depends on genetic basis of the individual.
Examples	**i)** Honey bees inherit the ability to form wing muscles and wings for flight. They inherit the tendency to fly towards flowers to seek nectar and pollen. **ii)** Behaviour of digger wasp is instinctive but it does learn certain things during its brief life such as locality of each of its nests where it has to return after hunting.	**i)** Conditioned reflex type I, in case of dogs where dogs learn to salivate on ringing of bell alone. **ii)** Trial and error learning in case of cat, when it learns to press the lever to open the door of cage. **iii)** Crawling snail on a sheet of glass, learns that tapping has no harmful effect and ceases to respond after few early responses.

QUESTIONS RELATED TO ABOVE ARTICLE

Enlist the types of learning behaviors. Explain the insight learning.
Give an account of innate behaviour. (SWL 2019)
Define learning behavior, describe its various types. (DGK 2019)
Describe different types of learning behaviour. (Exercise Question i)

KEY POINTS

Apical dominance

The phenomenon in plants in which terminal branches suppress the growth of the lateral branches of stem

Tract

Bundle of axons and dendrites bounded by connective tissue, present within the CNS.

Parthenocarpy

The formation and fruit without fertilization is called parthencarpic fruit. This phenomenon is called parthenocarpy.

Senescence

The negative changes in plants and leaves which are caused due to aging of plants are called senescence.

Seed dormancy

The inactive seed which temporarily fails to grow is called dormant see. This phenomenon is called seed dormancy.

Dopamine

Dopamine is a neurotransmitter. It causes sleep in brain.

Synergistic

It is the phenomenon in which one factor support the other. In this way the two factors shows strong combine reaction.

Difference between endocrine and exocrine glands:-

Endocrine glands

The ductless glands are called endocrine glands. These glands transfer their secretions through blood e.g. thyroid gland, pituitary gland.

Exocrine glands

The glands with ducts are called exocrine glands. They transfer their secretions through this duct. e.g. salivary gland, liver. Pancreas act as both endocrine and exocrine gland.

Neurofibrils

Intermediate filaments present in axon are mainly concerned with maintenance of shape of axon.

EXERCISE

Q 1 Fill in the blanks.

i) Neurotransmitter molecules bind to the receptors on the _____ membrane at synapse.

ii) Excess of _____ hormone is secreted in Addison's disease.

iii) Operant learning has been demonstrated and studied by _____ and _____.

iv) _____ are plant hormones which delay the life of fresh leaf crops.

v) All membranes of neurons have very active _____ and _____ pumps.

i) (Postsynaptic)
ii) (MSH)
iii) (Thorndike, B.F. Skinner)
iv) (Cytokinins)
v) (Na, K)

Q 2 Write whether the statement is true or false and write the correct statement if false.

i) Impulses travel much more rapidly along myelinated neurons. **(True)**

ii) All glial tissue consists of glial cells. **(True)**

iii) Saltatory conduction is carried out by those nerve fibers that have nodes of Ranvier. **(True)**

iv) The myelin sheath of neuron is particularly good conductor of electric impulse. **(False)**
The myelin sheath of neuron is particularly non-conductor of electric impulses.

v) The resting membrane potential is maintained largely by the sodium pump. **(False)**
The resting membrane potential is maintained largely by the sodium-potassium pump.

vi) Hormones initiate new biochemical reactions in the body. **(False)**
Hormones do not initiate new biochemical reactions in the body. Instead inhibit or accelerate already existing processes.

Q 3 Encircle the correct answer from the multiple choices.

i) The neuron net of *Hydra* lacks:
(a) Neurons
(b) Dendrites
(c) Connections
(d) Direction of impulse flow

ii) A nerve is a:
(a) Collection of neurons
(b) Concentration of dendrites and axons
(c) Bundles of axons or dendrites of neurons
(d) Bundle of axons or dendrites bounded by connective tissue

iii) Thyroid gland produces:
(a) T3 and T4 and calcitonin
(b) Calcitonin
(c) Tri-iodothyronine
(d) Tetra-iodothyronine

iv) What is the number of cranial and spinal nerves in man respectively?
(a) 12 and 31
(b) 24 and 62
(c) Both a and b
(d) None of these

v) The one which is not related to others is:
(a) Cretinism
(b) Myxoedema
(c) Exopthalmic goiter
(d) Diabetes mellitus

Answer key

i	**d**
ii	**d**
iii	**a**
iv	**b**
v	**d**

Q 5 Short Questions

i) Define circadian rhythms.

Ans. Circadian Rhythms:

Such rhythms which show periodicity of about 24 hours are called circadian rhythms.

In Latin Circa = about, dies = day, which means 1 day so they are also called diurnal rhythms.

ii) What is difference between CNS and PNS?

Ans.

CNS	PNS
It provides central control of all the activities of body.	It connects peripheral parts of the body with CNS.
It contains brain and spinal cord.	It contains nerves and ganglia.

iii) What are the functions of parathyroid gland?

Ans. In man the glands are found embedded in the posterior part of the lateral lobes of the thyroid. These produce a hormone called parathormone. Low levels of blood Ca^{++} ions stimulate the parathyroid directly to increase parathormone production whereas high levels of Ca^{++} ions suppress its release.

iv) Define the term hormone.

Ans. Hormones are organic compounds of varying structural complexity produced by endocrine glands. They are poured directly and are transported via blood to respective target tissues.

v) What are the commercial applications of auxins?

Ans.

- NAA and IPA are used for stimulating fruiting and parthenocarpy.
- 2, 4 D is used to kill weeds, to inhibit sprouting of potatoes and to prevent premature fruit drop.

vi) List different types of tropism.

Ans. **(i)** Phototropism
(ii) Geotropism
(iii) Hydrotropism
(iv) Thigmotropism
(v) Chemotropism

vii) Write a note on Alzheimer's disease.

Ans. Alzheimer's Disease:

"It is characterized by decline in brain function. Its symptoms are similar to those diseases that cause dementia (memory loss)."

It was first described by *Alois Alzheimer* in 1907.

Cause:

(i) In some people, there is genetic predisposition so running in families.

(ii) High level of aluminium may contribute to the onset of this disease.

Age may also be considered as an important cause in decline of brain function.

Q 5 Extensive Questions.

i) Describe different types of learning behaviour.

Ans (see article 17.5.3)

ii) Describe in detail the role of adrenal glands.

Ans (see article 17.4.2. f.)

iii) Define nerve impulse. Explain the mechanism involved by labeled diagram.

Ans (see article 17.3.3b)

iv) How is the nervous system of *Planaria* better developed than that of *Hydra*.

Ans (see article 17.3.5)

v) Describe the structure and functions of different parts of human brain.

Ans (see article 17.3.6.1. a.)

vi) Write a note on pituitary gland.

Ans (see article 17.4.2. b.)