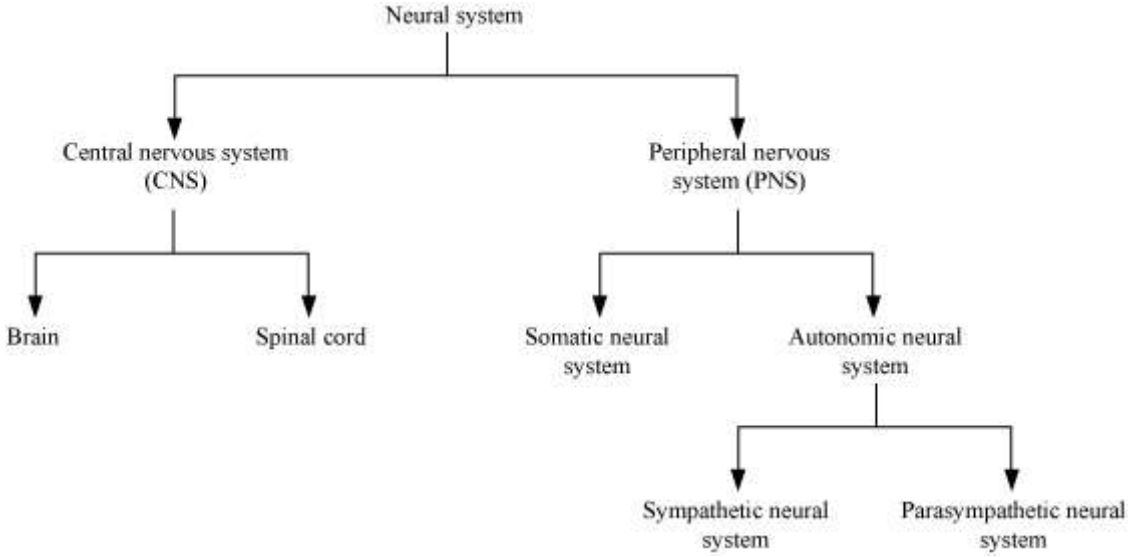
17. Control and Co-ordination

Human Neural System

Neural system

- It provides rapid coordination among the organs of the body.
- The coordination may be in the form of electric impulses, which is quick and short-lived.



Neurons

- Neurons are structural and functional units of nervous system.
- **Structure of neuron**

    1. **Cell body – Contains Nissl's granules**
    2. **Dendrite** – Conducts messages towards cell body
    3. **Axon** – Conducts messages away from cell body

- **Neurons are of three types:**

1. **Unipolar**
2. Bipolar
3. Multipolar
    - **Axons are of two types:**
    1. **Myelinated nerve fibre**
    -
        -
            - Fibre is coated with myelin sheath, which is impermeable to ions. Schwann cells enveloped the myelin sheath.
            - The place where myelin sheath is not present on the myelinated nerve fibre is called node of Ranvier.
            - Conduction of nerve impulse is from node to node in a jumping manner. Hence, the conduction is fast.

- Found in spinal and cranial nerves

1. **Non-myelinated nerve fibre**

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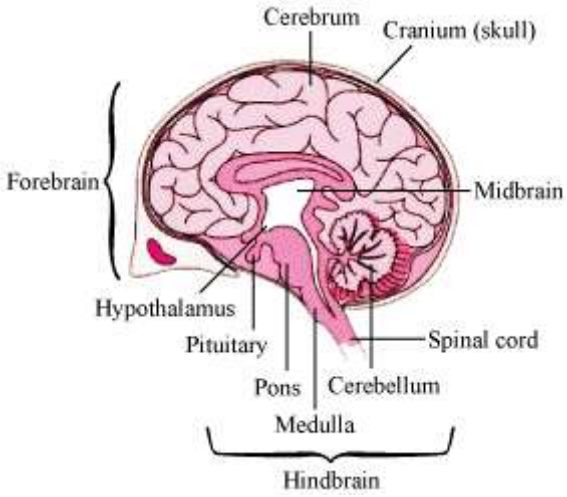
  -
    - Fibres are not coated by myelin sheath.
    - Conduction of nerve impulse occurs along the whole length of nerve fibre. Hence, the conduction is slow.
    - Found in autonomous and somatic neural systems

Parts of the nervous system

- Human nervous system divided into- central nervous system (CNS) and peripheral nervous system (PNS)
- CNS consists of the brain and spinal cord
- PNS consists of the nerves that connects the CNS to different parts of the body
- The Brain, spinal cord, and nerves are the important parts of the nervous system

Brain

- The brain is enclosed in a bony box called the **cranium** and spinal cord is protected by **vertebral column**.
- The brain and spinal cord are externally covered by protective covering called **meninges**.
- It is made up of three layers namely **duramater (outer layer)**, **arachnoid (middle laye**r), **piamater (inner lay**er).
- The space between meninges is filled by a watery fluid called **cerebro- spinal fluid (CSF)**.



Human brain is classified into- forebrain, midbrain, and hindbrain.

- **Forebrain-** It consists of cerebrum, thalamus, and hypothalamus.
- It has following functions:
  - It is the thinking part of the brain.
  - The forebrain has sensory regions that receive sensory impulses from various receptors.
  - It has motor regions that control the movement of various muscles (such as the leg muscles).
  - Cerebrum controls intelligence, learning, memory, thinking, and speech.
  - Hypothalamus contains many areas that control things such as body temperature, urge for eating and drinking, etc.
- **Midbrain-** It is mainly concerned with the sense of sight and hearing.
- **Hindbrain-** It consists of pons, medulla, and cerebellum.

- It has following functions:
    - Most of the involuntary actions such as heartbeat, blood pressure, movement of food in the alimentary canal, salivation, etc., are controlled by the midbrain and medulla of the hindbrain.
    - Cerebellum is responsible for voluntary actions and maintaining the posture and equilibrium of the body.

Spinal Cord

- It is the continuation of the medulla oblongata and runs through the vertebral column.
- The spinal cord is made up of two similar halves fused together to form a central canal containing the cerebrospinal fluid.
- The outer portion of the spinal cord is known as the **white matter**, which consists of nerve fibres.
- The inner portion contains the cell bodies of neurons and is known as the **grey matter**.

- **Autonomic Nervous System (ANS)**

- ANS comprises of sympathetic as well as parasympathetic nervous system

- The general functions of the sympathetic division are concerned with preparing the body for emergencies (increased blood pressure and rate of heartbeat, increased release of stored nutrients, increased respiration rate, dilation of pupils), whereas the parasympathetic division is primarily involved with conserving energy and replenishing energy stores.

- **Peripheral Nervous System (PNS)**

- PNS comprises of cranial nerves and the spinal nerves.

- The details of cranial nerves are as follows

Number	Name	Nature	Major function
1.	Olfactory	Sensory	Smell
2.	Optic	Sensory	Sight
3.	Oculomotor	Motor	Movement of eyeball
4.	Trochlear	Motor	Rotation of eyeball
5.	Trigeminal	Mixed	Sensation of touch and taste
6.	Abducens	Motor	Rotation of eyeball
7.	Facial	Mixed	Taste, facial expression saliva secretion, neck movement
8.	Auditory	Sensory	hearing, equilibrium
9.	Glosso-pharyngeal	Mixed	Taste, saliva secretion
10.	Vagus	Mixed	Gastric and pancreatic secretion, GI movement visceral reflexes
11.	Spinal accessory	Motor	Muscle movement visceral reflex
12.	Hypoglossal	Motor	Tongue movement

- **Spinal Nerves**

- Spinal nerves are the nerves originating from the spinal cord by means of two roots- a dorsal root and a ventral root.

- All the spinal nerves are mixed nerves

- Man has 31 pairs of spinal nerves which are again put into five different categories
    1. Cervical (8 pairs)
    2. Thoracic (12 pairs)
    3. Lumbar (5 pairs)
    4. Sacral (5 pairs)
    5. Coccygeal (1 pair)

Conduction of nerve impulse

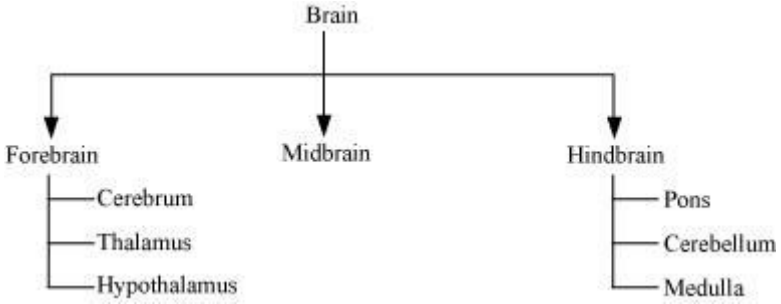
- **During resting condition:**
    - Concentration of K^+ ions is more inside axoplasm while concentration of Na^+ is more outside axoplasm.
    - Ionic gradient is maintained across membrane by transport of 3 Na^+ outward and $2K^+$ into the cell.
    - Membrane becomes positively charged outside and negatively charged inside. Nerve fibre is said to be polarized nerve fibre.
- **When stimulus is given to nerve fibre:**
    - Action potential is generated.
    - Nerve fibre becomes permeable to Na^+ ions than to K^+ ions.
    - Membrane becomes positively charged inside and negatively charged outside the axoplasm. The nerve fibre is said to be depolarized nerve fibre.
- **Synapse**
    - It is a small gap found between the last portion of axon of one neuron and dendrite of next neuron.
    - There are two types of synapses:
        - **Electrical synapse**
        - **Chemical synapse**

Reflex action –

- It is an automatic action or response provoked by a stimulus.
- **Reflex** pathway is comprised of the following.
    - **Afferent neuron** – Receives signal from sensory organ and transmits impulse into CNS(spinal cord level).
    - **Efferent neuron –** Carries signal from CNS to effectors

Central nervous system

- **Brain**
    - It is the main coordinating centre of the body.
    - Brain is protected by the skull and covered by cranial meninges.
    - Cranial meninges consist of three layers - outer dura mater, middle arachnoid, and inner pia mater.



- **Forebrain** is the largest and most developed region of brain.
- **Hypothalamus** region of forebrain regulates body temperature and the urge for eating and drinking.
- **Midbrain** is concerned with the sense of sight and hearing.
- The dorsal portion of the midbrain consists of four round swellings called **corpora quadrigemina**.
- **Cerebellum** maintains posture and equilibrium of the body.

- **Mechanism of vision:**

Light rays falls on retina

↓

Dissociation of retinal from opsin

↓

Structure of opsin changes

↓

Permeability of membrane changes

↓

Generation of action potential in ganglionic cells

↓

Transmission of impulse to cortical region of brain

↓

Image formed on retina

Sense Organs: Organs that helps us to be aware of our surroundings are known as sense organs.

Receptors: Any cell or tissue sensitive to a selective stimuli are called receptors.

Eye

Composed of three layers:

- **Outermost layer-** sclera and cornea
- **Middle layer-** choroid, ciliary body, iris
- **Innermost layer-** retina, with rod cells and cone cells.

- Just behind the iris, a transparent, biconvex, and elastic structure called **lens** is present.

- **Rods –** Contain rhodopsin pigment that is highly sensitive to dim light

- **Cones –** Contain iodopsin pigment that is sensitive to high intensity light. Cones are also responsible for colour vision.

- **Blind spot –** Area where photoreceptors such as rods and cones are absent

- **Fovea –** Area that contains only cones. Vision is finest and sharpest in this zone.

- **Aqueous chamber –** Space between cornea and lens; contains **aqueous humour**.

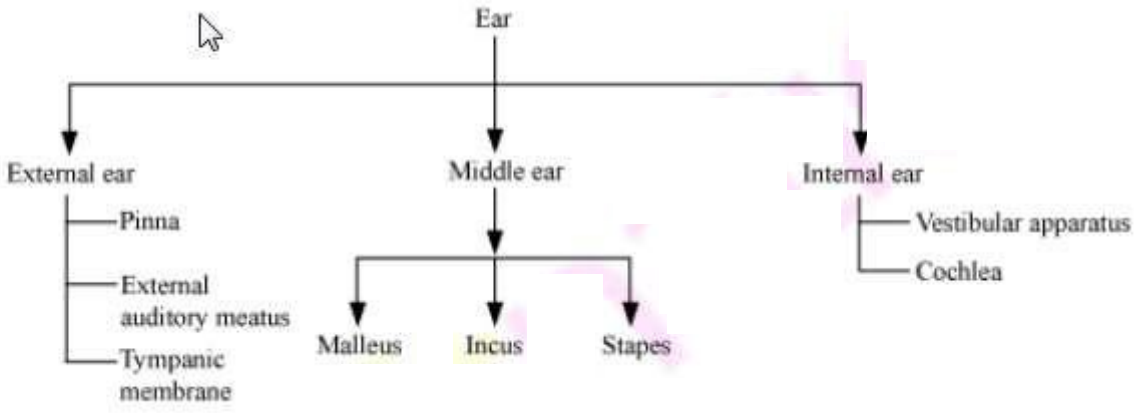
- **Vitreous chamber –** Space between lens and retina; contains **vitreous humour**

Pupil regulates the amount of light entering into the eyes.

- **Specific abilities of eyes**
  - Power of Accommodation
  - Stereoscopic Vision

Ear

- Organ for hearing and equilibrium



- **Crista and macula** are receptors of vestibular apparatus that are responsible for maintaining body balance and posture.

- **Organ of corti** is the main hearing structure of internal ear. It is located on basilar membrane that has hair cells. The middle ear contains three small bones – malleus, incus, and stapes (arranged from outside to inside).

- **Mechanism of hearing**

Pinna collects sound waves and directs it towards ear drum

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Transmission of vibrations towards fenestra ovalis through ear ossicles

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Generation of sound waves in lymph

↓

Ripple created in basilar membrane bends the hair cells (of organ of corti) against tectorial membrane

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Sound waves converted into nerve impulses

↓

Impulse carried to cortex of brain

↓

Impulse analyzed and sound is recognized

Role of Ear in balancing Body

When we turn our head

fluid inside the semicircular canals moves

pushing against the sensory hair cells

sending nerve impulse to brain -->via auditory nerve

cells present in the semicircular canals are highly sensitive to dynamic equilibrium.

we are able to balance our body.

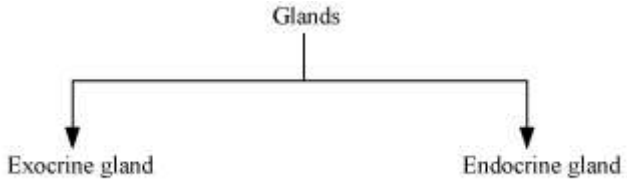
Hormones

- Hormones are chemical messengers that regulate the physiological processes in living organisms.
- These act upon specific target cells/tissues and organs.

Differences between Hormonal Control and Nervous Control

Hormonal Control	Nervous Control
Transmitted chemically through blood	Transmitted electro-chemically through nerve fibres
Transmitted slowly	Transmitted rapidly
Affects different organs	Affects specific organs
Is not affected by previous experience	Is affected by previous experience
Has both long lasting and short lasting effects	Has short lasting effect

Glands



- **Exocrine glands –** Glands that discharge their secretions into ducts

Examples: salivary gland in buccal cavity, sebaceous gland in skin

- **Endocrine gland–** Glands that do not discharge their secretions into ducts, but directly into blood

These are also called ductless glands. Examples: pituitary gland, thyroid gland, adrenal gland, etc.

Human Endocrine System

- Pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus, and gonads are the organised endocrine glands in our body.
- In addition, GI tract, liver, kidney, heart also produce hormones.

Human endocrine system

- **Hypothalamus:**
    - Contains neurosecretory cells that produce hormones
    - Hormones regulate the synthesis and secretion of pituitary glands.
    - Two types of hormones are released.
        - **Releasing hormones –** Stimulate pituitary gland to release hormones
        - **Inhibiting hormones –** Inhibit pituitary gland from releasing hormones
- **Pineal gland**

- It secretes a hormone called melatonin.
- It also regulates the rhythm of body.

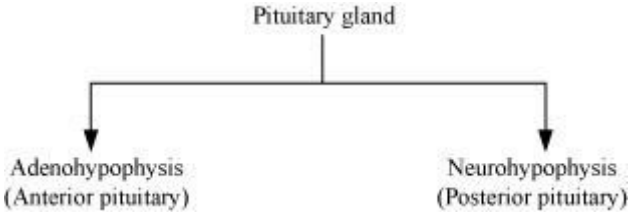
- **Thyroid gland**
  - It secretes two hormones:
    - **Tetraiodothyronine or thyroxin (T4)**
    - **Triiodothyronine (T3)**

Deficiency of iodine results into

- **Hypothyroidism.** The disease is known as **goitre**
- **Creatinism**
- **Myxodema**

- High level of iodine results into **hyperthyroidism.**
- Thyroid hormone plays a role in carbohydrate, fat, and protein metabolism in the body.
- It also secretes thyrocalcitonin, which lowers the calcium level in blood plasma.
- **Parathyroid gland:** It regulates calcium level in body. It increases the reabsorption of calcium ions by renal tubules and digested food.

- **Pituitary gland**



- **(i). Adenohypophysis** is further divided into two regions:
- **Pars distalis (anterior pituitary):**
  - **Growth hormone –** It is involved in growth and development of the body. Low secretion of growth hormone results in dwarfism and acromegaly (extra growth of bones in jaws, hands or feet)
  - **Prolactin –** It helps in growth of mammary gland and milk formation.
  - **Thyroid stimulating hormone –** It helps in secretion of thyroxine from thyroid glands.
  - **Adreno-corticotrophic hormone –** It helps in secretion of glucocorticoid hormone from adrenal cortex.
  - **Gonadotrophic hormone –** It includes the following.
    - **Luteinizing hormone –** It helps in secretion of androgen from testis. It also induces ovulation from Graafian follicles.

        - **Follicle stimulating hormone –** It maintains the growth and development of Graafian follicle.

- **Pars intermedia:** It secretes melanocyte-stimulating hormone (MSH), which maintains skin pigmentation.

- **(ii). Neurohypophysis (posterior pituitary): –** It contains pars nervosa region. Pars nervosa region secretes two hormones:
    - **Oxytocin –** It helps in contraction of uterus and milk ejection.
    - **Vasopressin (Anti-diuretic hormone) –** It stimulates reabsorption of water by distal convoluted tubules.Deficiency causes Diabetes Insipidus.

- **Thymus**
    - This gland is degenerated with the age.
    - Thymus produces a hormone called **thymosins.**
    - Thymosins produce T-lymphocytes that protect the body against infectious agents. It provides cell-mediated immunity and also humoral immunity.

- **Adrenal gland**
    - It is divided into:
        - **Adrenal medulla –** It secretes adrenaline (epinephrine) and noradrenaline (norepinephrine). These are collectively called as catecholamines. These hormones are also called emergency hormones.
        - **Adrenal cortex –** It secretes hormone called corticoids.
            - Corticoid such as glucocorticoid regulates carbohydrate metabolism. Example includes cortisol.
            - Corticoid such as mineralocorticoid maintains the sodium potassium level in blood and tissue. Example includes aldosterone.
    - **Hyposecretion** : Less secretion from adrenal cortex.
    - Disease caused is called **Addison's disease.**
    -
    - **Hypersecretion:** Excess of secretion from adrenal cortex
    - Disease caused is called **Cushing's Syndrome.**

- **Pancreas**

- The islets of Langerhans have two types of cells:
    - **α – cells –** secrete glucagon

1. **β – cells –** secrete insulin

- **Insufficient Secretion of Insulin**
- **Disease caused: Diabetes mellitus**
- **Over- Secretion of insulin**
- **Disease caused: Hypoglycemia**

- **Hyperglycemia –** Increased blood glucose level

    - Glucagon is a hyperglycaemic hormone.
    - **Hypoglycaemia –** Decreased blood glucose level
    - Insulin is a hypoglycaemic hormone.

    - Diabetes mellitus – Abnormal high glucose level in blood, which results in release of sugar in urine and formation of toxic ketone bodies

- **Testis**

    - **Leydig cells (Interstitial cells) –** Secrete androgens, mainly testosterone

    - Testosterone plays a role in spermatogenesis and development of male secondary sexual characters.

- **Ovary**

    - It secretes two hormones.

    - **Estrogen –** Secreted by Graafian follicle, it regulates the development of female secondary sexual characters.

    - **Progesterone –** Secreted by corpus luteum, it acts on mammary glands and helps in milk secretion.

Non-Endocrine Hormones

Hormone secreted by heart:

- **Atrial natriuretic factor (ANF) –** Secreted by atrial wall of heart, it decreases the blood pressure.

Hormone secreted by kidney:

- **Erythropoietin –** Stimulates erythropoiesis i.e., formation of RBCs

Hormones secreted by gastro-intestinal tract

- **Gastrin –** Stimulates gastric gland to secrete hydrochloric acid and pepsinogen
- **Secretin –** Stimulates secretion of HCO_3^- ions and water
- **Cholecystokinin (CCK) –** Stimulates secretion of bile juice and pancreatic juice
- **Gastric inhibitory peptide (GIP) –** Inhibits gastric secretion and mobility

Mechanism of hormone action:

Hormone

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Binds to hormone receptors in target tissues

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Hormone receptor complex

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Biochemical change in target tissue

Based on chemical nature, hormones are of four types:

SL NO	Nature	Example
1	Protein (peptide)	Insulin, glucagon
2	Steroids	Testosterone, estrogen, cortisols
3	Iodothyronines	Thyroid hormones
4	Amino acid derivatives	Epinephrine