NEURAL CONTROL AND COORDINATION

Coordination is the process through which two or more organs interact and complement the functions of one another.

For example, when we do physical exercises, energy demand is increased for maintaining an increased muscular activity as well as the supply of oxygen increases.

The increased supply of oxygen increases the rate of respiration, heart beat and increased blood flow via blood vessels.

When physical exercise is stopped,the activities of nerves, lungs, heart and kidney gradually return to their normal conditions.

The neural system and the endocrine system jointly coordinate and integrate all the activities of the organs so that they function in a synchronised fashion.

The neural system provides an organised network of point-to-point connections for a quick coordination.

The endocrine system provides chemical integration through hormones.

NEURAL SYSTEM

The neural system of all animals is composed of highly specialised cells called neurons which can detect, receive and transmit different kinds of stimuli.
The neural organisation is in lower invertebrates.

For example, in Hydra it is composed of a network of neurons.
The neural system is better organised in insects, where a brain is present along with a number of ganglia and neural tissues whereas the vertebrates have a more developed neural system.

HUMAN NEURAL SYSTEM

The human neural system divided into two parts
1. The central nervous system (CNS)
2. The peripheral nervous system (PNS)

The CNS includes the brain and spinal cord and is the site of information processing and control.

The PNS consists all the nerves of the body associated with the CNS (brain and spinal cord).
The nerve fibres of the PNS are of two types :
(a) afferent fibres
(b) efferent fibres

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(a) afferent fibres
(b) efferent fibres

The afferent nerve fibres transmit impulses from tissues or organs to the CNS and the efferent fibres transmit regulatory impulses
from the CNS to the concerned peripheral tissues or organs.

The PNS is divided into two divisions called:
i) somatic neural system and
ii) autonomic neural system.

The somatic neural system relays impulses from the CNS to skeletal muscles while the autonomic neural system transmits impulses from the CNS to the involuntary organs and
smooth muscles of the body.
The autonomic neural system is further classified into sympathetic neural system and parasympathetic neural system.

Visceral nervous system is the part of the peripheral nervous system that comprises the whole complex of nerves, fibres, ganglia, and plexuses is known as visceral nervous system

from which impulses travel from the central nervous system to the viscera and from the viscera to the central nervous system.

The somatic neural system relays impulses from the CNS to skeletal muscles.

The autonomic neural system transmits impulses from the CNS to the involuntary organs and smooth muscles of the body.

NEURON AS STRUCTURAL AND FUNCTUIONAL UNIT OF NERVOUS SYSTEM

Neuron: A microscopic structure composed of three major parts:

1. Cell body
2. Dendrites
3. Axon

Structure of Neuron

The cell body contains cytoplasm with typical cell organelles and specific granular body called **Nissl's granules**.
Short fibres which profusely branched projects out of cell body called dendrites.
The axon is a long fibre, branched at the end.
Each branch terminates as a bulb-like structure called synaptic knob.

Based on the number of axon and dendrites the neurons are of following types –
1. Multipolar: one axon and several dendrites - found in cerebral cortex.
2. Bipolar: one axon and one dendrite - found in retina of eye.
3. Unipolar: cell body with one axon only – found in embryonic stage.

The axon may be myelinated or non-myelinated.
The myelinated nerve fibres are enveloped with Schwann cells, which form myelin sheath around the axon. The gaps between two adjacent myelin sheath are called Nodes of Ranvier.
Cranial and spinal nerves are myelinated.
Autonomic and somatic neural fibres are non-myelinated.
Unmyelinated nerve fibre is enclosed by a Schwann cell that does not form a myelin sheath around the axon, and is commonly found in autonomous and the somatic neural systems.

Transmission of impulses through synapse

The functional junction between two neurons is called synapse.
A synapse is formed by the membranes of a pre-synaptic neuron and a post-synaptic neuron, which may or may not be separated by a gap called synaptic cleft.

There are two types of synapses:
1. Electrical synapse: pre and post synaptic membrane with close proximity without any synaptic cleft.
2. Chemical synapse: the pre and post synaptic membrane is separated by a fluid filled synaptic cleft.

CENTRAL NEURAL SYSTEM

The brain is the central information processing organ of our body and acts as the 'command and control system'.
It controls the voluntary movements, balance of the body, functioning of vital involuntary organs (e.g., lungs, heart, kidneys, etc.), thermoregulation, hunger and thirst,
circadian (24-hour) rhythms of our body, activities of several endocrine glands and human behaviour.

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It is also the site for processing of vision,hearing, speech, memory, intelligence, emotions and thoughts.
The human brain is well protected by the skull.
Inside the skull, the brain is covered by cranial meninges consisting of an outer layer called dura mater, a very thin middle layer called arachnoid and an inner layer
(which is in contact with the brain tissue) called pia mater.

The brain can be divided into three major parts:
(i) forebrain,
(ii) midbrain, and
(iii) hindbrain

Forebrain

The forebrain consists of cerebrum, thalamus and hypothalamus.
Cerebrum forms the major part of the human brain.

A deep cleft divides the cerebrum longitudinally into two halves, which are termed as the left and right cerebral hemispheres.
The hemispheres are connected by a tract of nerve fibres called corpus callosum.

The layer of cells which covers the cerebral hemisphere is called cerebral cortex and is thrown into prominent folds.
The cerebral cortex is referred to as the grey matter due to its greyish appearance.

The neuron cell bodies are concentrated here giving the colour.
The cerebral cortex contains motor areas, sensory areas and large regions that are neither clearly sensory nor motor in function.

These regions called as the association areas are responsible for complex functions like intersensory associations, memory and communication.
Fibres of the tracts are covered with the myelin sheath, which constitute the inner part of cerebral hemisphere.
They give an opaque white appearance to the layer and, hence, is called the white matter.

The cerebrum wraps around a structure called thalamus, which is a major coordinating centre for sensory and motor signaling.
Hypothalamus lies at the base of the thalamus.
The hypothalamus contains a number of centres which control body temperature, urge for eating and drinking.
It also contains several groups of neurosecretory cells, which secrete hormones called hypothalamic hormones.

The inner parts of cerebral hemispheres and a group of associated deep structures like amygdala, hippocampus, etc., form a complex structure called the limbic lobe or limbic system.
Along with the hypothalamus, it is involved in the regulation of sexual behaviour, expression of emotional reactions (e.g.,excitement, pleasure, rage and fear), and motivation.

Midbrain

The midbrain is located between the thalamus/hypothalamus of the forebrain and pons of the hindbrain.

Midbrain

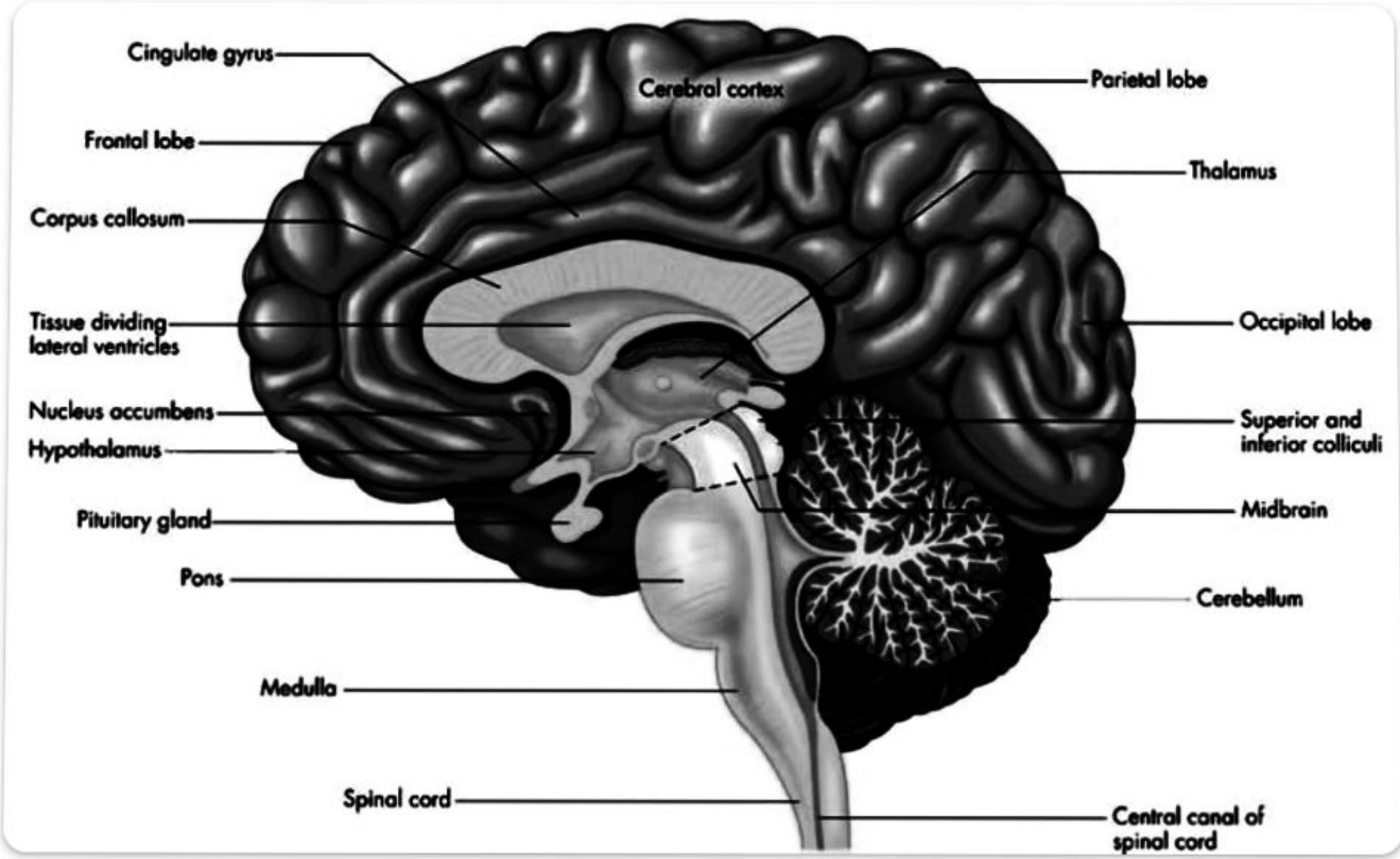
The midbrain is located between the thalamus/hypothalamus of the forebrain and pons of the hindbrain.
A canal called the cerebral aqueduct passess through the midbrain.

The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called corpora quadrigemina.
Midbrain and hindbrain form the brain stem.

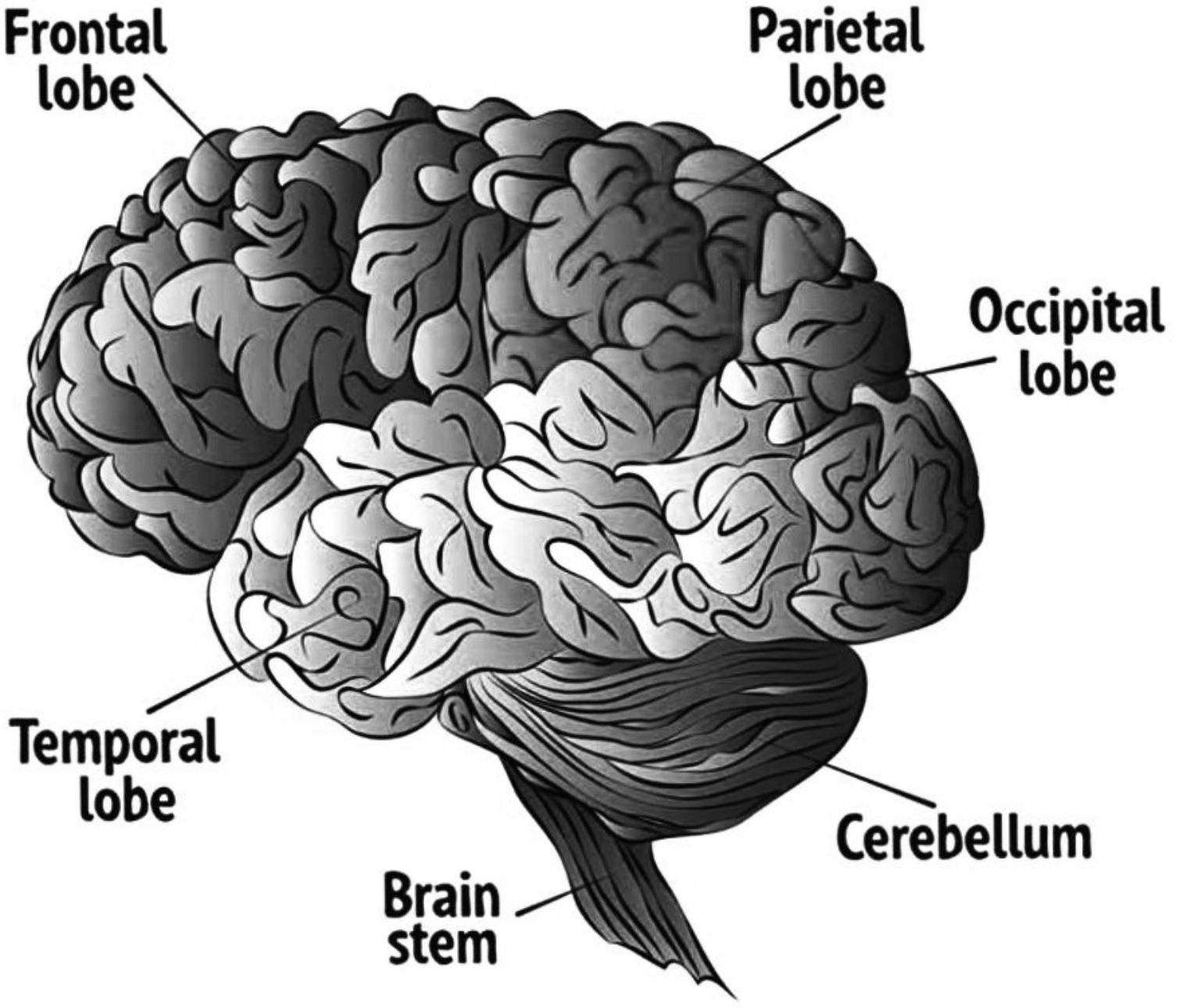
Hindbrain

The hindbrain consists of pons, cerebellum and medulla (also called the medulla oblongata).
Pons consists of fibre tracts that interconnect different regions of the brain. Cerebellum has very convoluted surface in order to provide the additional space for many more neurons.
The medulla of the brain is connected to the spinal cord.

The medulla contains centres which control respiration, cardiovascular reflexes and gastric secretions.
Brain stem forms the connections between the brain and spinal cord.
Three major regions make up the brain stem; mid brain, pons and medulla oblongata.

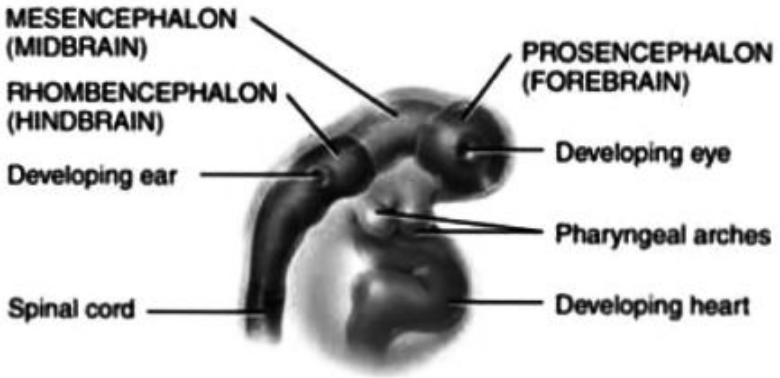

Cingulate gyrus
Cerebral cortex
Parietal lobe
Frontal lobe
Thalamus
Corpus callosum
Tissue dividing lateral ventricles
Occipital lobe
Nucleus accumbens
Superior and inferior colliculi
Hypothalamus
Pituitary gland
Midbrain
Pons
Cerebellum
Medulla
Spinal cord
Central canal of spinal cord

Important areas in the human brain

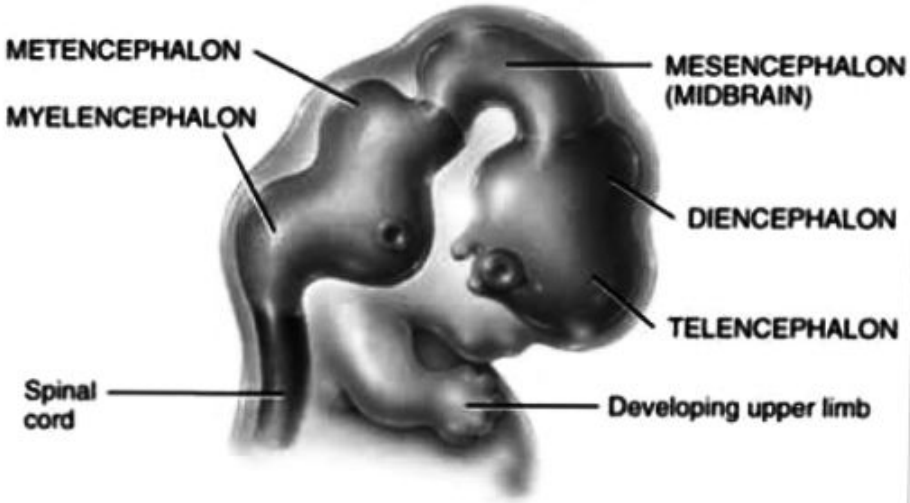


Brain (Encephalon)

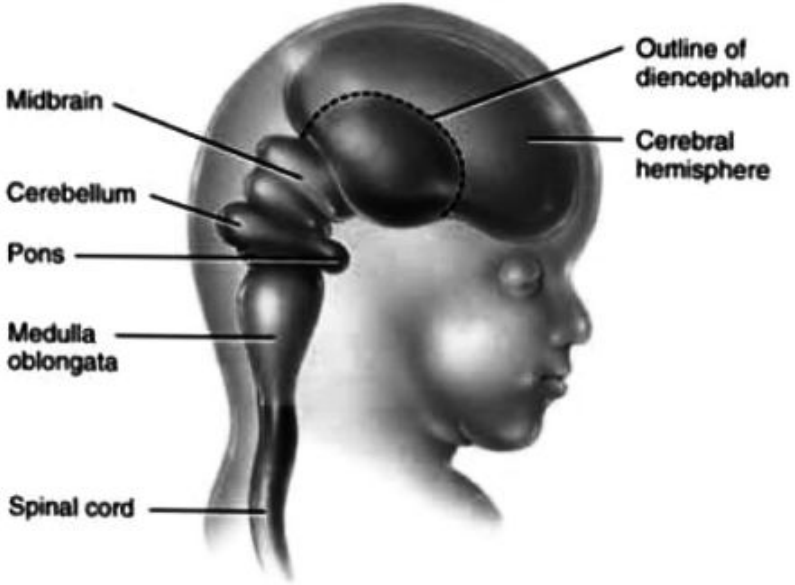
Encephalon – Brain



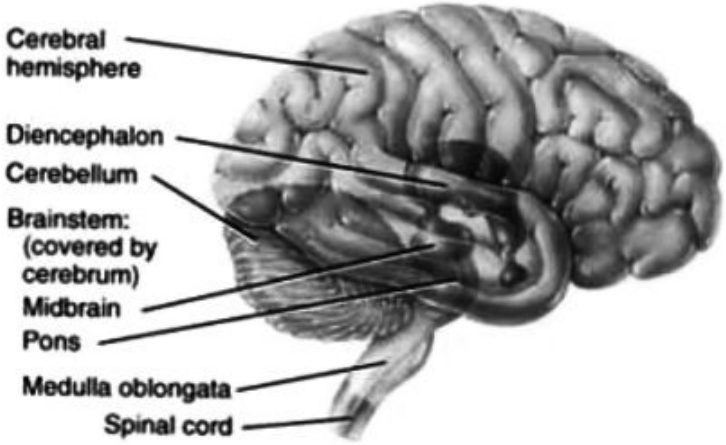
(a) Three- to four-week embryo showing primary brain vesicles



(b) Seven-week embryo showing secondary brain vesicles

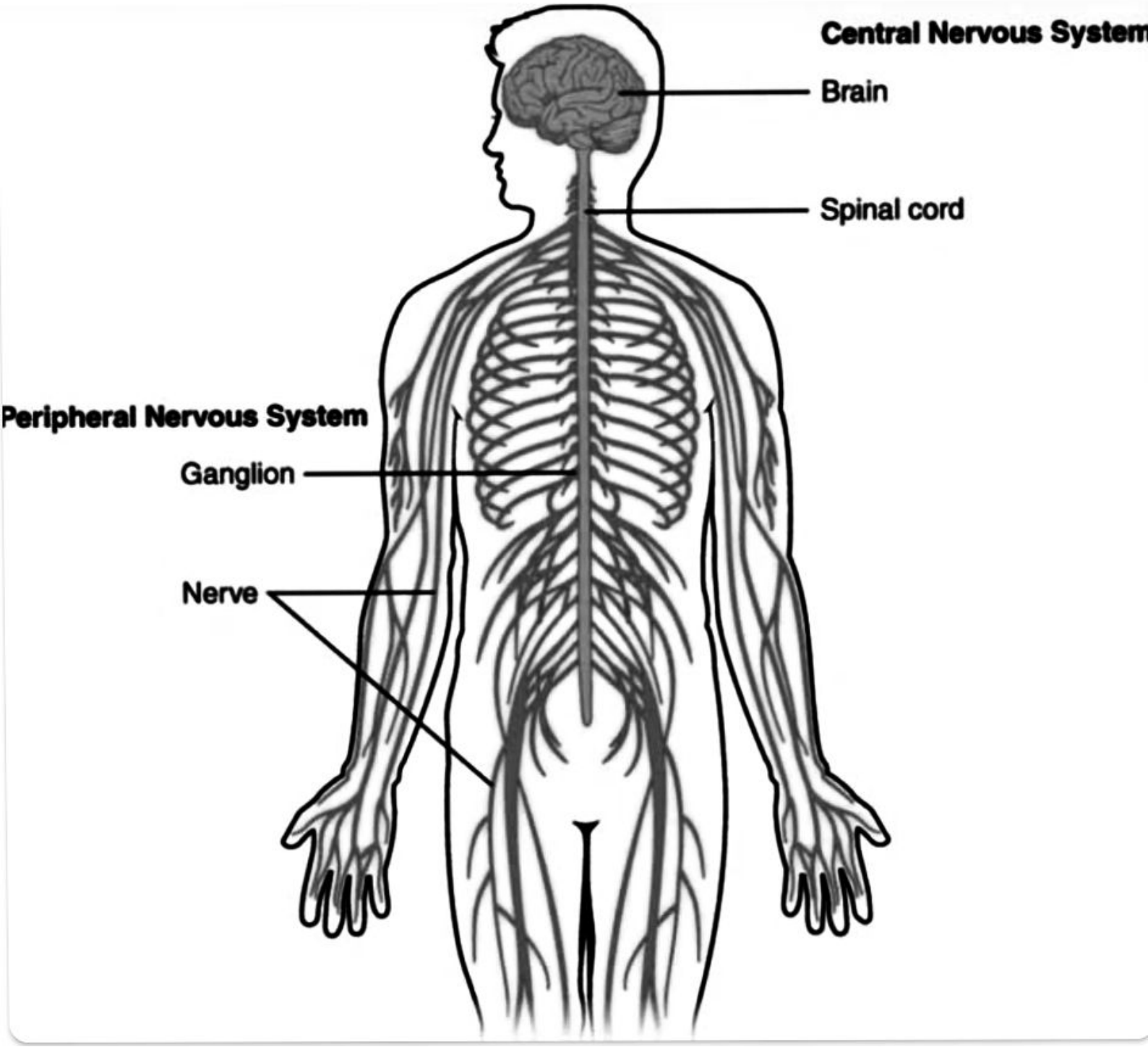


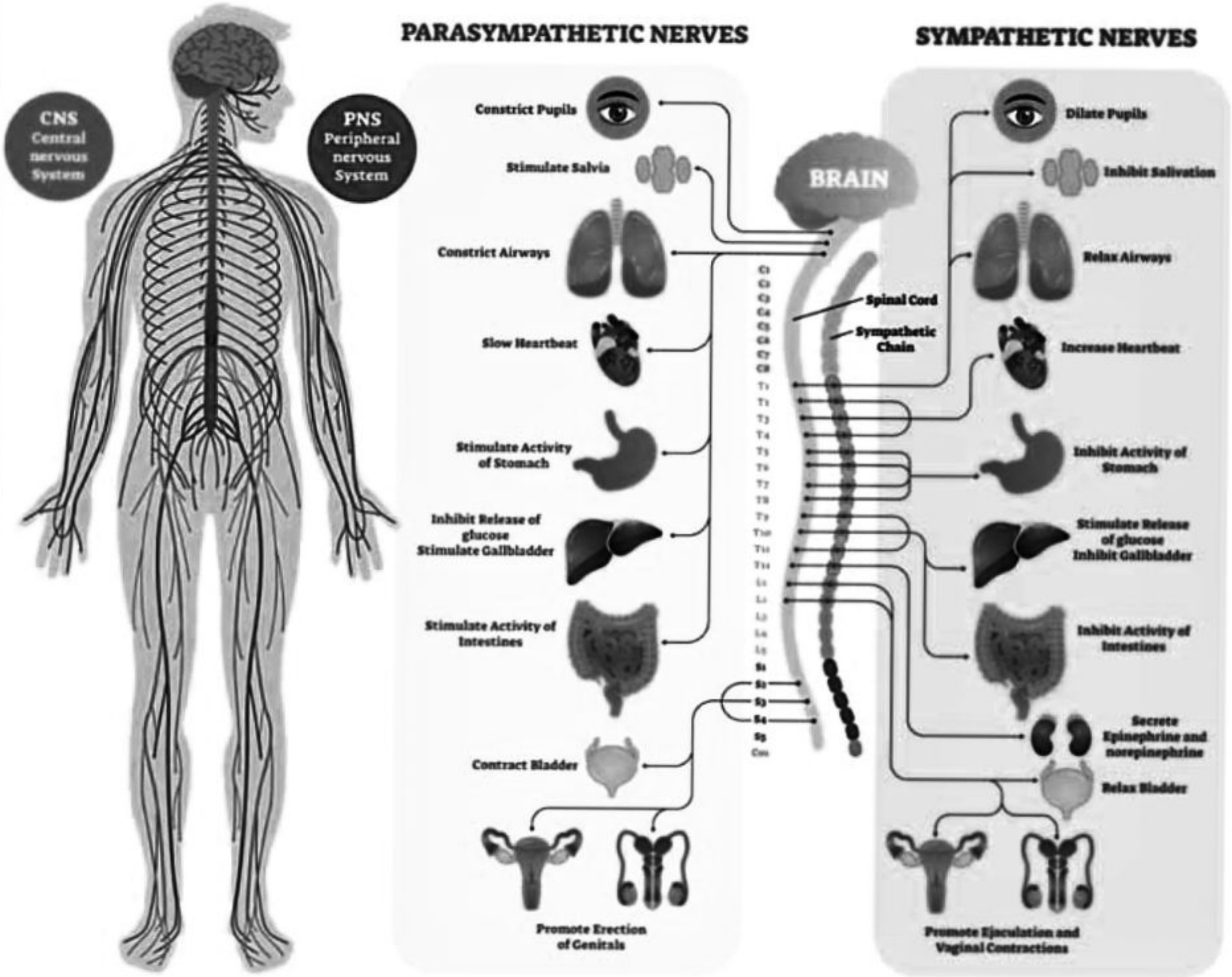
(c) Eleven-week fetus showing expanding cerebral hemispheres overgrowing the diencephalon



(d) Brain at birth (diencephalon and superior portion of brain stem projected to surface)

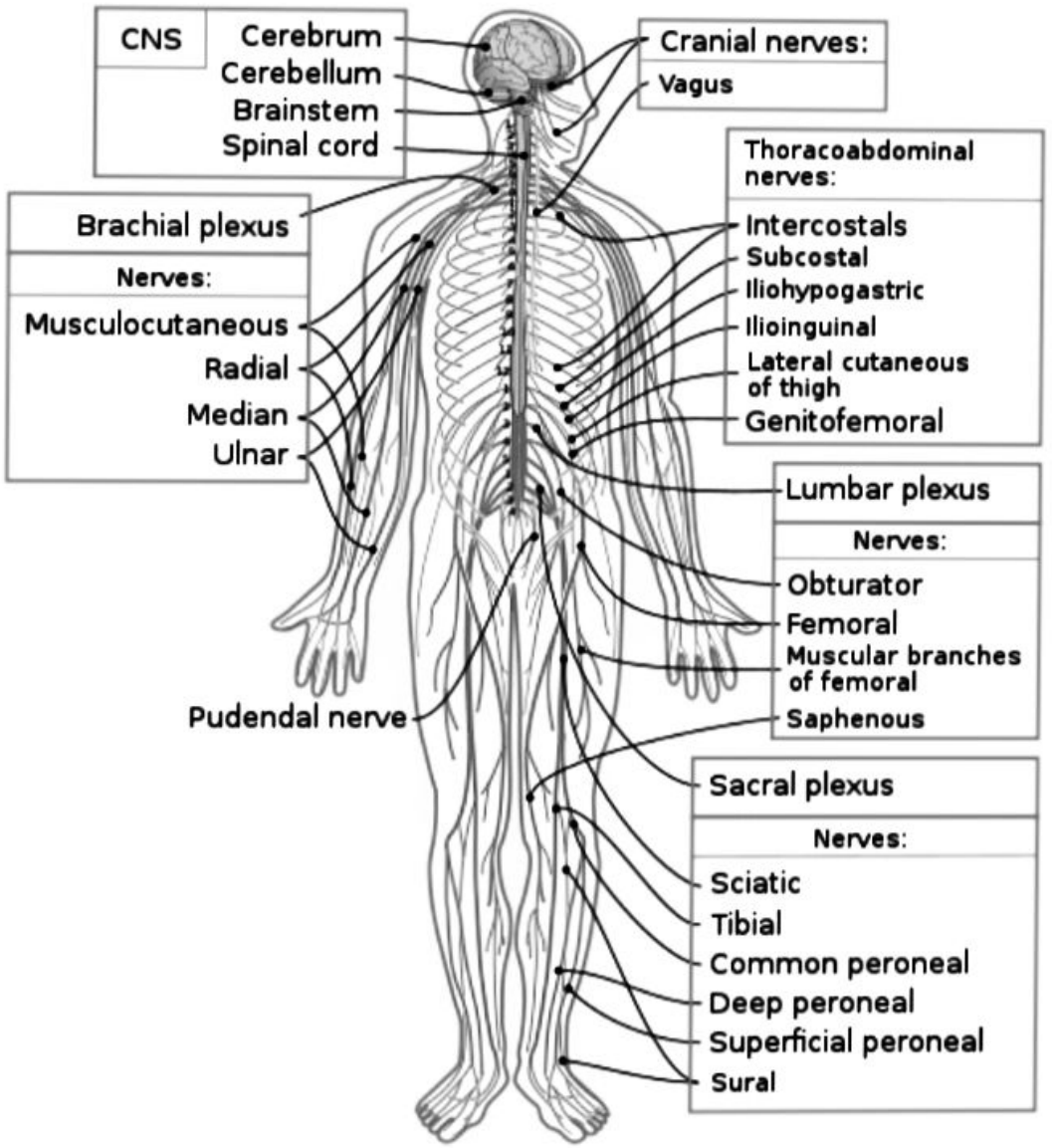
Central Nervous System




CNS
Central nervous System
PNS
Peripheral nervous System
PARASYMPATHETIC NERVES
SYMPATHETIC NERVES
BRAIN
Spinal Cord
Sympathetic Chain
Constrict Pupils
Stimulate Salvia
Constrict Airways
Slow Heartbeat
Stimulate Activity of Stomach
Inhibit Release of glucose
Stimulate Gallbladder
Stimulate Activity of Intestines
Contract Bladder
Promote Erection of Genitals
Dilate Pupils
Inhibit Salivation
Relax Airways
Increase Heartbeat
Inhibit Activity of Stomach
Stimulate Release of glucose
Inhibit Gallbladder
Inhibit Activity of Intestines
Secrete Epinephrine and norepinephrine
Relax Bladder
Promote Ejaculation and Vaginal Contractions

The **spinal cord** is a long, thin, tubular structure made up of nervous tissue, which extends from the medulla oblongata in the brainstem to the lumbar region of the vertebral column. It encloses the central canal of the spinal cord, which contains cerebrospinal fluid. The brain and spinal cord together make up the central nervous system (CNS). In humans, the spinal cord begins at the occipital bone, passing through the foramen magnum and entering the spinal canal at the beginning of the cervical vertebrae. The spinal cord extends down to between the first and second lumbar vertebrae, where it ends. The enclosing bony vertebral column protects the relatively shorter spinal cord. It is around 45 cm (18 in) in men and around 43 cm (17 in) long in women. The diameter of the spinal cord ranges from 13 mm ($^1/_2$ in) in the cervical and lumbar regions to 6.4 mm ($^1/_4$ in) in the thoracic area.

Spinal cord



The spinal cord (in yellow) connects the brain to nerves throughout the body.

The spinal cord functions primarily in the transmission of nerve signals from the motor cortex to the body, and from the afferent fibers of the sensory neurons to the sensory cortex. It is also a center for coordinating many reflexes and contains reflex arcs that can independently control reflexes.[1] It is also the location of groups of spinal interneurons that make up the neural circuits known as central pattern generators. These circuits are responsible for controlling motor instructions for rhythmic movements such as walking.[2]

Auxin

1. The term auxin is applied to indole-3-acetic acid
2. Generally produced by growing apices of the stems and roots.
3. IAA and IBA have been isolated from plants.
4. NAA and 2, 4-D (2, 4-dichlorophenoxyacetic acid) are synthetic auxin.
5. Promote rooting in stem cutting.
6. Promote flowering.
7. Inhibit fruit and leaf drop at early stages.
8. Promote abscission of older mature leaves and fruits.
9. The growing apical bud inhibit the growth of lateral bud, the phenomenon is called apical dominance.
10. Auxin induces parthenocarpy.
11. Used as herbicides.
12. Controls xylem differentiation.
13. Promote cell division.

Gibberellins

1. Ability to cause an increase in length of axis is used to increase the length of grapes stalks.
2. Gibberellins cause fruits like apple to elongate and improve its shape.
3. Delay senescence
4. GA3 is used to speed up the malting process in brewing industry.
5. Gibberellins promote to increase length of stem in sugar cane.
6. Promote early seed production.
7. Promote bolting (internodes elongation) in beet, cabbages.

Cytokinins

1. Cytokinins have specific effects on cytokinesis.
2. Zeatin isolated from corn-kernels and coconut milk.
3. Promote cell division.
4. Help to produce new leaves, chloroplast in leaves, lateral shoot growth
5. Promote formation of adventitious shoot.
6. Cytokinins help to overcome apical dominance.
7. Promote nutrient mobilization.
8. Delay senescence.

Ethylene

1. Ethylene is a simple gaseous PGR.
2. Synthesized in the tissue undergoing senescence and ripening fruits.
3. Promote horizontal growth of seedling.
4. Promote swelling of axis and apical hook formation in dicot seedlings.
5. Promote senescence and abscission of plant organs like leaf and flower.
6. Increase rate of respiration during ripening of fruits, called respiratory climactic.
7. Breaks seed and bud dormancy.
8. Initiate germination.
9. Promote rapid internodes elongation.
10. Promote root growth and root hair formation.
11. Used to initiate flowering and for synchronizing fruit-set.
12. Induce flowering in mango.
13. The source of ethylene is ethephon.
14. Promote female flower in cucumbers thereby increasing the yield.

Abscisic acid

1. Regulates abscission and dormancy.
2. Acts as general plant growth inhibitor and an inhibitor of plant metabolism.
3. Inhibit seed germination.
4. Stimulates the closure of stomata and increases the tolerance of plants to various kinds of stresses, hence called as stress hormone.
5. Important role in seed development, maturation and dormancy.
6. Inducing dormancy, ABA helps seeds to withstand desiccation and other factors unfavourable for growth.
7. Acts as antagonist to Gas.

Growth-related movements in plants

The movements which are growth related are called tropic movements. These movements occur in response to environmental stimuli and the direction of the response is dependent on the direction of the stimulus.

Examples:

- Phototropic movement (light dependent),
- Geotropic movement (gravity dependent),

Chemotropic movement (chemical dependent),
- Hydrotropic movement (water dependent) and
- Thigmotropic movement (touch dependent).

Geotropism

Movement of plant parts in response to earth's gravitational force is known as geotropism/gravitropism.

- Towards gravity - positive geotropism
- Away from gravity - negative geotropism
- Root grows towards gravity and shoot grows away from gravity

Phototropism

Movement of plant parts in response to light is known as phototropism.

- Towards light - positive phototropism
- Away from light - negative phototropism
- Stems move towards light and roots move away from light.

Hydrotropism

Movement of plant parts in response to water or moisture.

- Towards water - positive hydrotropism
- Away from water - negative hydrotropism
- Again, root movement in search of water is positive hydrotropism.

Chemotropism

Movement of plant parts in response to chemical stimuli is known as chemotropism.

- Towards chemical - positive chemotropism
- Away from chemical - negative chemotropism
- The growth of pollen tube towards the ovule is positive chemotropism.

Thigmotropism

Movement of plant parts in response to touch is called as thigmotropism.

- Towards touch - Positive thigmotropism
- Away from touch - negative thigmotropism
- Movement of tendrils around the support is positive thigmotropism.

CHEMICAL COORDINATION AND INTEGRATION

ENDOCRINE GLANDS AND HORMONES

Endocrine glands lack ducts and are hence, called ductless glands. Their secretions are called hormones.

The classical definition of hormone as a chemical produced by endocrine glands and released into the blood and transported
to a distantly located target organ has current scientific definition as follows:

Hormones are non-nutrient chemicals which act as intercellular messengers and are produced in trace amounts.

The new definition covers a number of new molecules in addition to the hormones secreted by the organised endocrine glands.

Invertebrates possess very simple endocrine systems with few hormones whereas a large number of chemicals act as hormones
and provide coordination in the vertebrates. The human endocrine system is described in next section.

HUMAN ENDOCRINE SYSTEM

The endocrine glands and hormone producing diffused tissues/cells located in different parts of our body constitute the endocrine system.

Pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus and gonads (testis in males and ovary in females) are the organised endocrine bodies in our body.

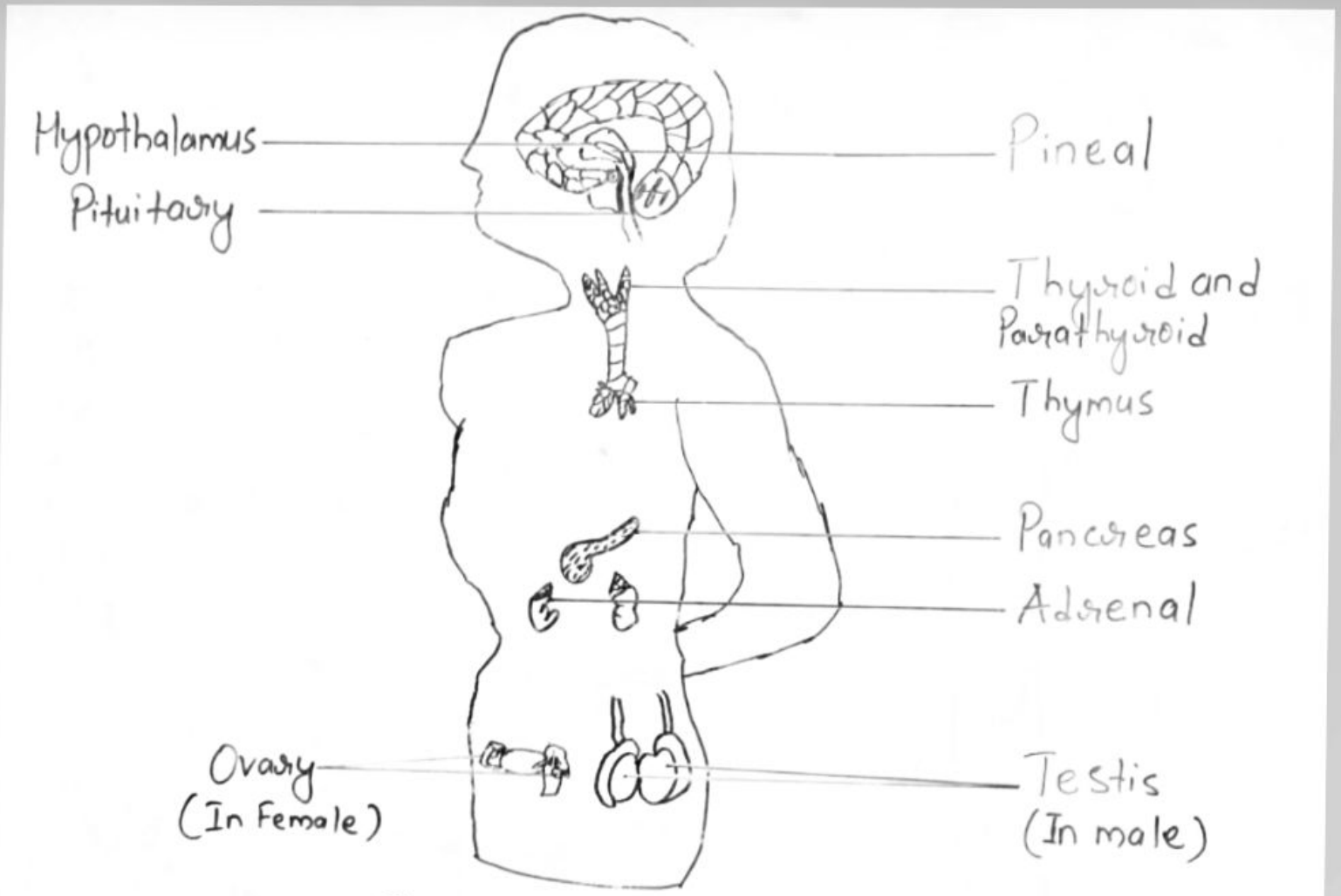


Fig:- Location of endrocrine glands

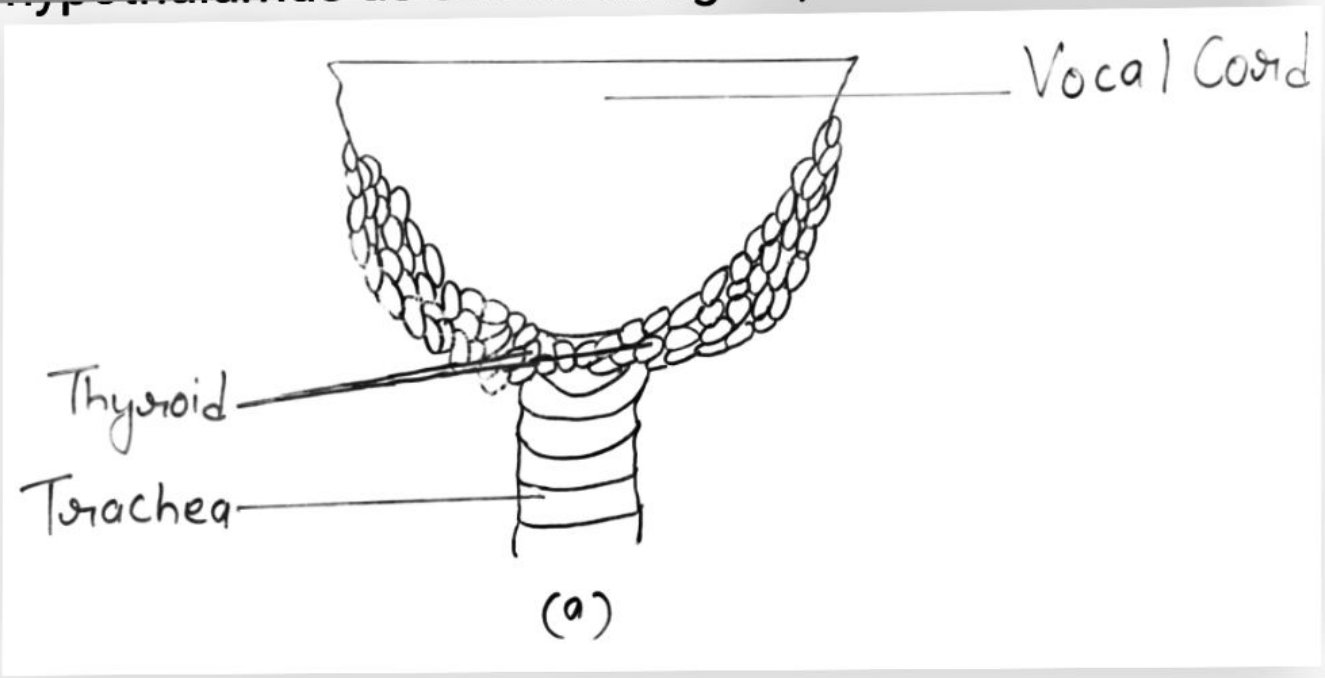
In addition to these, some other organs, e.g., gastrointestinal tract, liver, kidney, heart also produce hormones.

A brief account of the structure and functions of all major endocrine glands and hypothalamus of the human body is given in the following sections.

The Hypothalamus

The hypothalamus is the basal part of diencephalon, forebrain and it regulates a wide spectrum of body functions.
It contains several groups of neurosecretory cells called nuclei which produce hormones.
These hormones regulate the synthesis and secretion of pituitary hormones.
However, the hormones produced by hypothalamus are of two types, the releasing hormones (which stimulate secretion of pituitary hormones) and the inhibiting hormones (which inhibit secretions of pituitary hormones).

For example a hypothalamic hormone called Gonadotrophin releasing hormone (GnRH) stimulates the pituitary synthesis and release of gonadotrophins.
Whereas, somatostatin from the hypothalamus inhibits the release of growth hormone from the pituitary. These hormones originating in the hypothalamic neurons,
pass through axons and are released from their nerve endings. These hormones reach the pituitary gland through a portal circulatory system and regulate
the functions of the anterior pituitary. The posterior pituitary is under the direct neural regulation of the hypothalamus as shown in figure,



The Pituitary Gland

The pituitary gland is located in a bony cavity called sella tursica and is attached to hypothalamus by a stalk as shown in Figure.

It is divided anatomically into an adenohypophysis and a neurohypophysis.

Adenohypophysis consists of two portions, pars distalis and pars intermedia.

The pars distalis region of pituitary, commonly called anterior pituitary, produces growth hormone (GH), prolactin (PRL), hyroid stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), luteinizing hormone (LH) and follicle stimulating hormone (FSH).

Pars intermedia secretes only one hormone called melanocyte stimulating hormone (MSH). However, in humans, the pars intermedia is almost merged with pars distalis.

Neurohypophysis (pars nervosa) also known as posterior pituitary, stores and releases two hormones called oxytocin and vasopressin, which are actually synthesised by the hypothalamus and are transported axonally to neurohypophysis.

Over-secretion of GH stimulates abnormal growth of the body leading to gigantism and low secretion of GH results in stunted growth resulting in pituitary dwarfism.

Prolactin regulates the growth of the mammary glands and formation of milk in them.

TSH stimulates the synthesis and secretion of thyroid hormones from the thyroid gland.

ACTH stimulates the synthesis and secretion of steroid hormones called glucocorticoids from the adrenal cortex.

LH and FSH stimulate gonadal activity and hence are called gonadotrophins. In males, LH stimulates the synthesis and secretion of hormones called androgens from testis.

In males, FSH and androgens regulate spermatogenesis. In females, LH induces ovulation of fully mature follicles (graafian follicles) and maintains the corpus

luteum, formed from the remnants of the graafian follicles after ovulation. FSH stimulates growth and development of the ovarian follicles in females.

MSH acts on the melanocytes (melanin containing cells) and regulates pigmentation of the skin.

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luteum, formed from the remnants of the graafian follicles after ovulation. FSH stimulates growth and development of the ovarian follicles in females.
MSH acts on the melanocytes (melanin containing cells) and regulates pigmentation of the skin. Oxytocin acts on the smooth muscles of our body and stimulates their contraction.
In females, it stimulates a vigorous contraction of uterus at the time of child birth, and milk ejection from the mammary gland.
Vasopressin acts mainly at the kidney and stimulates resorption of water and electrolytes by the distal tubules and thereby reduces loss of water through urine (diuresis).
Hence, it is also called as anti-diuretic hormone (ADH).

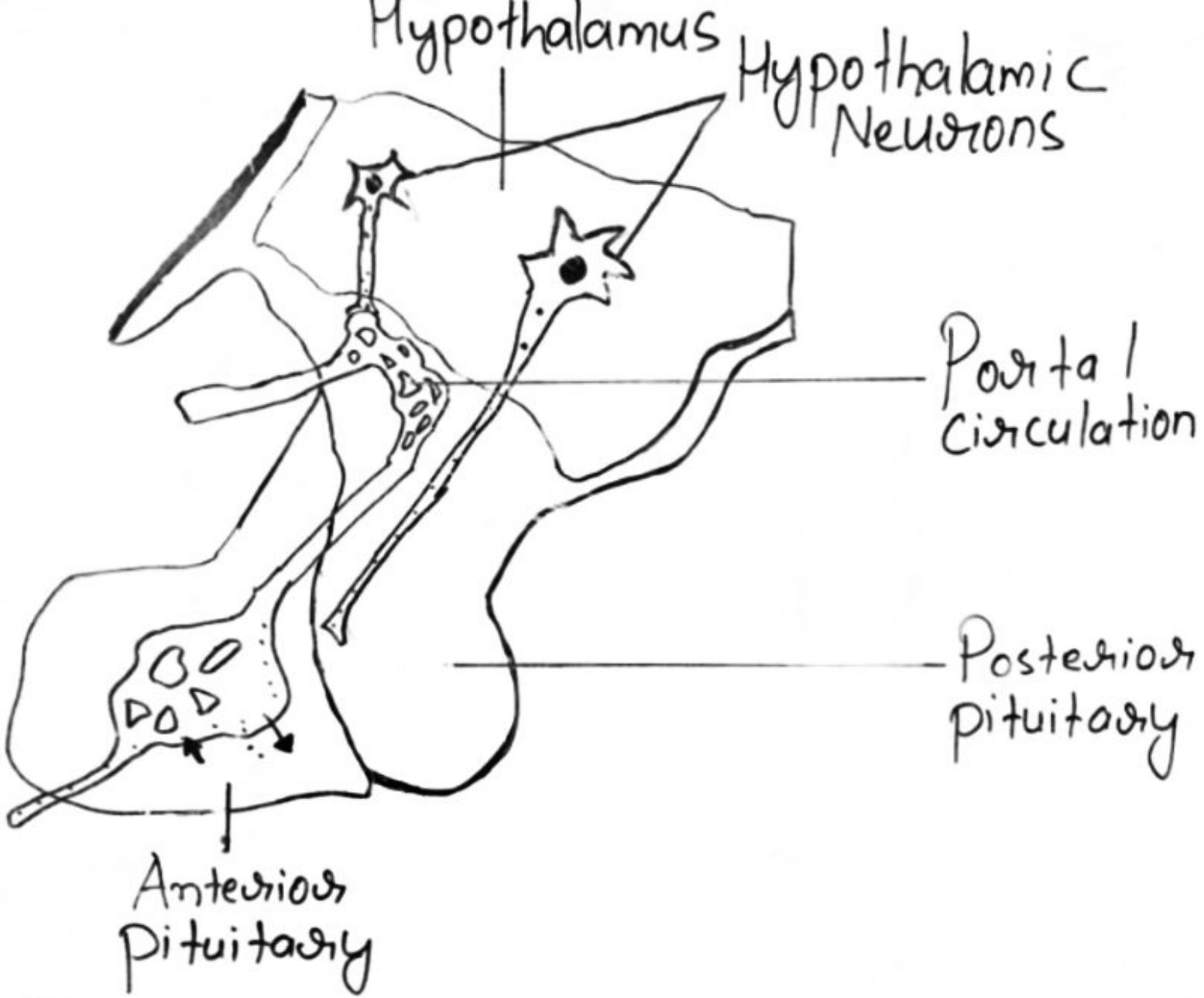

Fig:- Diagrammatic Representation of pituitary & it's relationship with hypothalamus

The Pineal Gland

The pineal gland is located on the dorsal side of forebrain. Pineal secretes a hormone called melatonin.

Melatonin plays a very important role in the regulation of a 24-hour (diurnal) rhythm of our body.

For example, it helps in maintaining the normal rhythms of sleep-wake cycle, body temperature.

In addition, melatonin also influences metabolism, pigmentation, the menstrual cycle as well as our defense capability.

Thyroid Gland

The thyroid gland is composed of two lobes which are located on either side of the trachea as shown in Figure .

Both the lobes are interconnected with a thin flap of connective tissue called isthmus. The thyroid gland is composed of follicles and stromal tissues.

Each thyroid follicle is composed of follicular cells, enclosing a cavity. These follicular cells synthesise two hormones, tetraiodothyronine or thyroxine (T4) and triiodothyronine (T3).

Iodine is essential for the normal rate of hormone synthesis in the thyroid.

Deficiency of iodine in our diet results in hypothyroidism and enlargement of the thyroid gland, commonly called goitre.

Hypothyroidism during pregnancy causes defective development and maturation of the growing baby leading to stunted growth (cretinism), mental retardation,
low intelligence quotient, abnormal skin, deaf-mutism, etc. In adult women, hypothyroidism may cause menstrual cycle to become irregular.
Due to cancer of the thyroid gland or due to development of nodules of the thyroid glands, the rate of synthesis and secretion of the thyroid
hormones is increased to abnormal high levels leading to a condition called hyperthyroidism which adversely affects the body physiology.

Thyroid hormones play an important role in the regulation of the basal metabolic rate. These hormones also support the process of red blood cell formation.
Thyroid hormones control the metabolism of carbohydrates, proteins and fats. Maintenance of water and electrolyte balance is also influenced by thyroid hormones.
Thyroid gland also secretes a protein hormone called thyrocalcitonin (TCT) which regulates the blood calcium levels.

Parathyroid Gland

In humans, four parathyroid glands are present on the back side of the thyroid gland, one pair each in the two lobes of the thyroid gland.

The parathyroid glands secrete a peptide hormone called parathyroid hormone (PTH). The secretion of PTH is regulated by the circulating levels of calcium ions.

Parathyroid hormone (PTH) increases the Ca^{2+} levels in the blood. PTH acts on bones and stimulates the process of bone resorption (dissolution/ demineralisation).

PTH also stimulates reabsorption of Ca^{2+} by the renal tubules and increases Ca^{2+} absorption from the digested food.

It is, thus, clear that PTH is a hypercalcemic hormone, i.e., it increases the blood Ca^{2+} levels.

Along with TCT, it plays a significant role in calcium balance in the body.

Thymus

The thymus gland is a lobular structure located between lungs behind sternum on the ventral side of aorta. The thymus plays a major role in the development of the immune system.
This gland secretes the peptide hormones called thymosins. Thymosins play a major role in the differentiation of T-lymphocytes,
which provide cell-mediated immunity. In addition, thymosins also promote production of antibodies to provide humoral immunity.
Thymus is degenerated in old individuals resulting in a decreased production of thymosins. As a result, the immune responses of old persons become weak.

Adrenal Gland

Our body has one pair of adrenal glands, one at the anterior part of each kidney . The gland is composed of two types of tissues.
The centrally located tissue is called the adrenal medulla, and outside this lies the adrenal cortex as shown in Figure.

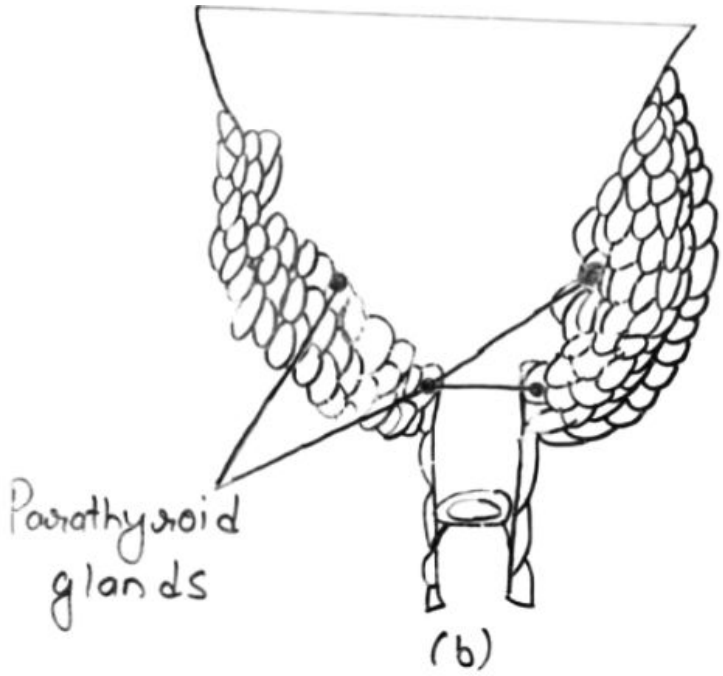

Fig:- Diagrammatic view of position of thyroid & Parathyroid

a) Ventral side
b) Dorsal side

The adrenal medulla secretes two hormones called adrenaline or epinephrine and noradrenaline or norepinephrine. These are commonly called as catecholamines.

Adrenaline and noradrenaline are rapidly secreted in response to stress of any kind and during emergency situations and are called emergency hormones or hormones of Fight or Flight. These hormones

In our body, cortisol is the main glucocorticoid. Corticoids, which regulate the balance of water and electrolytes in our body are called mineralocorticoids. Aldosterone is the main mineralocorticoid in our body. Glucocorticoids stimulate gluconeogenesis, lipolysis and proteolysis; and inhibit cellular uptake and utilisation of amino acids.

Cortisol is also involved in maintaining the cardio-vascular system as well as the kidney functions.

Glucocorticoids, particularly cortisol, produces antiinflammatory reactions and suppresses the immune response.

Cortisol stimulates the RBC production. Aldosterone acts mainly at the renal tubules and stimulates the reabsorption of Na+ and water and excretion of K+ and phosphate ions. Thus, aldosterone helps in the maintenance of electrolytes, body fluid volume, osmotic pressure and blood pressure.

Small amounts of androgenic steroids are also secreted by the adrenal cortex which play a role in the growth of axial hair, pubic hair and facial hair during puberty.

The adrenal medulla secretes two hormones called adrenaline or epinephrine and noradrenaline or norepinephrine. These are commonly called as catecholamines.

Adrenaline and noradrenaline are rapidly secreted in response to stress of any kind and during emergency situations and are called emergency hormones or hormones of Fight or Flight. These hormones increase alertness, pupilary dilation, piloerection (raising of hairs), sweating etc.

Both the hormones increase the heart beat, the strength of heart contraction and the rate of respiration.

Catecholamines also stimulate the breakdown of glycogen resulting in an increased concentration of glucose in blood.

In addition, they also stimulate the breakdown of lipids and proteins. The adrenal cortex can be divided into three layers, called zona reticularis (inner layer), zona fasciculata (middle layer) and zona glomerulosa (outer layer). The adrenal cortex secretes many hormones, commonly called as corticoids. The corticoids, which are involved in carbohydrate metabolism are called glucocorticoids.

Pancreas

Pancreas is a composite gland which acts as both exocrine and endocrine gland. The endocrine pancreas consists of 'Islets of Langerhans'.
There are about 1 to 2 million Islets of Langerhans in a normal human pancreas representing only 1 to 2 per cent of the pancreatic tissue.

The two main types of cells in the Islet of Langerhans are called α-cells and β-cells.
The α-cells secrete a hormone called glucagon, while the β-cells secrete insulin.

Glucagon is a peptide hormone, and plays an important role in maintaining the normal blood glucose levels.
Glucagon acts mainly on the liver cells (hepatocytes) and stimulates glycogenolysis resulting in an increased blood sugar (hyperglycemia).
In addition, this hormone stimulates the process of gluconeogenesis which also contributes to hyperglycemia.
Glucagon reduces the cellular glucose uptake and utilisation. Thus, glucagon is a hyperglycemic hormone.

Insulin is a peptide hormone, which plays a major role in the regulation of glucose homeostasis.

Testis

A pair of testis is present in the scrotal sac (outside abdomen) of male individuals. Testis performs dual functions as a primary sex organ as well as an endocrine gland.

Testis is composed of seminiferous tubules and stromal or interstitial tissue. The Leydig cells or interstitial cells, which are present in the intertubular spaces produce a group of hormones called androgens mainly testosterone.

Androgens regulate the development, maturation and functions of the male accessory sex organs like epididymis, vas deferens, seminal vesicles, prostate gland, urethra etc.

These hormones stimulate muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice etc.

Androgens play a major stimulatory role in the process of spermatogenesis (formation of spermatozoa).

Androgens act on the central neural system and influence the male sexual behaviour (libido).

These hormones produce anabolic (synthetic) effects on protein and carbohydrate metabolism.

Insulin acts mainly on hepatocytes and adipocytes (cells of adipose tissue), and enhances cellular glucose uptake and utilisation.

As a result, there is a rapid movement of glucose from blood to hepatocytes and adipocytes resulting in decreased blood glucose levels (hypoglycemia).

Insulin also stimulates conversion of glucose to glycogen (glycogenesis) in the target cells.

The glucose homeostasis in blood is thus maintained jointly by the two – insulin and glucagons.

Prolonged hyperglycemia leads to a complex disorder called diabetes mellitus which is associated with loss of glucose through urine and

formation of harmful compounds known as ketone bodies. Diabetic patients are successfully treated with insulin therapy.

Ovary

Females have a pair of ovaries located in the abdomen . Ovary is the primary female sex organ which produces one ovum during each menstrual cycle.

In addition, ovary also produces two groups of steroid hormones called estrogen and progesterone. Ovary is composed of ovarian follicles and stromal tissues.

The estrogen is synthesised and secreted mainly by the growing ovarian follicles.

After ovulation, the ruptured follicle is converted to a structure called corpus luteum, which secretes mainly progesterone.

Estrogens produce wide ranging actions such as stimulation of growth and activities of female secondary sex organs, development of growing ovarian follicles, appearance of female secondary sex characters (e.g., high pitch of voice, etc.), mammary gland development.

Estrogens also regulate female sexual behaviour. Progesterone supports pregnancy. Progesterone also acts on the mammary glands and stimulates the formation of alveoli (sac-like structures which store milk) and milk secretion.

HORMONES OF HEART, KIDNEY AND GASTROINTESTINAL TRACT

Hormones are also secreted by some tissues which are not endocrine glands.
For example, the atrial wall of our heart secretes a very important peptide hormone called atrial natriuretic factor (ANF), which decreases blood pressure.
When blood pressure is increased, ANF is secreted which causes dilation of the blood vessels. This reduces the blood pressure.

The juxtaglomerular cells of kidney produce a peptide hormone called erythropoietin which stimulates erythropoiesis (formation of RBC).
Endocrine cells present in different parts of the gastro-intestinal tract secrete four major peptide hormones, namely gastrin, secretin,
cholecystokinin (CCK) and gastric inhibitory peptide (GIP). Gastrin acts on the gastric glands and stimulates the secretion of hydrochloric acid and pepsinogen.
Secretin acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions.
CCK acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice, respectively.

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CCK acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice, respectively.
GIP inhibits gastric secretion and motility.

Several other non-endocrine tissues secrete hormones called growth factors.
These factors are essential for the normal growth of tissues and their repairing/regeneration.