NEURAL CONTROL AND COORDINATION

In Our body all activities are controlled and coordinated by two systems namely Nervous system and Endocrine system

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

- **In hydra** Neural system is represented by a network of neurons
- The neural system of insects represented by number of ganglia and neural tissues.

Human Neural system

The human neural system is divided into two parts

(i) **Central neural system** (CNS)

(ii) **Peripheral neural system** (PNS)

i) Central Neural system (CNS)

it include **brain** and the **spinal cord** and is **the site of information processing and control**.

(ii) Peripheral neural system (PNS)

it comprises of 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**

(a) Afferent fibres

The afferent nerve fibres transmit impulses from tissues/organs to the CNS

(b) Efferent fibres

The efferent fibres transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.

The PNS is divided into two divisions called **somatic neural system** and **autonomic neural system**.

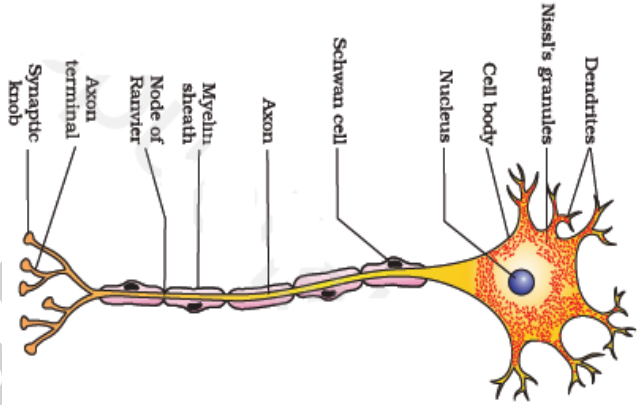
Somatic neural system : The somatic neural system relays impulses **from the CNS to skeletal muscles**

Autonomic neural system: 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**.

Structure of Neuron

Neurons are the structural and functional units of neural system. Neuron is a microscopic structure composed of three major parts, namely, **cell body**, **dendrites** and **axon**



a) The cell body/Soma/cyton

it contains cytoplasm with typical cell organelles and certain granular bodies called **Nissl's granules**.

b) Dendrites

Short fibres which branch repeatedly and **project out of the cell body** also contain Nissl's granules and are called dendrites.

- These fibres transmit **impulses towards the cell body**.

c) Axon

The axon is a **long fibre**, the distal end of which is branched. Each branch terminates as a bulb-like structure called **synaptic knob** which possess **synaptic vesicles** containing chemicals called **neurotransmitters (Eg:Acetyl choline, Dopamine etc.)**

- The axons transmit nerve impulses away from the cell body to a synapse or to a neuro-muscular junction

Types of Neurons

(A)Based on the number of axon and dendrites, the neurons are divided into three types

i**) Multipolar Neuron :** This type of neuron has one axon and two or more dendrites;

eg: This type of Neuron is found in the cerebral cortex

ii)Bipolar Neuron: This type of neuron has one axon and one dendrite,

eg: This type of neurons are found in the **retina of eye**

iii) Unipolar Neuron :This type of neuron has cell body with one axon only;

Eg: This type of neuron found usually in the **embryonic stage**

(B) Based on the **presence or absence of Myelin sheath around Axon**, Neurons can be classified into **myelinated** and **nonmyelinated Neuron**

a) Myelinated neuron

The myelinated nerve fibres are enveloped with **Schwann cells,** which form a myelin sheath around the axon. The **gaps** between two adjacent myelin sheaths are called **nodes of Ranvier**.

Myelinated nerve fibres are **found in spinal and cranial nerves**

b) Nonmyelinated Neuron

The non-myelinated nerve fibre **is enclosed by a Schwann cell that does not form a myelin sheath around the axon.**

This type of Neuron is commonly found in **autonomous and the somatic neural systems.**

Generation and Conduction of Nerve Impulse

Conduction of Nerve Impulse across nerve fibers can be explained in 3 steps

a)Maintenance of resting membrane potential

b) Initiation of action potential

c) Propagation of action potential

a)Maintenance of resting membrane potential

A resting neuron is one that has not been stimulated. The membrane of such neurons are called polarized membrane. In such neuron the **outer side is +ve charge** and **inner side is negative charge**. This differential electrical potential existing across the membrane of a resting neuron is called **Resting membrane potential.** The resting membrane potential results from the following 2 factors

a)the membrane of the resting neuron is poorly permeable to Na+ and has higher permeable for K+ ions

b)presence of an active Na+-K+ pump In the membrane of the resting neuron, which actively carries out more Na+ and has higher permeability for K+ions (3Na+ for 2K+)

- The above 2 factors acting together results in a higher concentration of +ve ions on the outerside of the membrane. The presence of Cl- inside the cell, which is greater than K+ provide net –ve charge on the inner side of the membrane

b) Initiation of action potential

When a stimulus is applied at a site on the polarised membrane, the membrane at that site becomes freely permeable to Na+ (sodium potassium pump stops). This leads to a **rapid influx of Na+** followed by the reversal of the polarity at that site, i.e., the outer surface of the membrane becomes negatively charged and the inner side becomes positively charged. The polarity of the membrane at the point of stimulus is thus reversed and hence **depolarised.** The electrical potential difference across the plasma membrane at that site called the **action potential**, which is in fact termed as a **nerve impulse**

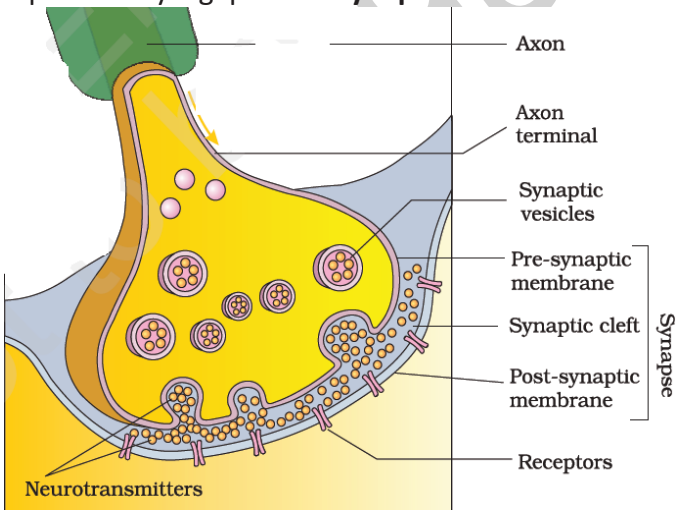
The rise in the stimulus-induced permeability to Na+ is **extremely shortlived.** It is quickly followed by a rise in permeability to K+. Within a fraction of a second, K+ diffuses outside the membrane and restores the resting potential of the membrane at the site of excitation

c)Propagation of action potential

At sites immediately ahead, the axon (e.g., site B) membrane has a positive charge on the outer surface and a negative charge on its inner surface. As a result, a current flows on the inner surface from site A to site B. On the outer surface current flows from site B to site A to complete the circuit of current flow. Hence, the polarity at the site is reversed, and an action potential is generated at site B. Thus, the impulse (action potential) generated at site A arrives at site B. The sequence is repeated along the length of the axon and consequently the impulse is conducted

Transmission of Impulses

A **synapse** is a junction 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, namely**, electrical synapses and chemical synapses**.

I) Electrical synapses; Here the membranes of pre- and post-synaptic neurons are in **very close proximity**. Electrical current can flow directly from one neuron into the other across these synapses. Transmission of an impulse across electrical **synapses is very similar to impulse conduction along a single axon**. Impulse transmission across an electrical synapse is always **faster than that across a chemical synapse**. Electrical **synapses are rare in our system.**

ii) Chemical synapse : the membranes of the pre- and post-synaptic neurons are separated by a fluid-filled space called **synaptic cleft.** Chemicals called neurotransmitters are involved in the transmission of impulses at these synapses. The axon terminals contain **synaptic vesicles.** It is filled with these **neurotransmitters**. When an impulse (action potential) arrives at the axon terminal, it stimulates the movement of the **synaptic vesicles** towards the membrane where they fuse with the plasma membrane and **release** their neurotransmitters in to the synaptic cleft. The released neurotransmitters **bind to their specific receptors**, present on the **post-synaptic membrane**. This binding opens ion channels allowing the entry of ions which can generate a new potential in the post-synaptic neuron. **The new potential developed may be either excitatory or inhibitory.**

CENTRAL NEURAL SYSTEM

CNS include Brain and spinal cord

A) BRAIN

The brain is the central information processing organ of our body, and acts as the '**command and control system**'.

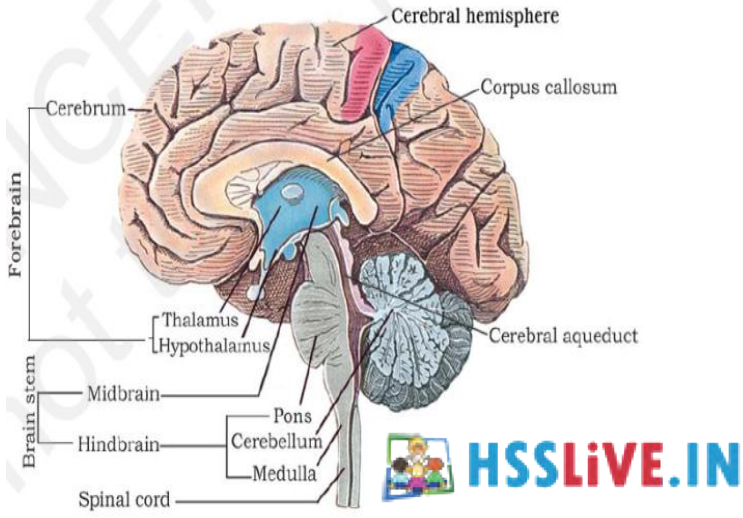
Functions of brain :

- 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
- human behavior.
- processing of vision, hearing, speech, memory, intelligence, emotions and thoughts.

The human brain is well protected by the skull. Inside the **skul**l, the brain is covered by **cranial meninges** consisting of 3 Layers

- ✓ an **outer layer called dura mater,**
- ✓ **a very thin middle layer called arachnoid**
- ✓ **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**



(i)Fore brain

The forebrain consists of **cerebrum**, **thalamus** and **hypothalamus.**

a) **Cerebrum:**

- 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 t**ract of nerve fibres called corpus callosum**.
- Each cerebral hemisphere has two Parts

Cerebral cortex-Outer region

Cerebral medulla-Inner region

Cerebral cortex

Outer region of each cerebral hemisphere is cerebral cortex. The **cerebral cortex** is called 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.**

Cerebral Medulla

The Inner region of cerebral hemisphere is called cerebral medulla Fibres of the tracts are **covered with the myelin sheath**, They give an opaque white appearance to the layer and, hence, is called the **white matter.**

b) **Thalamus**

The cerebrum wraps around a structure called thalamus, which is a major coordinating centre for sensory and motor signaling.

c) **Hypothalamus**

Hypothalamus located 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 **neurosecretor**y cells, which secrete hormones called **hypothalamic hormones (Relaeasing hormone,inhibitoryhormone,ADH,Oxytocin)** .

Limbic system

- 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.**

(ii)Midbrain

It 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**

III) Hindbrain

It comprises **pons**, **cerebellum** and **medulla** (also called the **medulla oblongata**).

a) **Pons** : it consists of fibre tracts that interconnect different regions of the brain.

b) **Cerebellum** : it has very convoluted surface in order to provide **the additional space for many more neurons**. It Concerend with **muscular coordination, maintain posture,orientation and equilibrium of the body**. Cerebellar cortex is grey matter and medulla white matter..

c) **The medulla** : medulla connected to the spinal cord. The medulla **contains centres which control respiration, cardiovascular reflexes ,peristalsisi, vomiting, and gastric secretions (Involuntary functions)**

B) SPINAL CORD

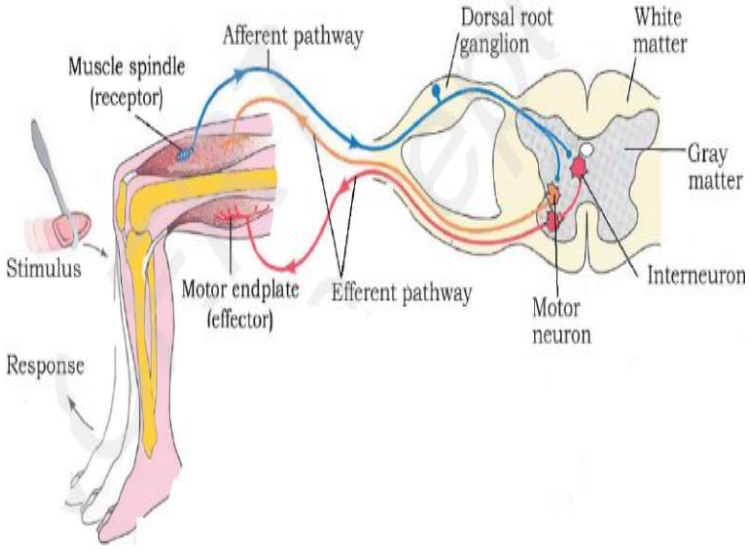
- It act as the link between brain and nerves that stretch throughout the body.
- **Spinal cord is located within the neural canal of vertebral coloumn. Thus Vertebral column protect the spinal cord**
- **The grey matter of spinal cord is inner part and the outer surface of spinal cord Is white matter. Cavity of spinal cord is called central canal.**

Reflex action:

- it is the immediate involuntary response of the body to a stimulation without the intervention of brain.
- **Reflex action is under the control of spinal cord.**
- **Reflex arc is the arrangement of neurons in the pathways that always pass through CNS.** The reflex pathway comprises at least **one afferent neuron (receptor**) and **one efferent (effector or excitor)** neuron appropriately arranged in a series.
- The **afferent neuron receives signal from a sensory organ** and transmits the **impulse via a dorsal nerve root into the CNS** (at the level of spinal cord). The **efferent nueuron then carries signals from CNS to the effector**

Ie:

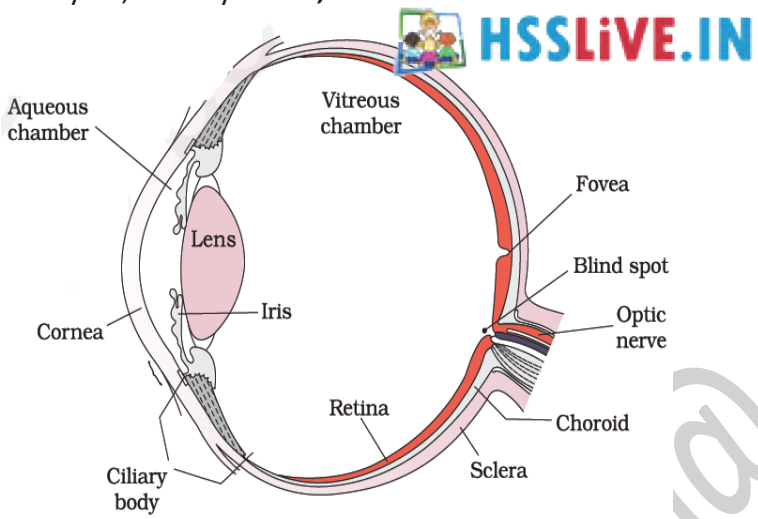
Receptor---→Afferent Neuron--→ spinal cord---→Inter neuron-→Efferent neuron---→Effector



SENSORY ORGANS

1. EYE

- Eyes are located in sockets of the skull called **orbits.**
- The adult human eye ball is nearly a **spherical structure**.
- The wall of the eye ball is composed of three layers, namely **sclera, choroid and Retina**



a)Sclerotic layer:

- It is the external layer of eye
- It is composed of a dense connective tissue.
- The anterior portion of sclera is called the **cornea (Transpearant part of sclera) and is non vascular**.
- This layer give shape to the eye ball

b) Choroid layer

- It is the middle layer
- it contains **many blood vessels and looks bluish in colour**.
- The choroid layer is thin over the posterior two-thirds of the eye ball, but it becomes **thick in the anterior part to form** the **ciliary body**. **The ciliary body itself continues forward to form a pigmented and opaque structure called the iris which is the visible coloured portion of the eye**.
- The eye ball contains a transparent crystalline **lens (Biconvex)** which is held in place by **ligaments** attached to the **ciliary body**.
- In front of the lens, the aperture surrounded by the iris is called the **pupil**. **The diameter of the pupil is regulated by the muscle fibres of iris (Round muscle and Radial muscle)**
- The space between the cornea and the lens is called the **aqueous chamber** and contains a thin **watery fluid** called **aqueous humor**. The space between the lens and the retina is called the **vitreous chamber** and is filled with a **transparent gel** called **vitreous humor**.

c) Retina

- It is the innermost layer of the eye
- it contains three layers of cells – from inside to outside – **ganglion cells, bipolar cells and photoreceptor cells.**

Photoreceptor cells in Retina

- There are two types of photoreceptor cells, namely, **rods** and **cones**.
- These cells contain the light-sensitive **proteins** called the **photopigments**.
- photopigments in the human eyes is composed of
  - **opsin (a protein) and**
  - **retinal (an aldehyde of vitamin A)**

Cones

- **The daylight (photopic) vision and colour vision** are functions of cones .
- In the human eye, there are **three types of cones** which possess their own characteristic photopigments that respond **to red, green and blue lights**.
- The sensations of different colours are produced by various combi nations of these cones and their photopigments.
- **When these cones are stimulated equally, a sensation of white light is produced**

Rods

- The **twilight (scotopic)** vision is the function of the rods.
- The rods contain a **purplish-red** protein called the **rhodopsin or visual purple**, which contains a derivative of **Vitamin A**.

The **optic nerves** leave the eye and the retinal blood vessels enter it **at a point medial to and**

slightly above the posterior pole of the eye ball. Photoreceptor cells (Cones and rods) **are not** present in that region and hence it is called the **blind spot**.

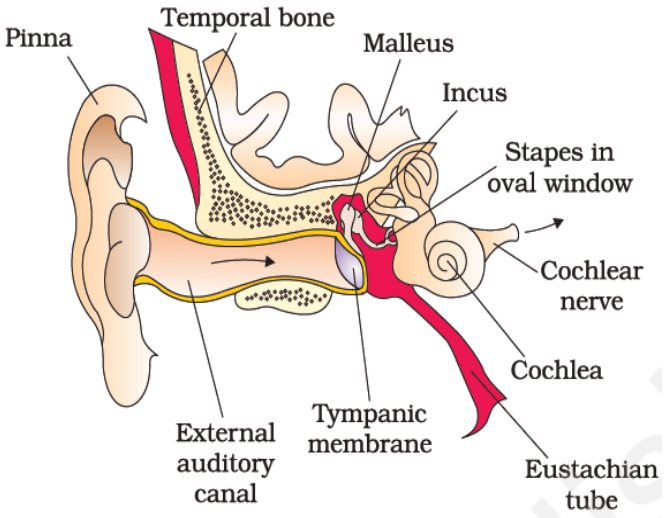
At the posterior pole of the eye lateral to the blind spot, there is a yellowish pigmented spot called **macula lutea** or **yellow spot** with a central pit called the **fovea**. The fovea is a thinned-out portion of the retina where only the cones are densely packed. It is the point where the **visual acuity (resolution) is the greatest.**

Mechanism Of Vision

- The light rays in visible wavelength passed through the cornea and lens and focused on retina.
- Light induces **dissociation** of the **retinal from opsin**
- It result change in the structure of the opsin.
- This causes membrane permeability changes. As a result, potential differences are generated in the photoreceptor cells
- This generate action potentials (impulses) in rods and cones of retina
- These action potentials passed into the ganglion cells through the bipolar cells.
- Then action potentials (impulses) are transmitted by the **optic nerves** to the **visual cortex** area of the brain, where the neural impulses are analysed and the image formed on the retina is recognised based on earlier memory and experience.

2. The Ear

- The ears Helps in hearing as well as maintenance of body balance, that is why ear is also called **stato-acoustic organ**.
- Anatomically, the ear can be divided into three major sections called the **outer ear**, the **middle ear** and the **inner ear**



a) Outer ear/External ear

- Outer ear consists of the **pinna** and **external auditory meatus** (canal).
- The pinna collects the vibrations in the air which produce sound.
- The external auditory meatus leads inwards and extends up to the **tympanic membrane** (**ear drum**).
- The tympanic membrane is composed of connective tissues covered with skin outside and with mucus membrane inside
- There are very fine hairs and wax-secreting **sebaceous glands** in the skin of the **pinna and the meatus**.

b) Middle ear

- The middle ear contains three ossicles called **malleus**, **incus** and **stapes** which are attached to one another in a **chain-like fashion**.
- The malleus is attached to the tympanic membrane
- the stapes is attached to the **oval window** of the cochlea.

Function of ear ossicle:

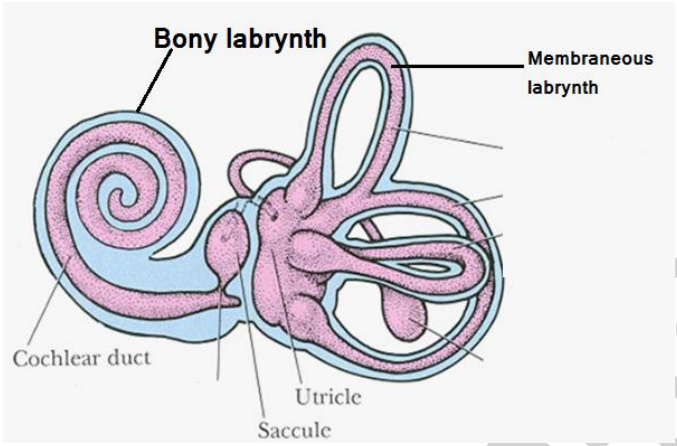
- The ear ossicles increase the efficiency of transmission of sound waves to the inner ear.

Function of Eustachian tube:

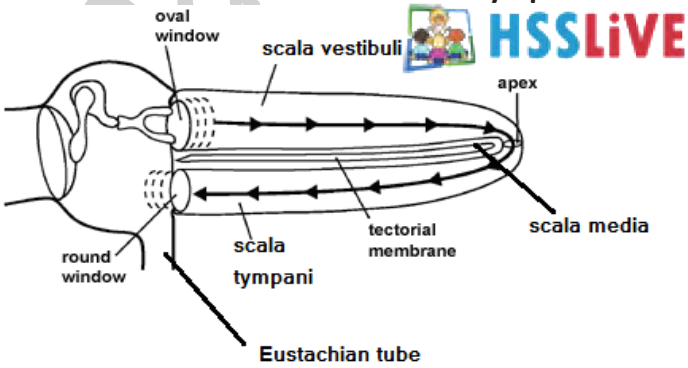
- An **Eustachian tube** connects the **middle ear cavity with the pharynx**. **The Eustachian tube helps in equalising the pressures on either sides of the ear drum.**

c) Inner ear

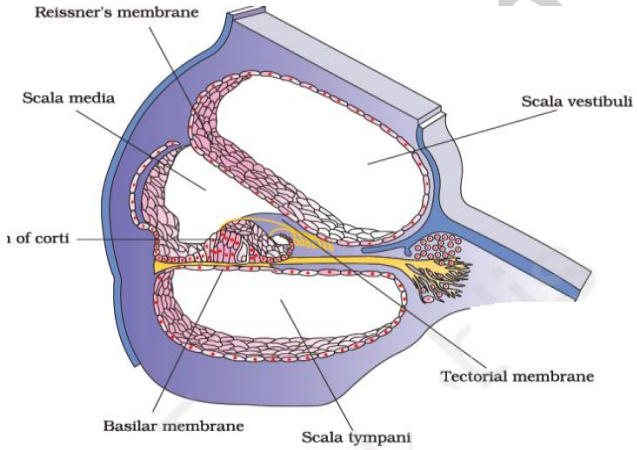
The Inner ear consist of **cochlea, semicircular canal and vestibule** The fluid-filled inner ear called **labyrinth** consists of two parts, the **bony and the membranous labyrinths**.



- The bony labyrinth is a series of channels. Inside these channels lies the **membranous labyrinth**, which is **surrounded by a fluid called perilymph.**
- **The membranous labyrinth is filled with a fluid called endolymph**. The coiled portion of the labyrinth is called **cochlea**.
- The membranes constituting **cochlea, the reissner's and basilar, divide the surounding perilymph filled bony labyrinth into an upper scala vestibuli and a lower scala tympani**



- The space within cochlea called **scala media** is filled with endolymph.
- **At the base of the cochlea, the scala vestibuli ends at the oval window, while the scala tympani terminates at the round window which opens to the middle ear**.



Diagrammatic representation of the sectional view of cochlea

- The **organ of corti** is a structure located on the basilar membrane
- Organ of corti contains **hair cells** that act as **auditory receptors**.
- A large number of processes called **stereo cilia** are projected from the **apical part of each hair cell**. Above the rows of the hair cells is a thin elastic membrane called **tectorial membrane**.
- The hair cells are present in rows on the internal side of the organ of corti.
- The basal end of the hair cell is in close contact with the **afferent nerve fibres**.

Vestibular apparatus

- The inner ear also contains a complex system called **vestibular apparatus**, located above the cochlea.
- The vestibular apparatus is composed of three **semi-circular canals** and the **otolith organ** consisting of the **saccule and utricle**.

i) Semi circular canal

- Each semi-circular canal lies in a different plane at right angles to each other.
- The membranous canals are suspended in the perilymph of the bony canals.

- The base of canals is swollen and is called **ampulla,** which contains a projecting ridge called **crista ampullaris** which has hair cells.

ii) Utricle and saccule

The saccule and utricle contain a projecting ridge called **macula**. macula is the sensory part of saccule and utricle

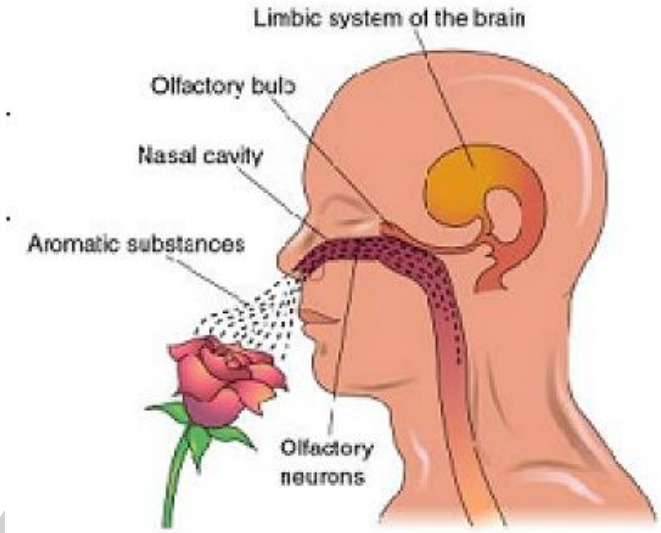
- The crista and macula are the specific receptors of the vestibular apparatus **responsible for maintenance of balance of the body and posture**.

Mechanism of Hearing

- ✓ The **external ear** receives sound waves and directs them to the ear drum.
- ✓ The **ear drum** vibrates in response to the sound waves
- ✓ these vibrations are transmitted through the **ear ossicles** (malleus, incus and stapes) to the oval window.
- ✓ The vibrations are passed through the oval window on to the fluid of the cochlea, where they generate waves in the **lymphs**.
- ✓ The waves in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells, pressing them against the **tectorial membrane**. As a result, nerve impulses are generated in the associated afferent neurons.
- ✓ These impulses are transmitted by the **afferent fibres via auditory nerves to the auditory cortex of the brain,** where the impulses are analysed and the sound is recognized

3. Nose

- It contains **mucus coated receptors** which are specialized for receiving the sense of smell and called **Olfactory receptors**.
- These are made of olfactory epithelium, that consist of 3 kinds of cells.
- The neurons of the **olfactory epithelium** extend from the outside the environment directly into a pair of broad bean sized organs called **olfactory bulb** ,which are the extensions of the brain's limbic system.



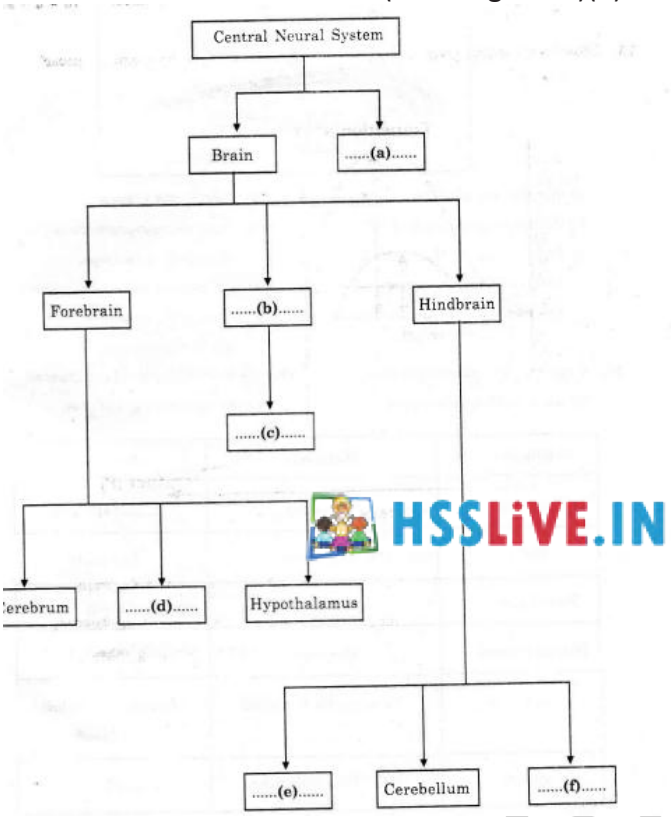
4. Tongue

- It can detect taste through **taste buds.**
- It contains **gustatory receptors**.
- with each taste of food the brain integrate the differential inputs from the taste buds and a complex flavor is perceived.

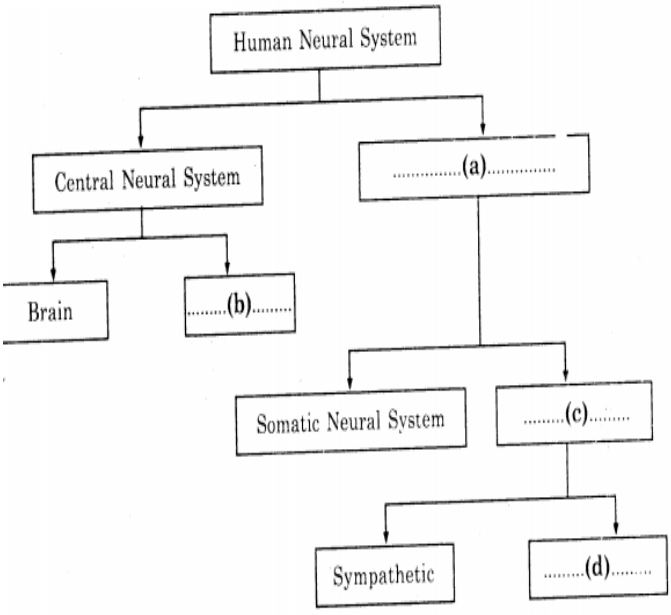
- Both tongue and nose detect dissolved chemicals.
- The chemical sense of taste (gustation) and olfactory (smell) are **functionally similar and interrelated.**

Previous Years question Papers

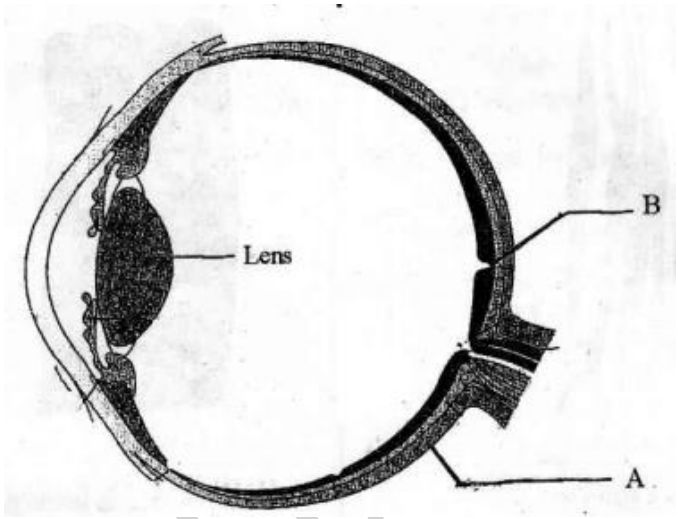
1. Complete the flow chart given below
(HSE-Aug-2018)(3)



2. The innermost eyeball is .....(HSE-March 2018)(1)
a) Choroid b) Iris c) Retina d) Sclera
3. Complete the given flow chart (HSE-March-2018)(2)



4. Redraw the diagram. Name and label the parts indicated below (HSE-Model-2018)(3)



A - External layer of the eye ball.
B - Part where cones are densely packed.

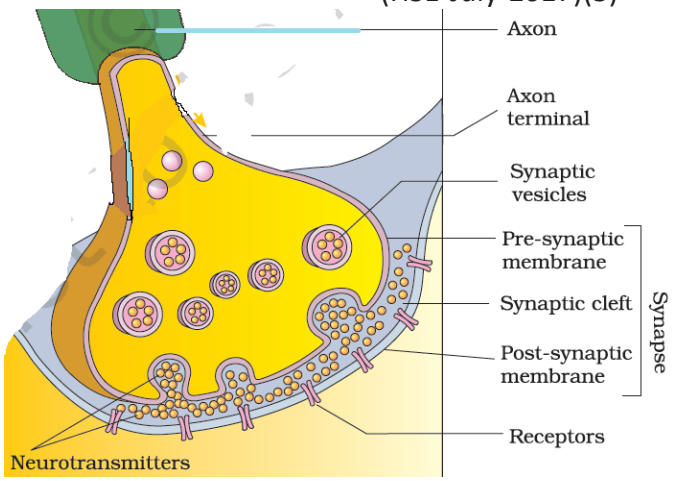
5. In…(a) type of synapse the membranes of pre synaptic and post synaptic neurons are in very close proximity
In…(b)..type of synapse the membrane of pre synaptic and post synaptic neurons are separated by a fluid filled space
a)Name the type of synapse A and B
b)name the fluid filled space in the synapse B
(HSE-Model-2018)(2)

6.

7. Nerve impulse transmission include generation and propagation of action potential.
Write various stages or events in the generation of action potential
(HSE-July-2017)(3)

OR

8. Observe the diagram and construct a flow chart to show the mechanism of transmission of nerve impulse across a chemical synapse
(HSE-July-2017)(3)

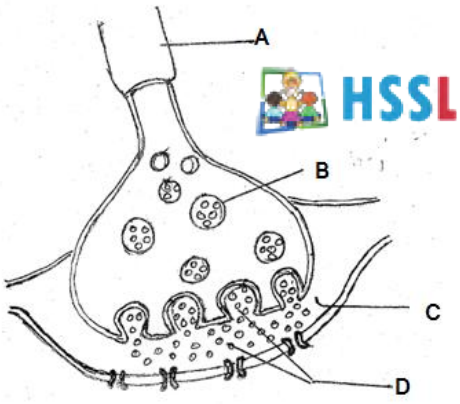


9. Answer the following (HSE-March-2017)(1)

a)Cerebral hemispheres of Human Brain are connected by……

i)Association area
ii)Corpus callosum
iii)Corpora quadrigemina
iv)Pons varoli

b)Observe the diagram and Label A,B,C and D (HSE-March-2017)(2)



10. Fovea of Retina of eye contains……

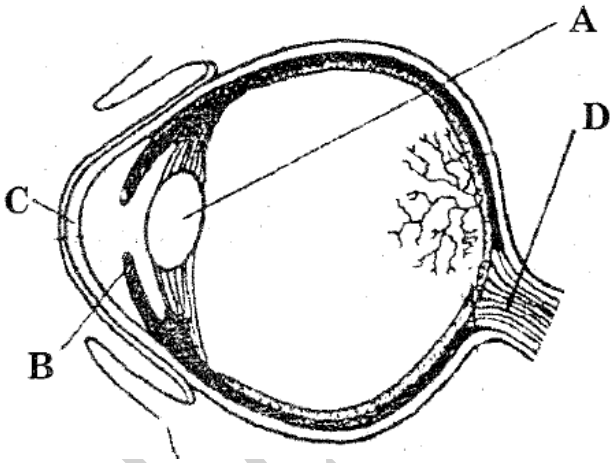
a) Rod cells only
b) Cone cells only
c) Both Rods and cones
d) Rods and cones are absent (HSE-SEPT-2016)(1)

11. a)Complete the given table (Parts of Human brain) (HSE-SEPT-2016)(2)

Fore brain		Hind brain	
	Parts/ഭാഗങ്ങൾ		Parts/ഭാഗങ്ങൾ
i)	Cerebrum/സെറിബ്രം	i)	Pons/പോൺസ്
ii)	Thalamus/തലാമസ്	ii)	……
iii)	……	iii)	Medulla/മെഡുള്ള

b) Which one of the above parts of brain that controls gastric secretion?

12. Observe the diagram carefully and answer the following (HSE-March-2016)(3)



a) Label the parts marked as A,B,C,D?
b) Identify the photoreceptor cells present in the human eye?

13. Where do you find the following structure in Human body? (HSE-SEPT-2015)(1)
a)Cochlea b)Neurotransmitter

14. Mention the function of the following structure in Human body? (HSE-SEPT-2015)(2)
a) Hypothalamus b)axon

15. a)Prepare a pathway of an action by using the following hint (HSE-March-2015)(3)
(**Hint :** Receptor, motor neuron, afferent neuron, efferent neuron, inter neuron in the spinal cord, effector organ)
b) Give an example of such an action

OR

16. Compare rods and cones of the retina based on the following features (HSE-March-2015)(3)
i)Shape
ii)Type
iii)Ability to detect colour
iv)Pigments
v)Vision

17. (HSE-August-2014)(3)

Given below are the stages in the generation of optic nerve impulse or action potential on the retina and the role of opsin and retinal in the mechanism of vision. Arrange them in a sequential order.

a) Action potential (impulses) are transmitted by the optic nerves to the visual cortex area of the brain.

b) Light induces dissociation of retinal from opsin.

c) Generates action potential in the ganglion cells through bipolar cells.

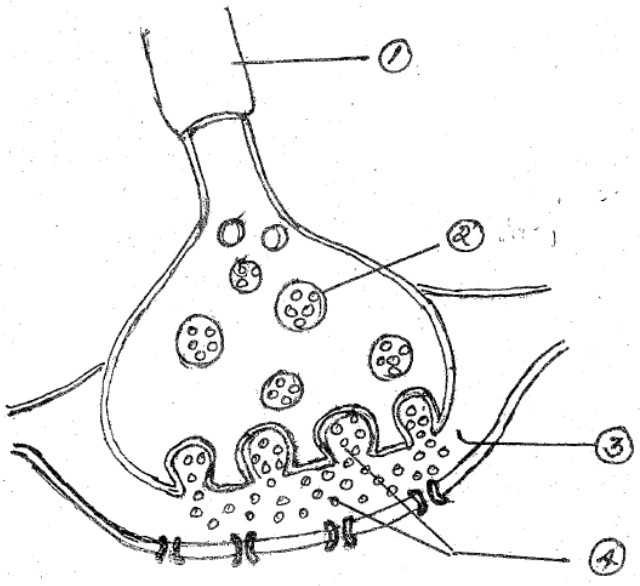
d) Structural changes in the opsin which induce membrane permeability changes.

e) Potential differences are generated in the photoreceptor cells.

f) Neural impulses are analyzed by visual cortex area of the brain.

18. Write the function of part-1 and 4. Label part 2 and 3 in the following figure showing synapse (No need to Copy the picture)

(HSE-March-2014)(3)



19. (HSE-Sept-2013)(3)

Nerve impulse transmission involves.

- Maintenance of resting potential
- Development of action potential
- Propagation of action potential

a) Diagrammatically represent the polarised and depolarised state of axon of a neuron.

b) Describe how the resting potential of a neuron is maintained.

c) "Electrical currents fade as they pass along a wire but nerve impulses do not fade as they pass along neurons". Evaluate the statement and substantiate your answer.

20. (HSE-March-2013)(3)

Arrange the following processes in nerve impulse conduction in a sequential order.

a) Bursting of synaptic vesicle

b) Development of action potential

c) Na^+–K^+ pump starts functioning

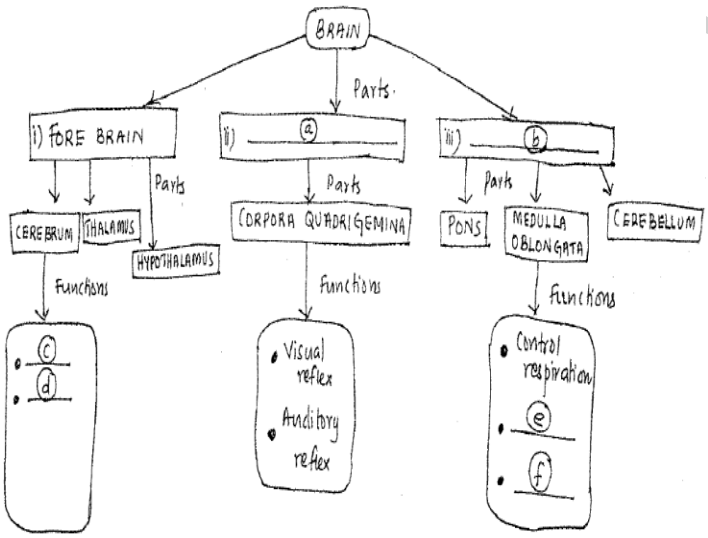
d) Stimulus received and influx of Na^+ ions

e) Binding of neurotransmitter with postsynaptic membrane

f) Maintenance of resting potential

21. Analyze the concept map given below and fill the gap appropriately so as to explain the concept of human brain

(HSE-Sept-2012)(3)



Chapter-22

CHEMICAL COORDINATION AND INTEGRATION

The neural system and the endocrine system jointly coordinate and regulate the physiological functions in the body.

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.
- current scientific definition of hormone is follows: **Hormones are non-nutrient chemicals which act as intercellular messengers and are produced in trace amounts**.

HUMAN ENDOCRINE SYSTEM

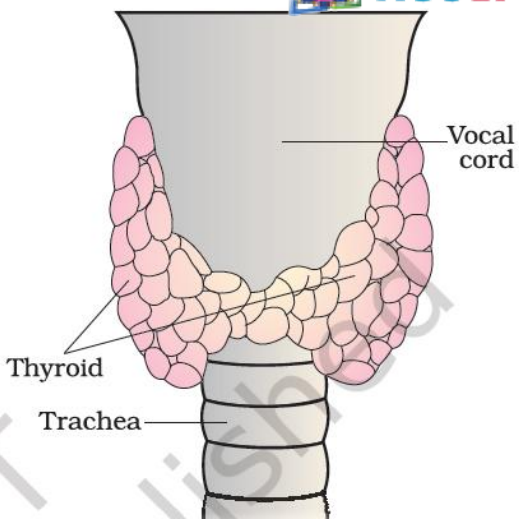
1.Thyroid Gland

- The thyroid gland is composed of **two lobes** which are located **on either side of the trachea.**
- 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.

Functions of Thyroid hormones

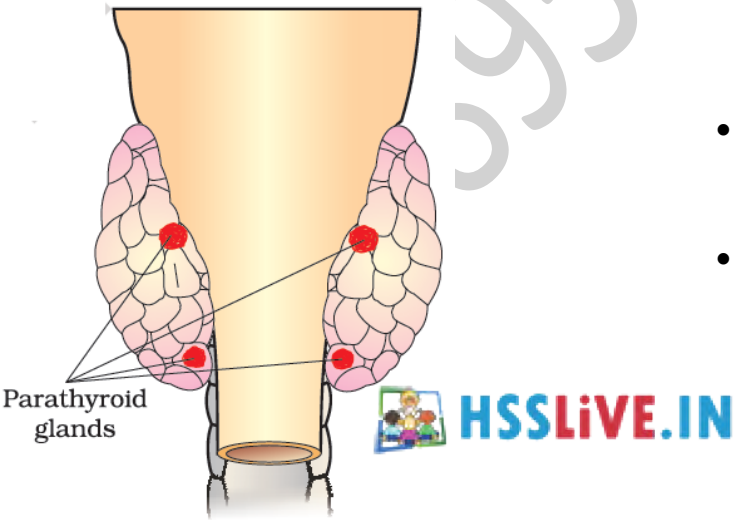
i) regulation of the basal metabolic rate.
ii) support the process of red blood cell formation.
iii) it control the metabolism of carbohydrates, proteins and fats.
iv) Maintenance of water and electrolyte balance is also influenced by thyroid hormones.
v) Thyroid gland also secretes a protein hormone called **thyrocalcitonin (TCT**) which regulates the blood calcium levels.

- **Exophthalmic goiter :** It is a form of **hyper thyroidism**. It is characterized by enlargement of thyroid gland, protrusion of the eyeballs, increased basal metabolic rate, and weight loss ,also called **Grave's disease.**



2.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 Ca2+ levels in the blood.
- PTH acts on bones and stimulates the process of **bone resorption** (dissolution/ demineralisation). PTH also stimulates reabsorption of Ca2+ by the renal tubules and **increases Ca2+ absorption** from the digested food. Since it increase the level of calcium in the blood PTH is called **hypercalcemic hormone**, i.e., **it increases the blood Ca2+ levels**. Along with **TCT**, it plays a significant role in calcium balance in the body.



3.Thymus gland/Juvenile gland

- 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 (CMI)**. 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.

4.The Pineal Gland/Biological clock

- 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

5.Adrenal Gland/Supra renal gland

- We have one pair of adrenal glands, one at the anterior part of each kidney, hence the name supra renal gland.
- 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

a)The adrenal medulla

It is the centrally located tissue of adrenal gland. it 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.

b)The adrenal cortex

It is the tissue outside the adrenal medulla . 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.**

i)Glucocorticoids

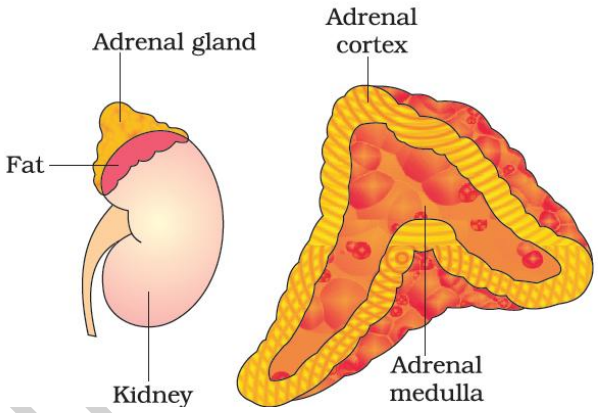
- The corticoids, which are involved in **carbohydrate metabolism** are called glucocorticoids. In our body, **cortisol** is the main glucocorticoid. Glucocorticoids stimulate gluconeogenesis, lipolysis and proteolysis; and inhibit cellular uptake and utilisation of amino acids. Cortisol is also involved in maintaining the cardio-vascular system as well as the kidney functions. Glucocorticoids, particularly cortisol, produces **anti-inflammatory reactions** and **suppresses the immune response**. Cortisol stimulates the RBC production

ii)Mineralocorticoids

the Corticoids, which regulate the **balance of water and electrolytes** in our body are called mineralocorticoids. **Aldosterone** is the main mineralocorticoid in our body. 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.

iii)Sex corticoids

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.



- **Addison's disease :** Underproduction of hormone by the adrenal cortex alter carbohydrate metabolism causing acute weakness and fatigue leading to a disease called Addison's disease

6.Pancreas

- Pancreas is a composite gland which acts as both exocrine and endocrine gland hence called mixed gland/heterocrine gland/composite 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.

i) α-cells

- The α-cells secrete a hormone called glucagon
- 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**.

ii) β-cells

- the β-cells of islets of langerhans secrete insulin.
- Insulin is a peptide hormone, which plays a major role in the regulation of glucose homeostasis. 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.
- Thus 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**.

7.Gonads

a)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

b)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.

Estrogen

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

- 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 behavior.

Progesterone

- After ovulation, the ruptured follicle is converted to a structure called **corpus luteum**, which secretes mainly progesterone.
- Progesterone **supports pregnancy** (Hence called **pregnancy hormone**). Progesterone also acts on the mammary glands and stimulates the formation of alveoli (sac-like structures which store milk) and milk secretion.

8.The Hypothalamus

- The hypothalamus is the **basal part of diencephalon, forebrain**.
- Hypothalamus contains several groups of **neurosecretory cells called nuclei** which produce hormones. These hormones regulate the synthesis and secretion of **pituitary hormones.**
- 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** (FSH and LH)
- ✓ **somatostatin** from the hypothalamus **inhibits** the release of **growth hormone** from the pituitary.

These hormones(**GnRH and Somatostatin**) are 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.

Oxytocin and Vasopressin

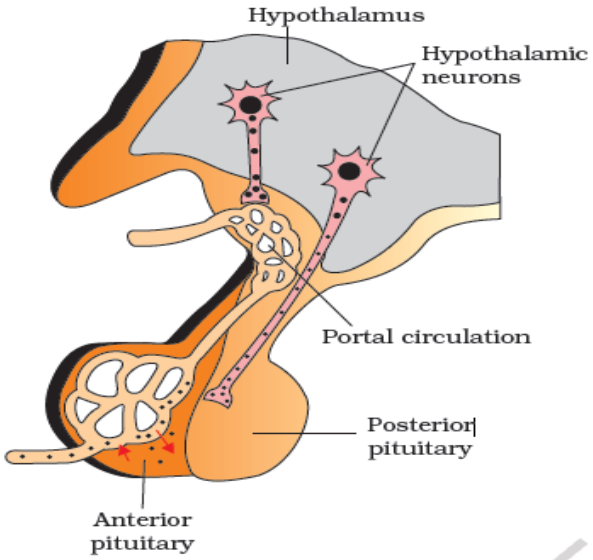
Hypothalamus also secrete two hormones namely **Oxytocin (OT) and vasopressin** (ADH), Oxytocin and vasopressin, which are actually synthesised by the hypothalamus and are transported **axonally to neurohypophysis.**

Oxytocin (OT)

It 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 (Hence called **delivery hormone**), and milk ejection from the mammary gland (hence called **milk ejecting hormone**).

Vasopressin (ADH)

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).An **impairment** affecting the synthesis or **release of ADH** results in diminished ability of the kidney to conserve water leading to **water loss and dehydration**. This condition is called **Diabetes Insipidus.**



9.The Pituitary Gland/Master Gland

- The pituitary gland is located in a bony cavity called **sella tursica** and is attached to hypothalamus by **a stalk**
- Pituitary gland is divided anatomically into an **adenohypophysis** and a **neurohypophysis**.

a)Adenohypophysis

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

i)The pars distalis

This region of pituitary commonly called **anterior pituitary**, produces

- ✓ growth hormone (GH),
- ✓ prolactin (PRL),
- ✓ thyroid stimulating hormone (TSH),
- ✓ adrenocorticotrophic hormone (ACTH),
- ✓ luteinizing hormone (LH) and follicle
- ✓ stimulating hormone (FSH).

Growth hormone: 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. Excess** secretion of growth hormone in **adult** especially in the middle age can result in severe disfigurement (especially of the face) called **acromegaly.** It lead to premature death if unchecked. This disease is hard to diagnose in early stages and often goes undetected for many years, until changes in external features become noticeable.

Prolactin : Prolactin regulates the growth of the mammary glands and formation of milk in them (hence called Milk synthesizing hormone)

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

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

FSH : In males, FSH regulate spermatogenesis. FSH stimulates growth and development of the ovarian follicles in females

LH : In males, LH stimulates the synthesis and secretion of hormones called androgens from testis. 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.

- ✓ **LH and FSH stimulate gonadal activity and hence are called gonadotrophins.**

ii) Pars intermedia

It secretes only one hormone called **melanocyte stimulating hormone (MSH).** In humans, the **pars intermedia** is almost merged with **pars distalis.** MSH acts on the **melanocytes** (melanin containing cells) and regulates **pigmentation of** the skin.

b)Neurohypophysis (pars nervosa)

It is 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.

.

Hormones are also secreted by some tissues which are not endocrine glands.

Hormones of heart

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.

Hormones of Kidney

The **juxtaglomerular cells(JG cells)** of kidney produce a peptide hormone called **erythropoietin** which stimulates **erythropoiesis (formation of RBC).**

Hormones of Gastro intestinal tract

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).

1)Gastrin: it acts on the **gastric glands** and stimulates the secretion of **hydrochloric** acid and **pepsinogen.**

2)Secretin: it acts on the **exocrine pancreas** and stimulates secretion of **water and bicarbonate ions**.

3)CCK acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice, respectively.

4)GIP: it inhibits gastric secretion and motility

Growth factors

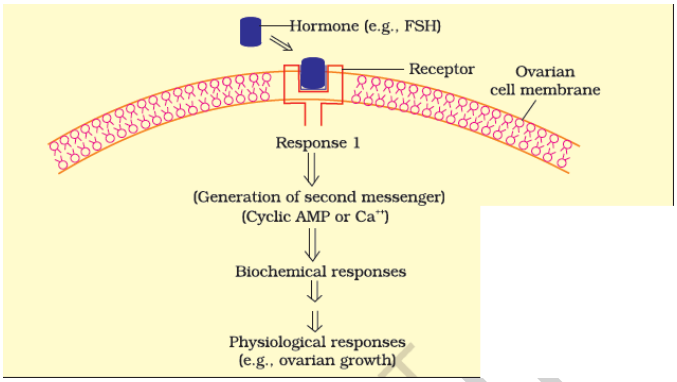
Several other non-endocrine tissues secrete hormones called growth factors. These factors are essential for the normal growth of tissues and their repairing/regeneration

MECHANISM OF HORMONE ACTION

Hormone receptor : Hormones produce their effects on target tissues by binding to specific proteins called **hormone receptors** located in the target tissues only. Each receptor is specific to one hormone only and hence receptors are specific. Binding of a hormone to its receptor leads to the formation of a **hormone-receptor complex** Hormone-Receptor complex formation leads to certain biochemical changes in the target tissue. Target tissue metabolism and hence physiological functions are regulated by hormones. Depending upon the postion of recptors, recptors are of two types - **membrane-bound receptors and intracellular receptors**

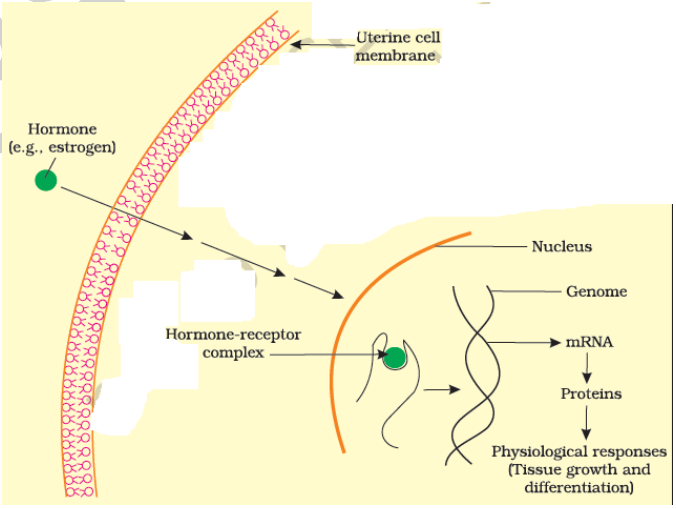
membrane-bound receptors

Hormone receptors present on the cell membrane of the target cells are called membrane-bound receptors. Hormones which interact with membrane-bound receptors normally do not enter the target cell, but generate **second messengers** (e.g., **cyclic AMP, IP3, Ca++ etc**) which in turn regulate cellular metabolism



intracellular receptors

the receptors present inside the target cell are called intracellular receptors, mostly **nuclear receptors** (present in the nucleus).). Hormones which interact with intracellular receptors **(e.g., steroid hormones, iodothyronines, etc.)** mostly regulate gene expression or chromosome function by the interaction of hormone-receptor complex with the genome. Cumulative biochemical actions result in physiological and developmental effects



On the basis of their chemical nature, hormones can be divided into groups :

(i) **peptide, polypeptide, protein hormones**

e.g., insulin, glucagon, pituitary hormones, hypothalamic hormones, etc.

(ii) steroids

e.g., cortisol, testosterone, estradiol and progesterone

(iii) iodothyronines

thyroid hormones

(iv) amino-acid derivatives

e.g., epinephrine.

Previous Years Question Paper

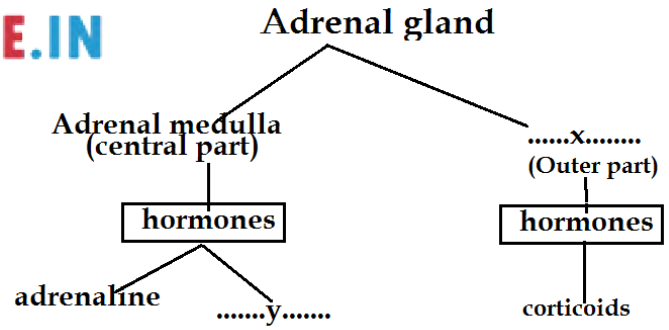
1. Expand the following hormones :
   a) TSH b) ACTH c) ANF d) FSH (HSE-Aug-2018)(2)
2. Complete the table given below by using appropriate terms (HSE-Aug-2018)(3)

Gland	Hormone	Function
Pancreas	Glucagon	.....(a).....
.....(b).....	Thymosin	Immunity
Pineal gland	.....(c).....	24-hr diurnal rhythm
Pituitary gland	Oxytocin	.....(d).....
.....(e).....	Parathyroid hormone	Increases Ca^{2+} level in blood
Thyroid	TCT/ Thyrocalcitonin	.....(f).....

3. Name the hormones whose deficiency is responsible for the following :
   a) Dwarfism b) I)diabetes mellitus
   c) Cretinism d) dieresis (HSE-March 2018)(2)
4. Classify the given hormones in the table
   Prolactin, Oxytocin, Leutinising hormone, Vasopressin (HSE-Model2018)(2)

Released from adenohypophysis	Released from neurohypophysis
–	–
–	–

5. Observe the following branching tree diagram (HSE-July-2017)(2)



a)Complete the representation by filling X and Y?
b)Adrenal medullary hormones are called 'Hormones of fight or flight' why ?

6. Complete the table (HSE-March-2017)(2)

Endocrine gland	Hormone	Functions
Heart	……A…..	Decrease blood pressure
Pancreas	Insulin	…….B…..
…..c……	Eryrthropoietin	Stimulate erthropoiesis
Thymus	…….D…….	Gives Immunity

7. A table shown below, based on their endocrine gland and their secretions. Complete it by filling A,B,C and D (HSE-sept-2016)(2)

Endocrine gland അന്തഃസ്രാവി ഗ്രന്ഥി	Hormone ഹോർമോൺ	Functions ധർമ്മങ്ങൾ
Pancreas ആഗ്നേയഗ്രന്ഥി	..... (A)	Hypoglycemic hormone of blood രക്തത്തിലെ ഗ്ലൂക്കോസിന്റെ അളവ് കുറക്കുന്നു
..... (B)	Thymosin തൈമോസിൻ	Provide immunity രോഗപ്രധിരോധ ശേഷി നൽകുന്നു
Pituitary gland പിറ്റ്യൂറ്ററി ഗ്രന്ഥി	ADH/Vasopressin ADH/വാസോപ്രെസിൻ	..... (C) .....
Ovary അണ്ഡാശയം	..... (D)	Support pregnancy ഗർഭധാരണത്തെ നിലനർത്തുന്നു

8. Hormonal abnormality is responsible for certain disease in man. List of Some

disease are given below. Write the hormone related to it. (HSE-March-2016)(2)

a)Diabetes mellitus
b)Gigantism
c)Diabetes insipidus
d)Cretenism

or

9. Like insulin and Glucagon, PTH and calcitonin are antagonistic in their action in maintaining Blood calcium level. Substantiate your answer? (HSE-March-2016)(2)

10. Write any two examples for the following
a)Hormone which control blood sugar level
b)Hormones which control blood sugar level
(HSE-sept-2015)(2)

11. Match column B and C with column A (HSE-March-2015)(2)

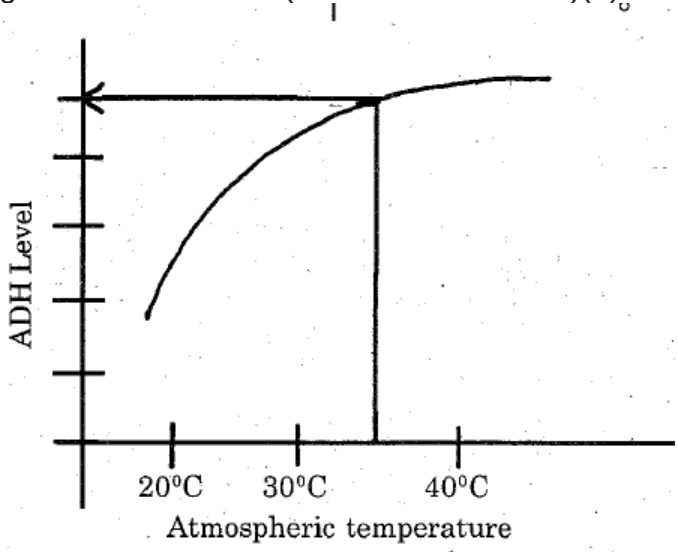
A	B	c
Thyroid തൈറോയ്ഡ്	Insulin ഇൻസുലിൻ	Weak Immunity വീക്ക് ഇമ്മ്യൂണിറ്റി
Pituitary പിറ്റ്യൂട്ടറി	Thymosin തൈമോസിൻ	Gigantism ജൈജാന്റിസം
Pancreas പാൻക്രിയാസ്	Growth hormone ഗ്രോത്ത് ഹോർമോൺ	Diabetes mellit ഡയബറ്റിസ് മെലി
Thymus തൈമസ്	Thyroxine തൈറോക്സിൻ	Goitre ഗോയിറ്റർ

12. Complete the following table?
(HSE-August-2014)(2)

Hormone ഹോർമോൺ	Endocrine gland അന്തസ്രാവി ഗ്രന്ഥി	Function ധർമ്മം
.....A.....	Ovary ഓവറി	Hormone supports pregnancy ഗർഭാവസ്ഥയെ സഹായിക്കുന്ന ഹോർമോൺ
Thyroxine തൈറോക്സിൻ	.....B.....	Hormone regulates BMR BMR നെ നിയന്ത്രിക്കുന്ന ഹോർമോൺ
Adrenaline അഡ്രിനാലിൻ	.....C.....	Emergency hormone എമർജൻസി ഹോർമോൺ
.....D.....	Pancreas പാൻക്രിയാസ്	Hyperglycemic hormone ഹൈപ്പർഗ്ലൈസീമിക് ഹോർമോൺ

13. Complete the following sentence using appropriate words (HSE-March-2014)(1)
a)……Hormone controls diurnal (24hour)Rhythm
b)Insulin controls……level of blood

1. The output of urine increase in cold days while decreased in hot and sunny days. Can you give the reason for this phenomenon as realized from the graph given below ? (HSE-MARCH-2014)(2)



14. Observe the relationship between the first two terms and fill up the blanks (HSE-SEPT-2013)(1)
Hyperglycemic hormone:Glucagon
Hypoglycemic hormone:……..

15. Complete the chart showing hormone and Hormonal disease (HSE-SEPT-2013)(1)

Diseases	Causes
Dwarfism	Low secretion of growth hormone
a) _____	Over-secretion of growth hormone
Goitre	Deficiency of iodine
Diabetes mellitus	b) _____

16. Fill the table appropriately

(HSE-March-2013)(2)

Hormones	Site of production	Function
CCK	Gastrointestinal tract	a) .....
Erythropoietin	b)	RBC formation
c)	Heart	Reduced BP
PTH	d)	Increased blood Ca^{2+}

17. Match Column B and C with Column A

(HSE-SEPT-2012)(2)

A Hormone	B Endocrine gland	C Principal function
1) Thyroxin	i) Adrenal gland	a) Contraction of smooth muscles
2) Oxytocin	ii) Thymus gland	b) Stimulates ovulation
	iii) Pitutory gland	c) Regulates basal metabolic rate
	iv) Thyroid gland	d) Increases calcium level in the blood