CHAPTER:3
COMMUNICATION:3-NERVOUS SYSTEM

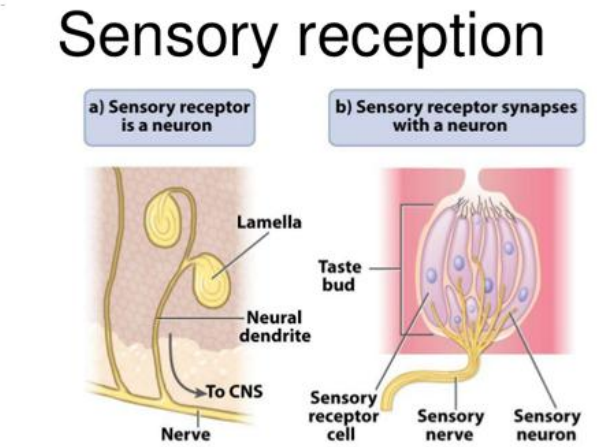
INVERTEBRATES SENSORY RECEPTORS

There are about nine types of receptors:

- Baroreceptors
- Chemoreceptors
- Georeceptors
- Hygroreceptors
- Phonoreceptors
- Proprioceptors
- Tactile Receptors
- Thermoreceptors

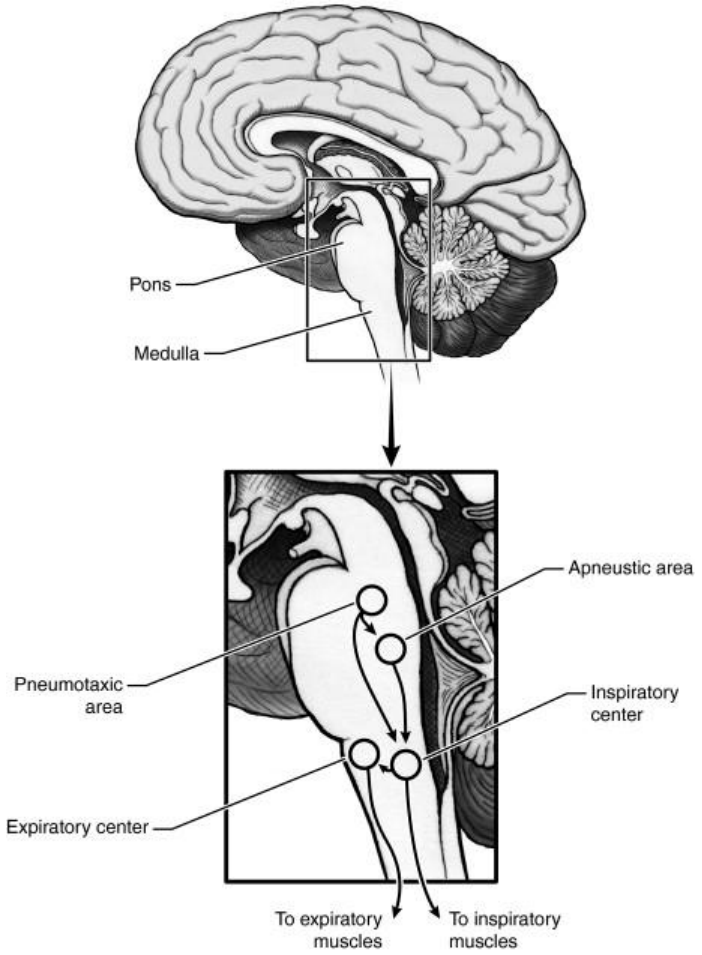
BARORECEPTORS

- Sense changes in pressure
- Response in ocean-dwelling, copepod crustaceans, ctenophores, jellyfish medusa, and squids
- Intertidal crustaceans coordinate migratory activity
- No specific structure



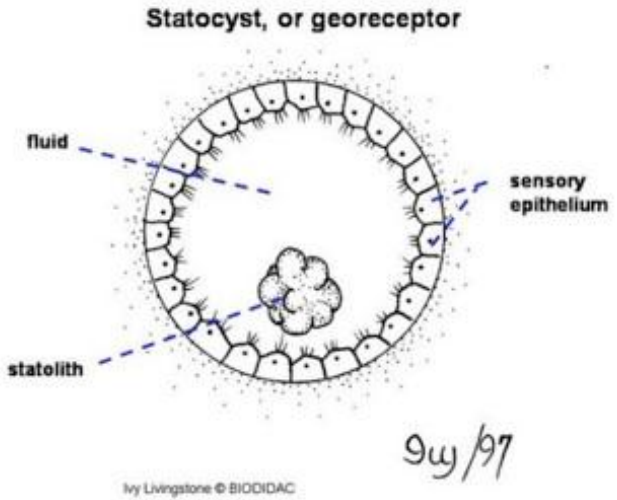
CHEMORECPTORS

- Respond to chemicals
- Oldest and universal sense in animal kingdom
- Protozoa has avoidance response to acid, alkali and salt stimuli
- They are present in depressions or pits in aquatic invertebrates



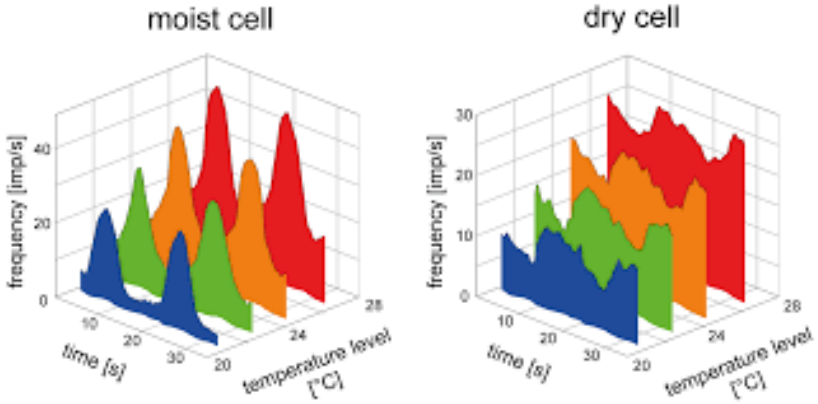
GORECEPTORS

- Georeceptors (geo, earth+receptor) respond to the force of gravity. This gives an animal information about its orientation relative to “up” and “down.” Most georeceptors are statocysts (statos: standing , kystis: bladder)



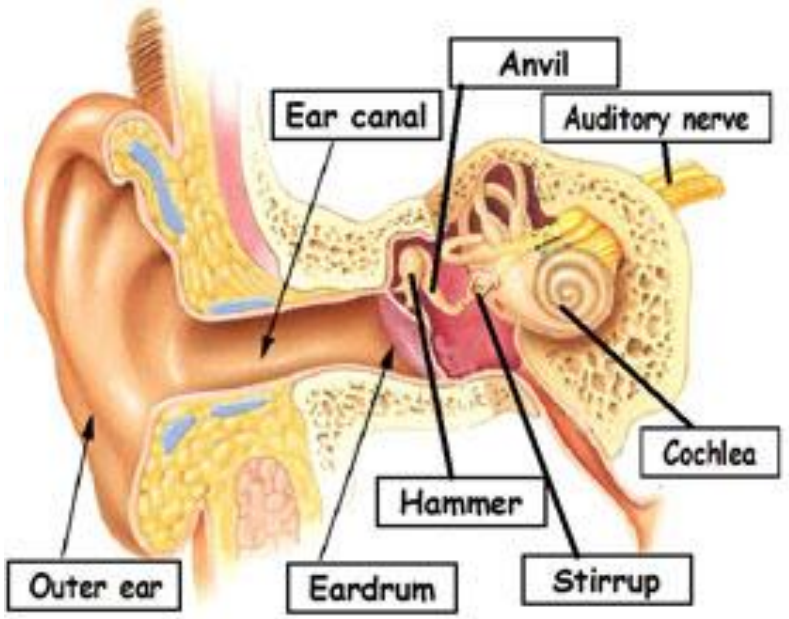
HYGRORECEPTORS

- Hygroreceptors (hygros, moist) detect the water content of air. For example, some insects have hygroreceptors that can detect small changes in the ambient relative humidity. This sense enables them to seek environments with a specific humidity or to modify their physiology or behavior with respect to the ambient humidity.



PHONORECEPTORS

- True phonoreceptors (phone, voice + receptor) that respond to sound have been demonstrated only in insects, arachnids, and centipedes, although other invertebrates seem to respond to sound-induced vibrations of the substratum. For example, crickets, grasshoppers, and cicadas possess phonoreceptors called tympanic or tympanal organs

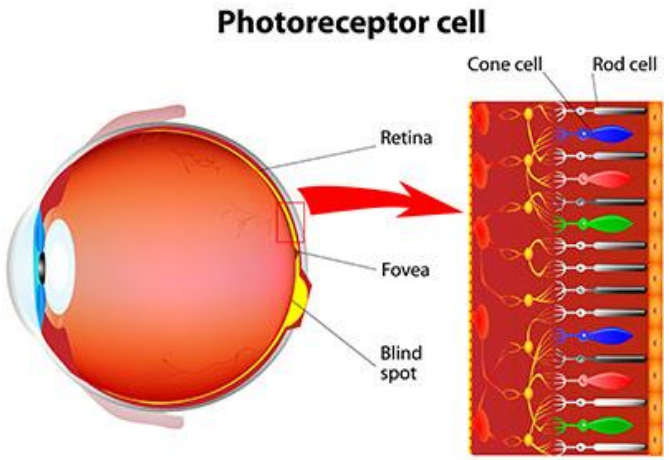


INVERTEBRATES PHOTORECEPTORS

- Flagellated protozoa possess a mass of bright red photoreceptor granules called **stigma.**
- **Earthworm** has simple unicellular photoreceptors cells scattered over the epidermis
- **Annelids and Molluscan** possess **ocellus.** It is the simple eye of insects and some other
- invertebrates, consisting basically of light-sensitive cells.
- **Compund eyes** of arthropods like insects, crustaceans and millipedes are composed of units
- called **ommatidia**. An ommatidium contains a cluster of **photoreceptor** cells surrounded by
- support cells and pigment cells

PHOTORECETORS

- **Photoreceptors** are the cells in the retina that respond
- to light. Their distinguishing feature is the presence of large amounts of tightly packed membrane that contains the photopigment rhodopsin or a related molecule.



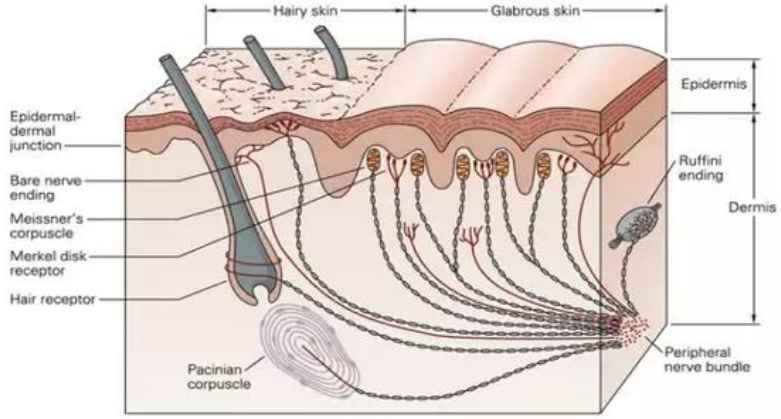
PROPRIOCEPTORS

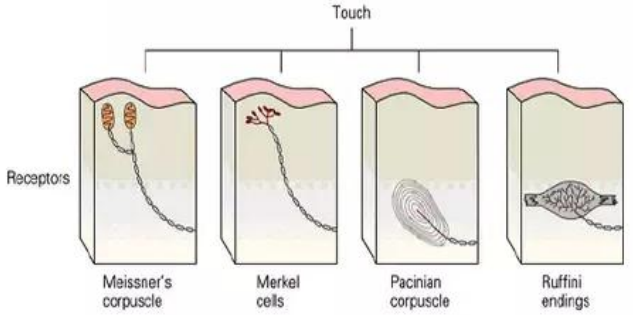
- **proprioceptors** sensory receptors in muscles, joint capsules and surrounding
- tissues, that signal information to the central nervous system about position
- and movement of body parts, for example the angle at a joint or the length of
- a muscle.

- Tactile receptors are basically **touch** receptors.
- Most tactie receptors involves the projection from the body surface.

TACTILE RECEPTORS

- Tactile receptors are sensory receptors which respond to touch. In the glabrous skin (skine without hairs) of the hand we have four types of receptors: Meissner, Merkel, Pacinian, Ruffini.
- The former two are located just under the skin while the latter two are located deeper. All four have highly specialized encapsulated endings as you can see from the figure. In the hairy skin Meissner corpuscles are replaced by hair follicles.

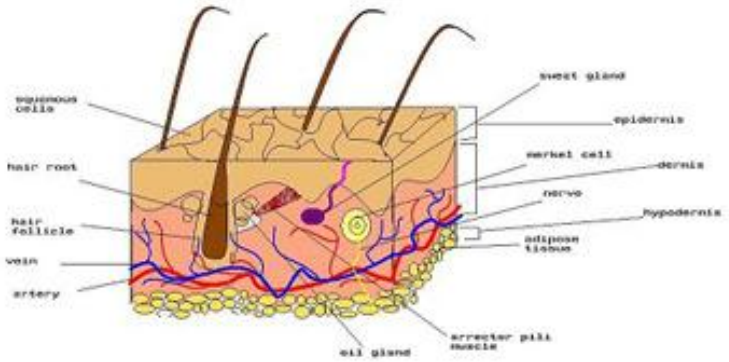




Touch receptors in the skin

THERMORECEPTORS

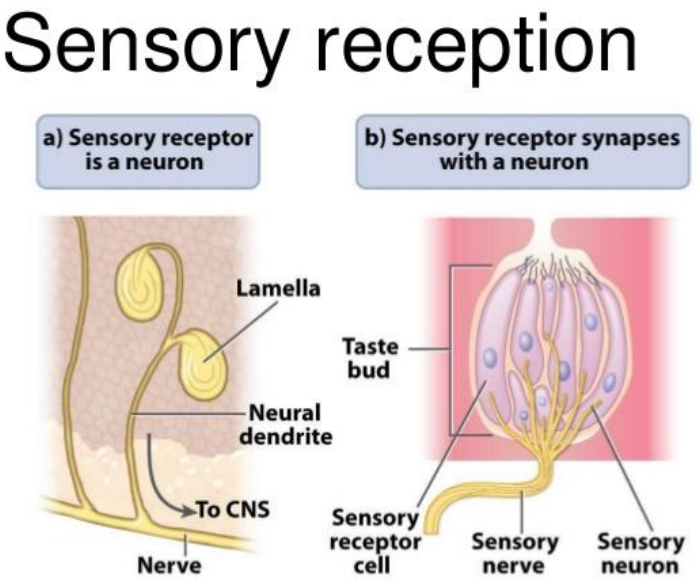
- **Thermoreceptors** are able to detect heat and cold and are found
- throughout the skin in order to allow sensory reception throughout the body



SENSORY RECEPTORS OF VERTBRATES

- It reflects the adaptation to sensory stimulus both external or internal
- Physical and chemical characteristics of environment effect the energy ,molecule that carry sensory information.

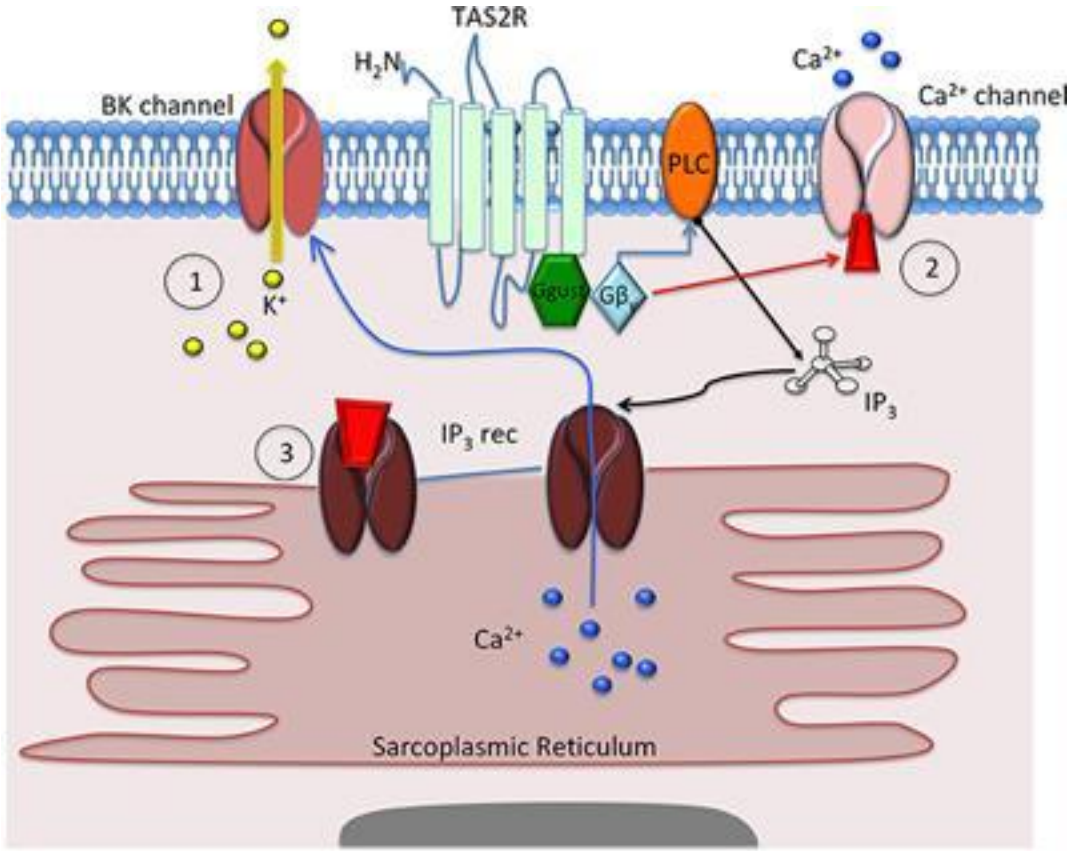
Figure 1



VERTEBRATES RECEPTORS

- There are two systems of vertebrate receptors.

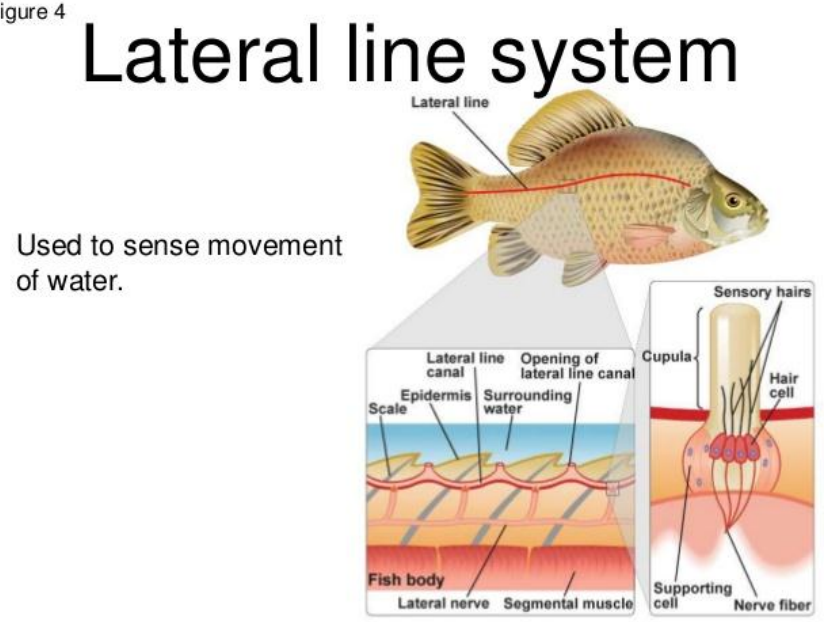
- Lateral line system and electrical sensing.
- Lateral line system and mechanorecptors.



ELECTRICAL SENSING

- It is in the head and body region of fishes, amphibians and platypus.
- It consist of sensory pores in the epidermis.
- These pores connect to canals leading to electroreceptors called ampullary organs.

Figure 4



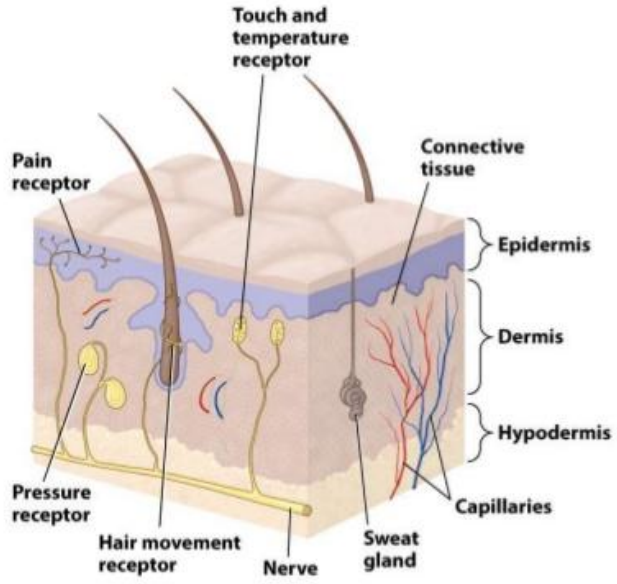
MECHANORECETION

- A mechanoreceptor is excited by mechanical pressures or distortion.
- Examples : sharks,cyclostomes,aquatic amphibians.
- These animals contains different kind of hair cell mechanorecptors called neuromast.

Figure 3

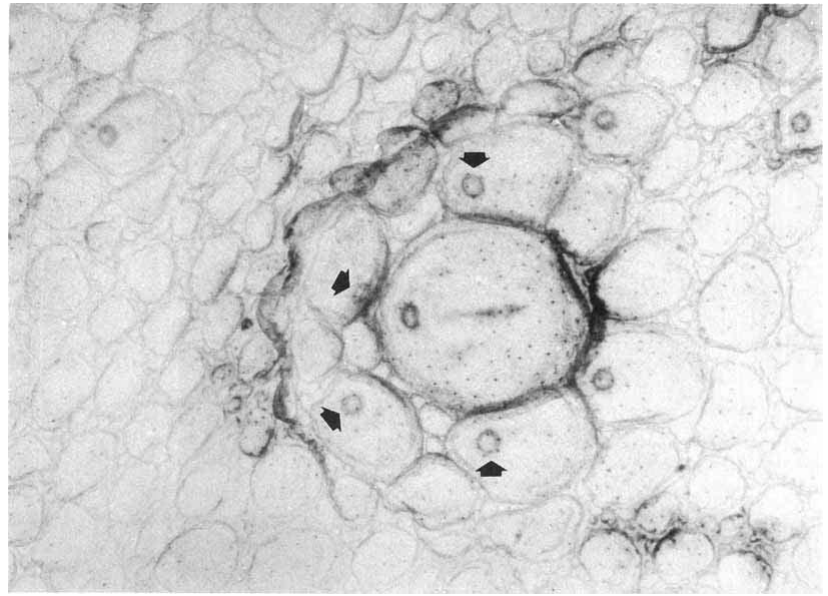
Skin mechanoreceptors

Sensory receptors in the skin and surrounding hair follicles respond to pressure.



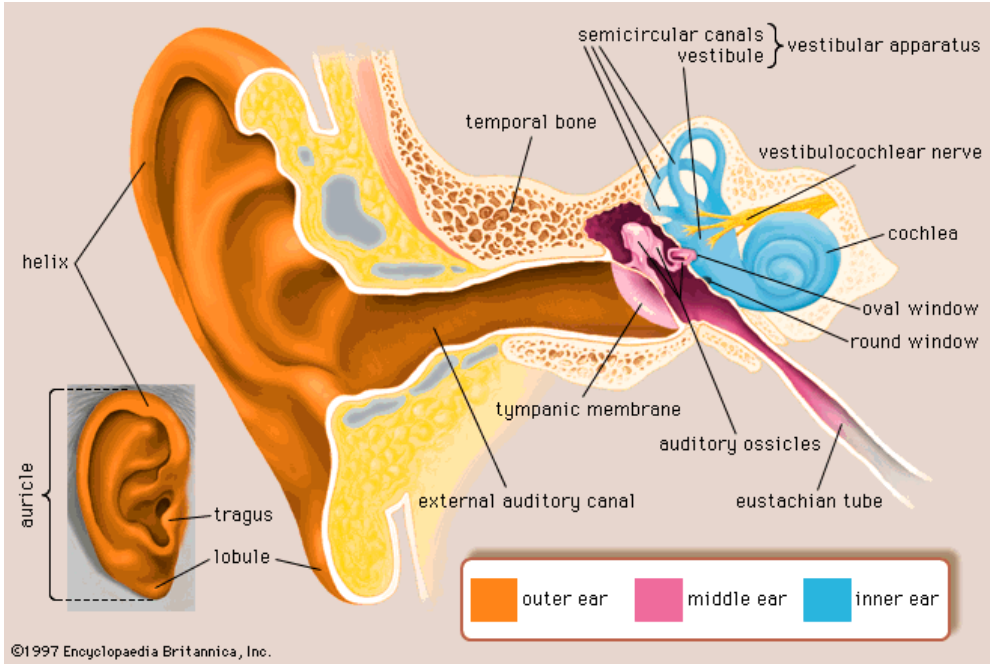
HEARING AND EQUILIBRIUM IN AIR

- Hearing has been very important to vertebrate.
- It is important in search of food and communication.
- Hearing and equilibrium are received by same organ.



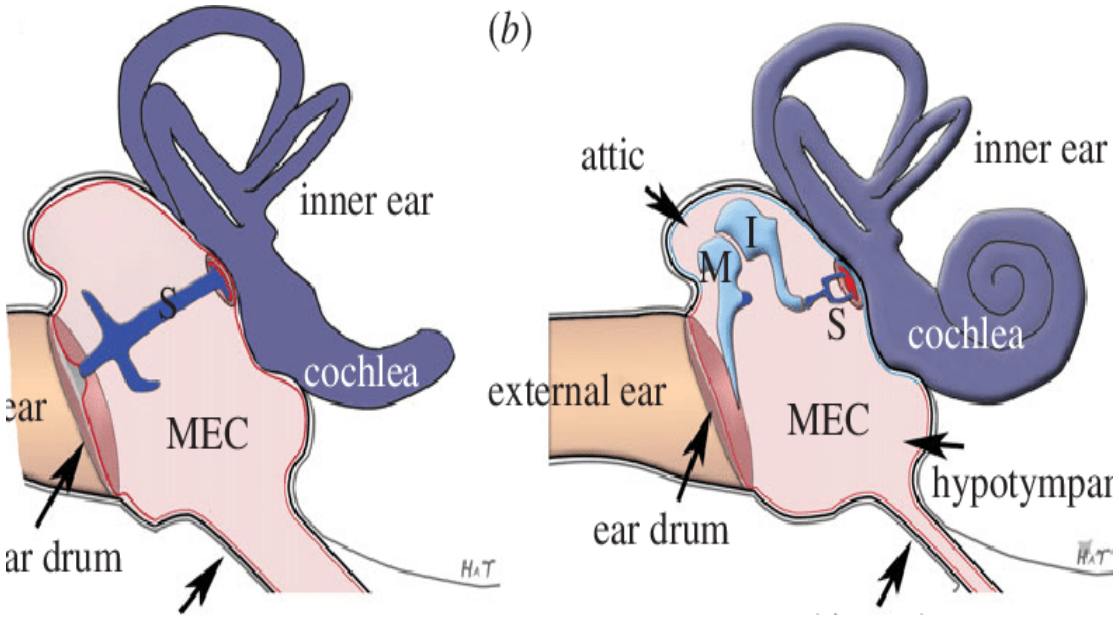
STRUCTURE OF HUMAN EAR

- Ear of human consist of three parts: outer, middle and inner ear.
- The outer ear consist of auricle and external auditory canal.
- The middle ear consist of tympanic membrane.
- The inner ear has three components: the first two are vestibule and semicircular canal,third part is cochlea.



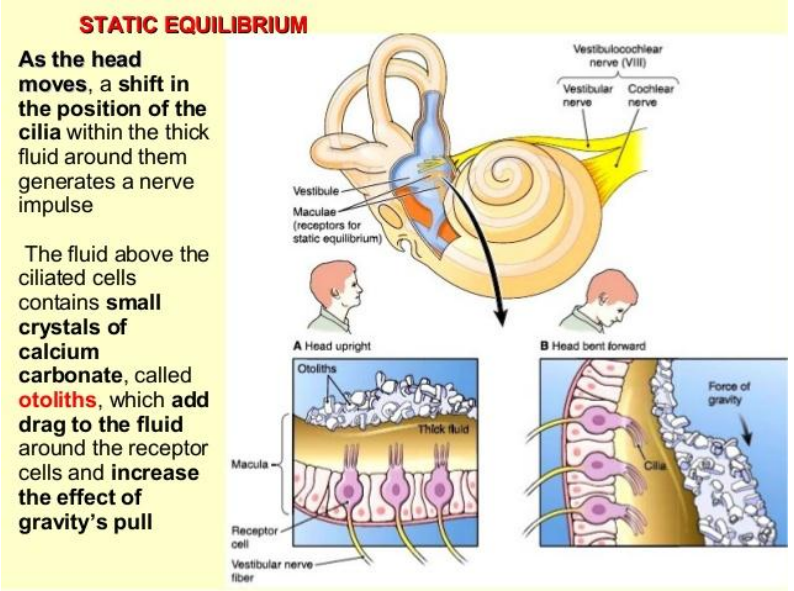
EAR OF ANIMALS

- Ear was first evolved in amphibians.
- Salamandar lack tympanic membrane and middle ear.
- The ear of snake lack middle ear cavity.
- Mammals and birds have well developed ears.



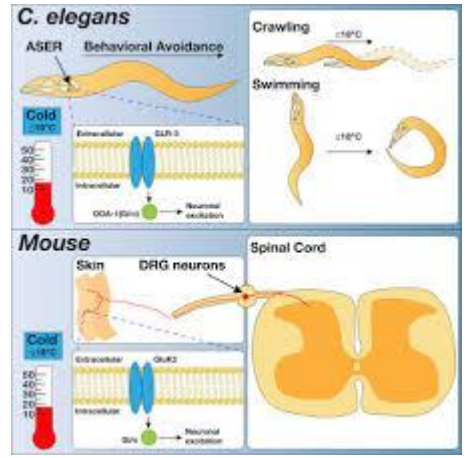
HEARING AND EQUILIBRIUM IN WATER

- Receptors for equilibrium,balance and hearing are inner ear.
- Semicircular canals in bony fishes.
- Some fishes lack outer or middle ear so vibrations may pass from waterthrough the bone of skull to inner ear.



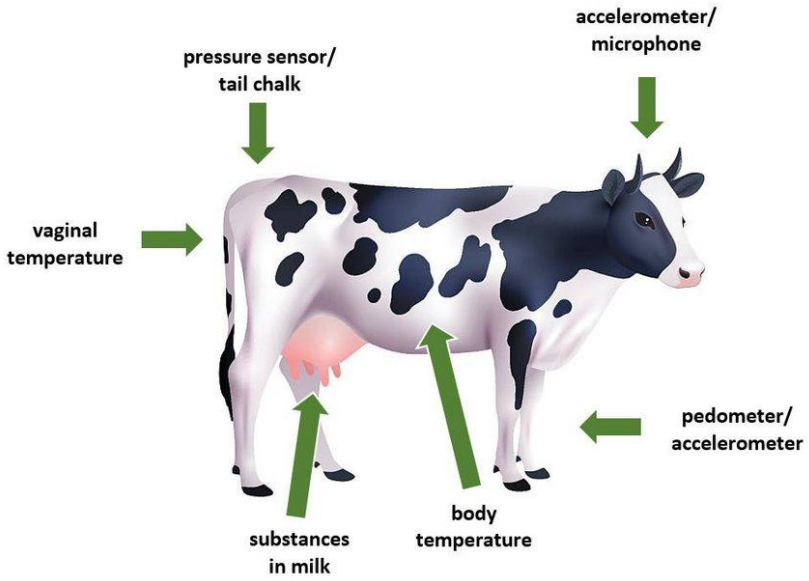
SKIN SENSORS OF HEAT AND COLD

- Thermoreceptors have bare nerve endings.
- They may be present either in epidermis or dermis.
- There are also cold or warm spots on the skin.
- Cold receptors respond to temperature above skin temperature.
- Heat receptors respond to temperature below skin temperature.



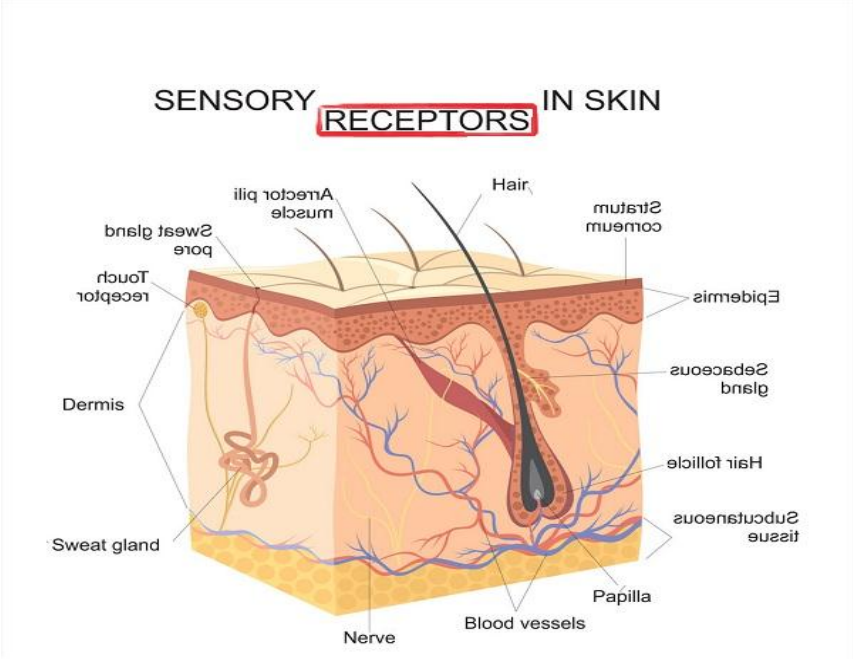
DETECTION OF TEMPERATURE

- Skin of animals can detect temperature.
- Rattle snakes and Pit vipers have heat sensitive pit organs between eye and nostril.
- These depressions are lined with sensory epithelium containing receptor cells respond to
- temperature of snakes differ from surroundings.
- Snakes also use pit organs to locate warm-blooded prey.



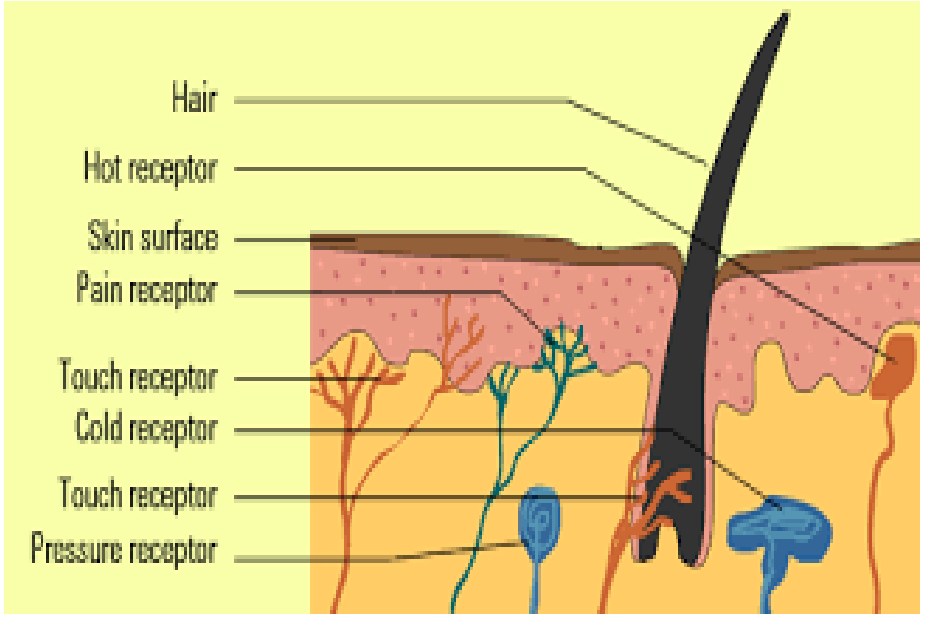
SKIN SENSORS OF DAMAGING STIMULI

- Pain receptors are present throughout the body (except brain and intestines).
- Pain receptors are called Nocireptors.
- They have bare nerve endings.
- Severe heat, cold, irritating chemicals elicit response from nocireceptors thatthat braindetects as pain and itching.



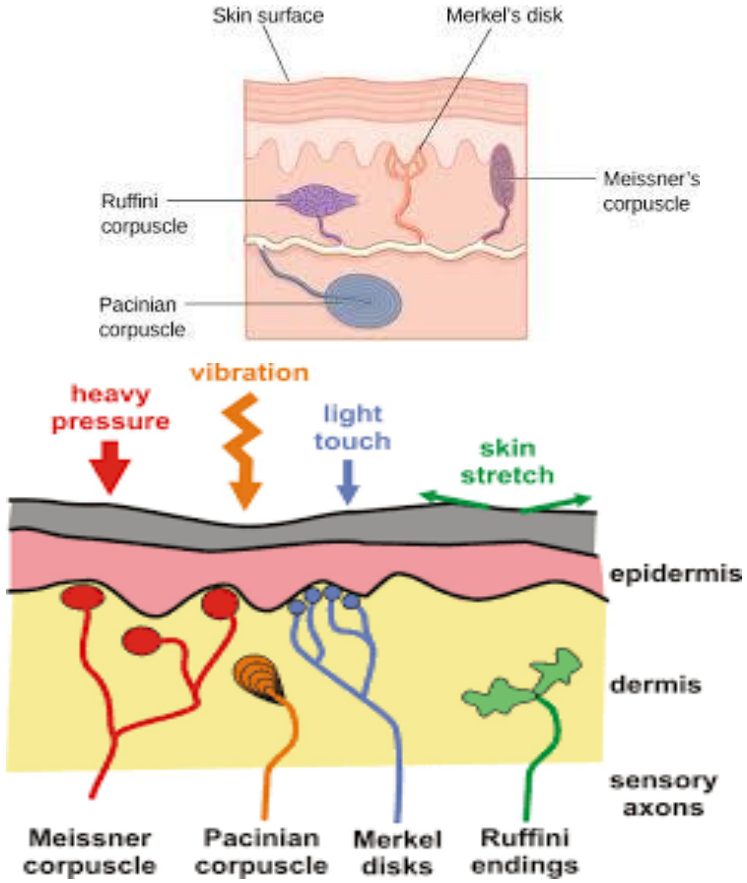
SKIN SENSORS OF MECHANICAL STIMULI

- Tactile stimulus; Pertaining to touch.
- Tactile receptors act as a link between organism and there environment .
- Mechanical sensory receptor detect mechanical sensory stimuli that the brain interprets.
- For example
- light-touch
- Touch-pressure
- vibration



TYPES OF TOUCH RECEPTORS

1 Light touch receptors include:
bare nerve endings.
meissners corpuscles or tactile corpuscles.
2 .Pain receptors are distributed throughout the body.
3. Bulb of Krause found in dermis of skin respond to position changes.
4. Pascinian corpuscles are touch pressure receptor also called organs of ruffians.

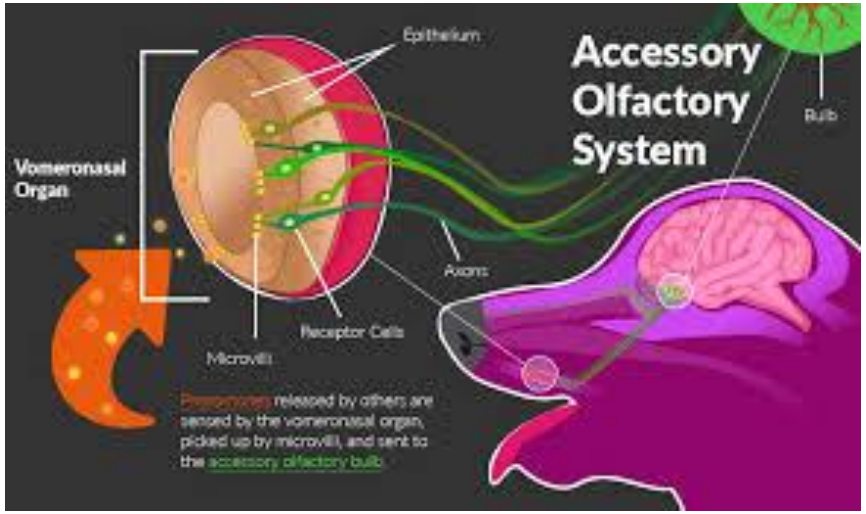


SONAR

- It is a process by which many animals can determine distance and depth by a force of echolocation.
- Animals emit high frequency sounds and determine how long it takes for the sound to return after bouncing off the objects in environment .
- Bats
- Dolphins
- shrews

SMELL

- Also called as olfaction .
- Smell receptor are present in roof of nasal cavity of vertebrates.
- These cells lie among the supporting epithelial cells .
- Olfactory cells vary in animals .
- For example
- Dog has 40 million olfactory cells per square centimeter .

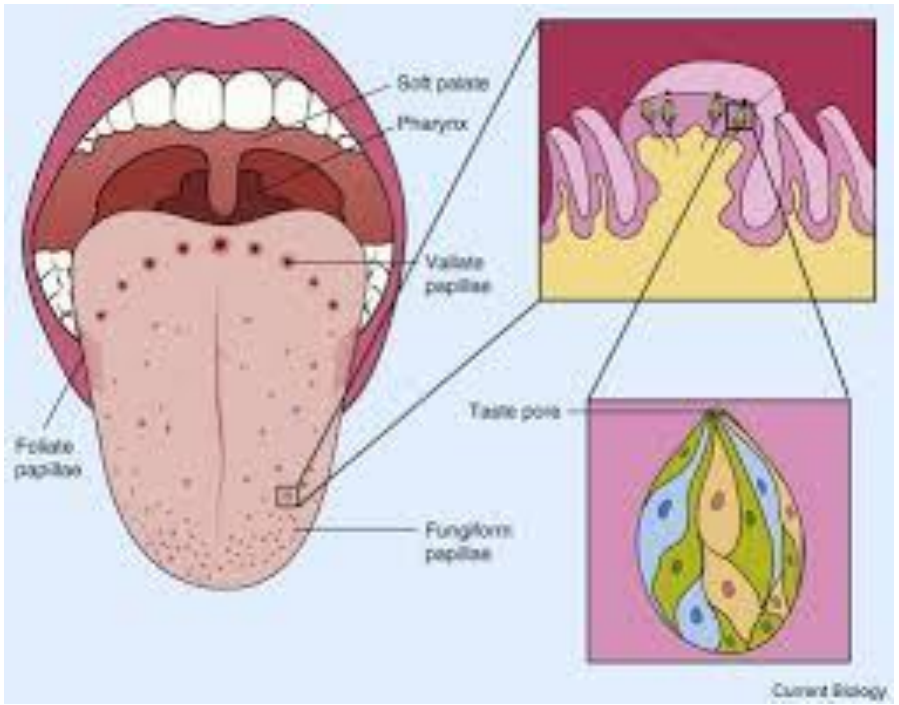


SMELL PERCIEVED IN ANIMALS

- fishes;:openings in snout lead to olfactory receptor .
- Spawning depends on olfaction .
- In amphibians :opening through nostril .
- Helps in search of food
- Mate recognition
- Noxious chemical detection .
- In Reptiles: Blind ending pouches known as Jackobson's organs, that open into
- mouth are present along the olfactory epithelium.
- Snake takes out its tongue and strike it with Jackobson's organ in order to perceive odor.
- In Birds: External nares open near the beak.
- Olfactory epithelium is poorly developed
- Vulture is exception .
- In mammals :nose for smell.

TASTE

- Also called as gustation.
- Receptor of taste are chemoreceptor.
- They are present in mouth or throat .
- Surface of mammalian tongue covered with small protuberances called papillae.
- Bumpy texture of tongue is due to papillae.
- Taste buds are barrel shaped chemoreceptor cell called gustatory cells.
- Taste buds :present in crevices between the papillae.
- Taste pore: Extending from each receptor are gustation hair that open through small openings called taste pore.

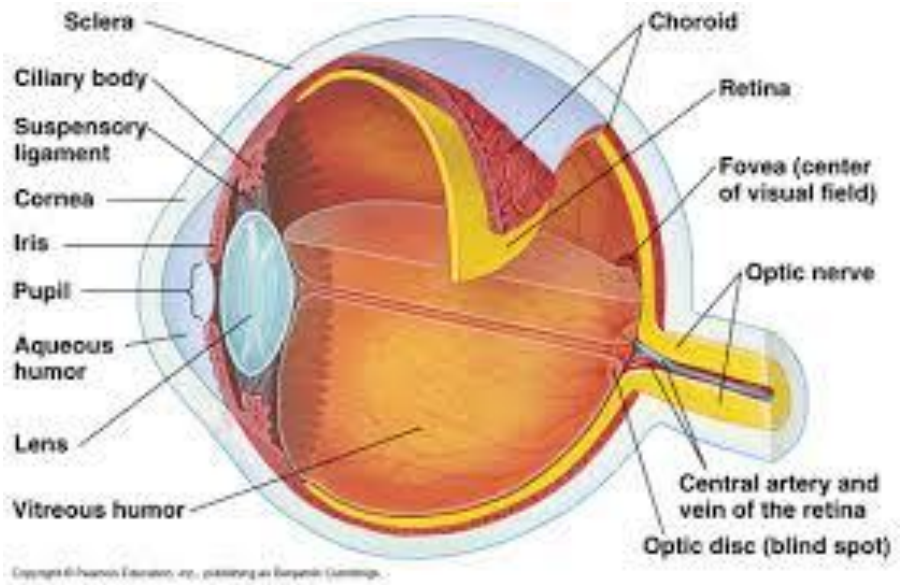


TASTE SENSATION

- There are 4 Taste sensations.
- Sweet (sugars)
- Sour (acids)
- Bitter (alkaloids)
- Salty (electrolytes)
- Location of taste buds in different animals.
- Mammals :In their mouth
- Reptiles: In pharynx
- Birds: In pharynx
- Fishes: On skin
- For example
- Sturgeon :have taste buds in roof , on side walls and in pharynx.
- These help in monitoring the flow of water.

VISION

- Most of the species have eyes for vision .
- Eyeball consists of
- Lens
- Sclera
- Choroid
- Inner retina consists of photoreceptors.
- Transparent cornea
- Colored iris



- Cornea along with sclera cover the front of eyeball .
- Iris is endowed with light-screening pigments made up of circular smooth muscles controlling the amount of light entering the pupil.
- A clear fluid fills the posterior and anterior chambers between lens and cornea .
- Lines is behind iris.

- Conjunctiva :Mucus membrane that cover
- eyeball .
- Accomodation :Process of focusing light rays precisely on retina.
- Stretching and relaxation of muscles and fibers is coordinated in vertebrates

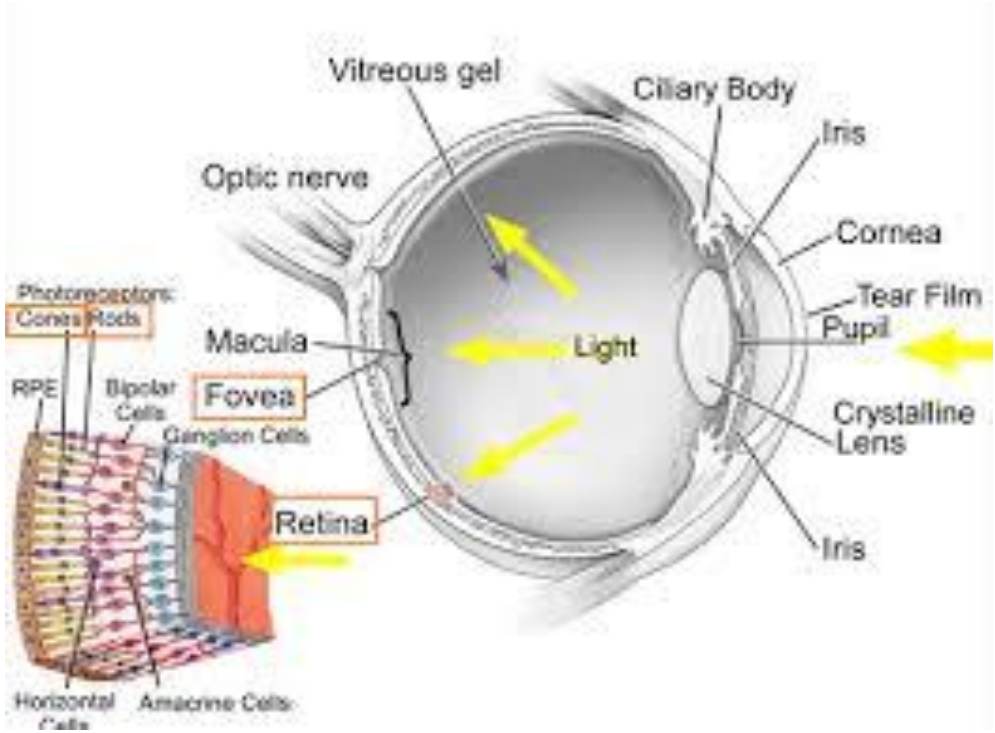
EYES OF VERTEBRATES

- Fishes:
- Lidless, rounded and close to retina
- Focusing require moving lens forward and backward .
- Amphibians: Sight feeders
- Binocular vision in anurans which help in depth perception for capturing prey.
- Salamander lack binocular vision .
- Nictitating membrane clean the eyes .

- Reptiles :
- Upper an lower eyelids ,blood sinus ,nictitating membrane cleans the eye.
- Median eye develops from roof of optic tectum or mid brain.
- For example
- Tuatara have median eye with complete lens ,nerve and retina.
- Birds:
- Double focusing mechanism helps in instant capture of prey.

VERTEBRATES EYES

- Rods and cones are present in vertebrate eyes .
- Rods are sensitive to dim light.
- Cones respond to high intensity of light and involved in color perception .
- Generator potential triggered by the rhodopsin in rod cell which absorb light .
- When photoreceptors are not stimulated vitamin A and ATP convert rhodopsin to light sensitive form.
- Retinal nerves translate relative amount of light that cones absorb .
- Generator potential that are then transmitted as nerve impulse to brain where overall sensation of sight is perceived .



CHAPTER:4
COMMUNICATION:3-THE ENDOCRINE SYSTEM AND CHEMICAL MESSENGER.

COMMUNICATION

- ***"Communication is a process in which the sender transmits signals to one or more receivers to control and coordinate the actions".***
- In human body two, major organ systems participate in relatively ***"long distance"*** communication***: The nervous system*** and ***the endocrine system***.
- Together these two systems are primarily responsible for maintaining **homeostasis** in the body.

CHEMICAL MESSENGERS

"Chemical messenger is any compound that serves to transmit a message".

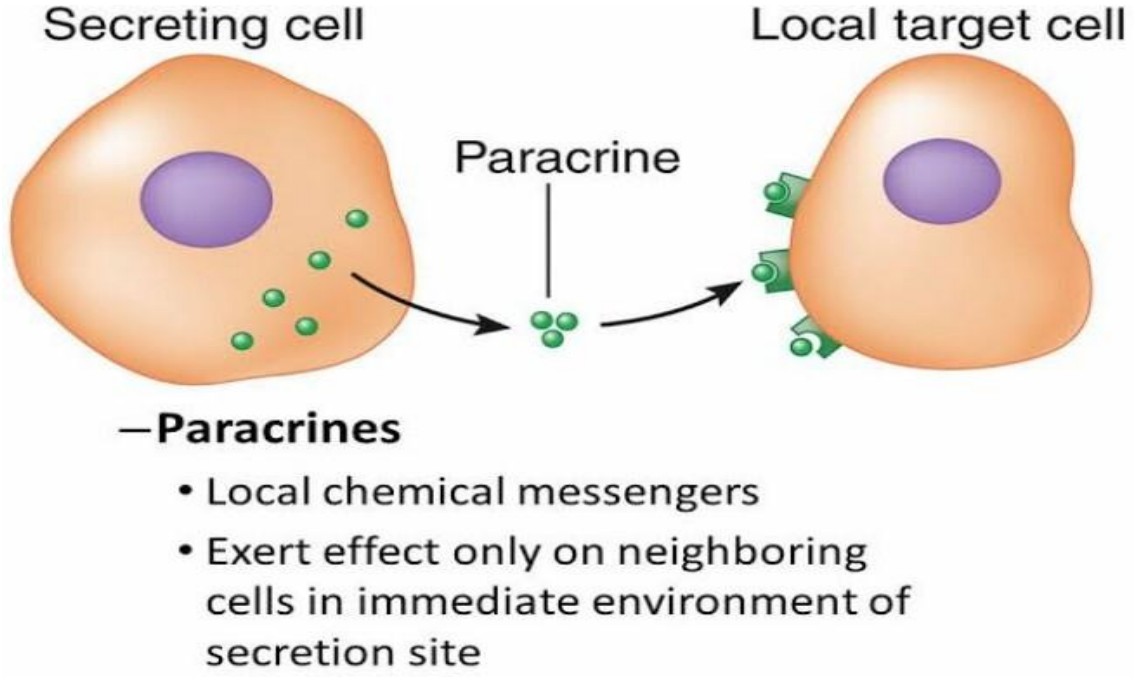
A chemical messenger may refer to: ***Hormone*** , ***Long range chemical messengers.*** **Neurotransmitter**, communicates to adjacent cells.

Neuropeptide , a protein sequence which act as a hormone or neurotransmitter.

Pheromones.

LOCAL CHEMICAL MESSENGERS

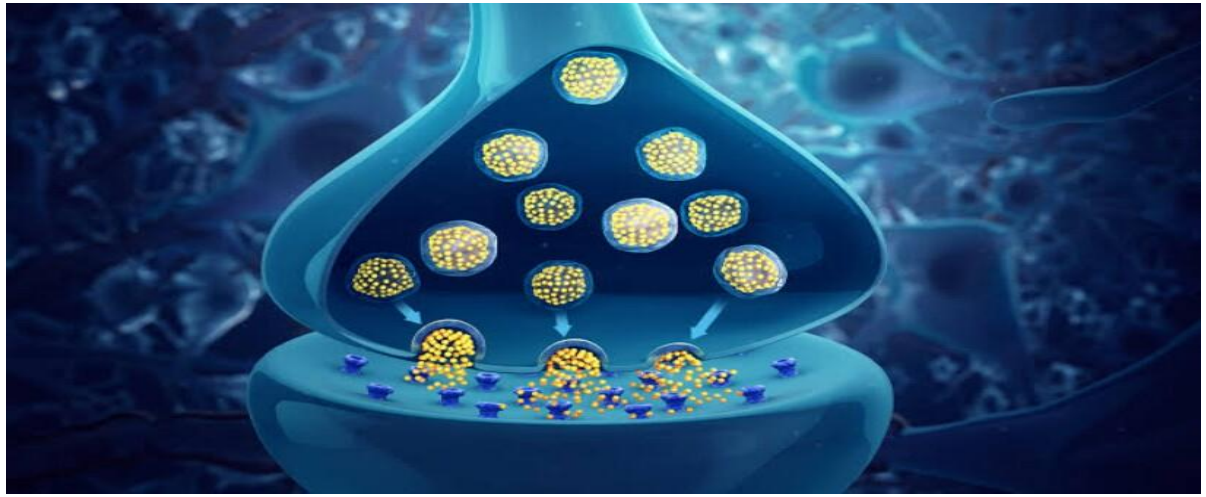
- Alter physiological conditions
- Most of these act on adjacent cells
- Do not accumulate in blood
- In vertebrates ***lumones*** (**in gut**, **regulate digestion**)



NEUROTRANSMITTERS

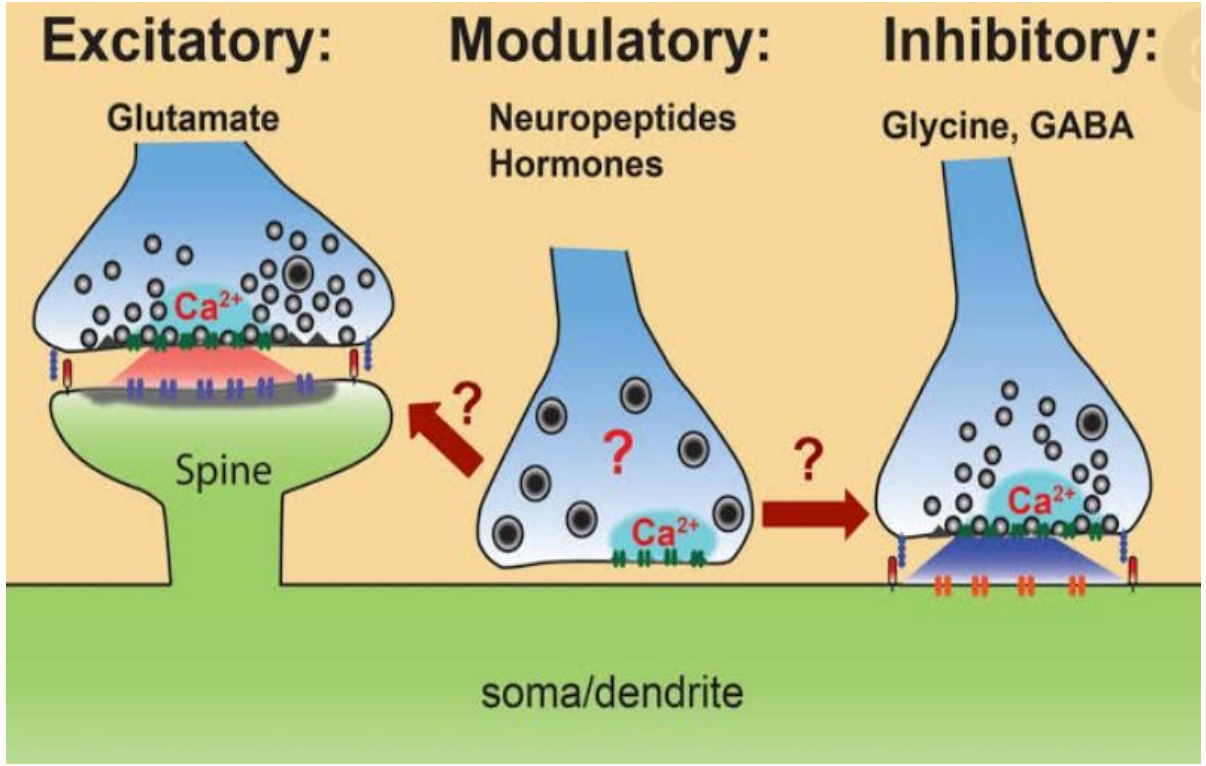
- Chemicals, act on adjacent target cells
- Act quickly, recycled

- Actively degraded
- Reach high concentration in synaptic cleft
- Example ***Acetylcholine***



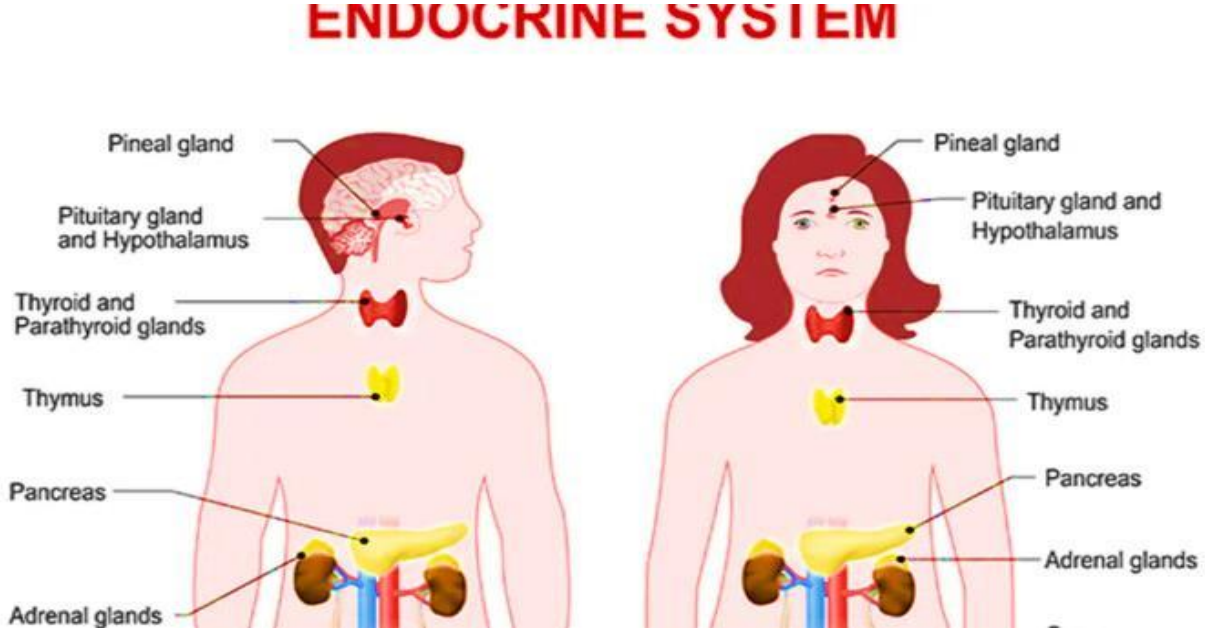
NEUROPEPTIDES

- Also ***NEUROHORMONES***
- Transported by blood to nonadjacent cells
- In mammals, certain nerve cells in **hypothalamus** release neuropeptides, cause **pituitary gland** to release hormone **oxytocin**



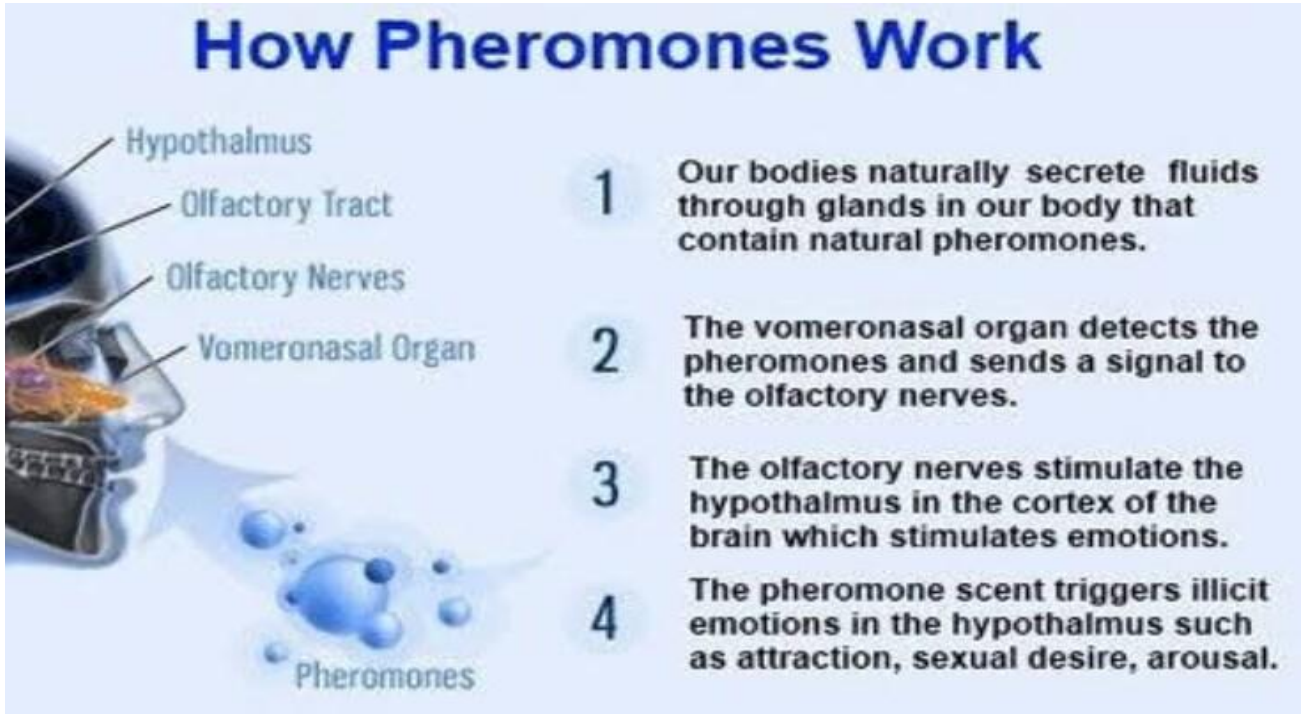
HORMONES

- Secreted by endocrine glands and cel
- Transported by blood to nonadjacent cells
- Example **Oxytocin, FSH, LH** etc.



PHEROMONES

- Released to the exterior of one animal that affect behavior of other animal of same species



HORMONES AND THEIR FEEDBACK SYSTEMS

"A hormone (Gr. hormaein, to set in motion or to spur on) is a specialized chemical messenger produced by Endocrine gland or tissue".

- Study of endocrine glands and their hormones is known as ***ENDOCRINOLOGY***.
- Hormones circulate through body fluids, affect metabolic activity of target cell.
- A **target cell** has receptors to which chemical messengers either selectively bind or on which they have an effect.
- Only rarely does a hormone operate independently.
- More typically one hormone influences, depends on, and balances on other hormones in a controlled **feedback network**.

BIOCHEMISTRY OF HORMONES

- Most hormones are proteins ,derivatives of amino acids
- Few, fatty acid derivatives, fore example most invertebrate neurosecretory cells produce Neuropeptides
- Vertebrate pancreas secretes proteins
- Ovaries, testes, cortex of adrenal gland secretes steroids.

Polypeptides

Insulin
glucagon
somatotropin
FSH
LH
vasopressin
Oxytocin
thyrotropin
ACTH

Steroids

Estrogen
testosterone
cortisol
Aldosterone
corticosterone
Progesterone

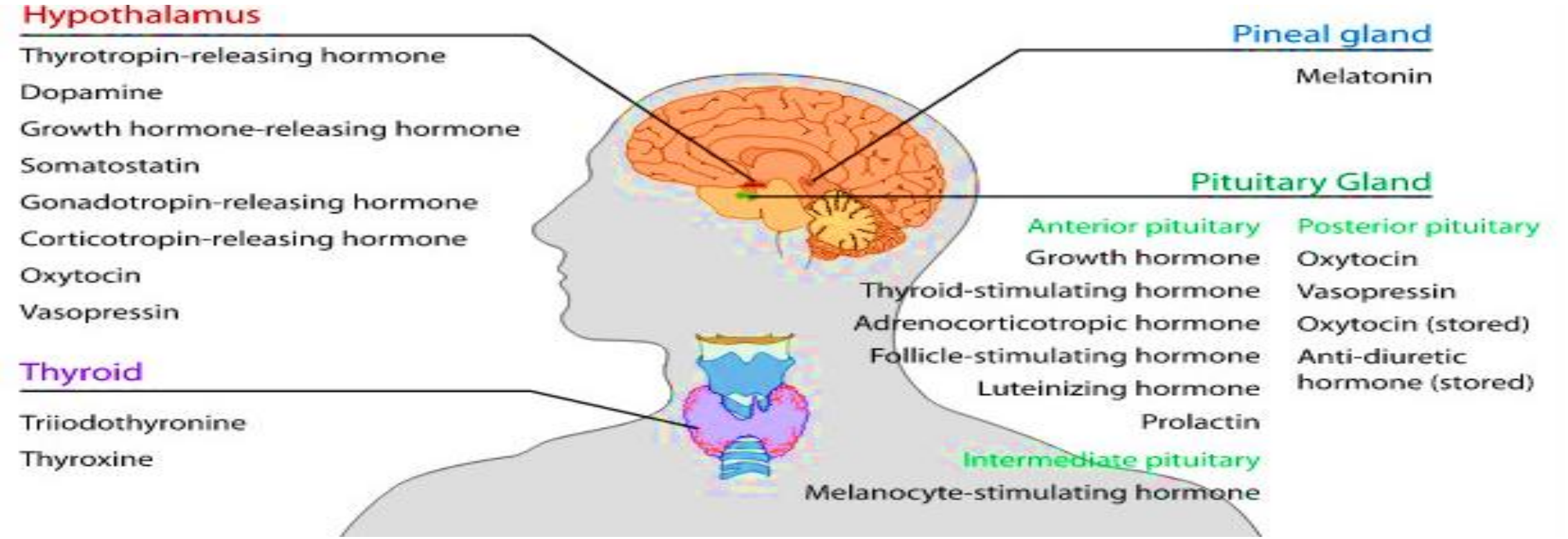
Amino acid derivatives

Epinephrine
norepinephrine
dopamine
Thyroxine, T3 and T4
Melatonin
Serotonin

- ***Hormones are effective in extremely small amounts.***

Hormones help to control biochemical reactions in three ways

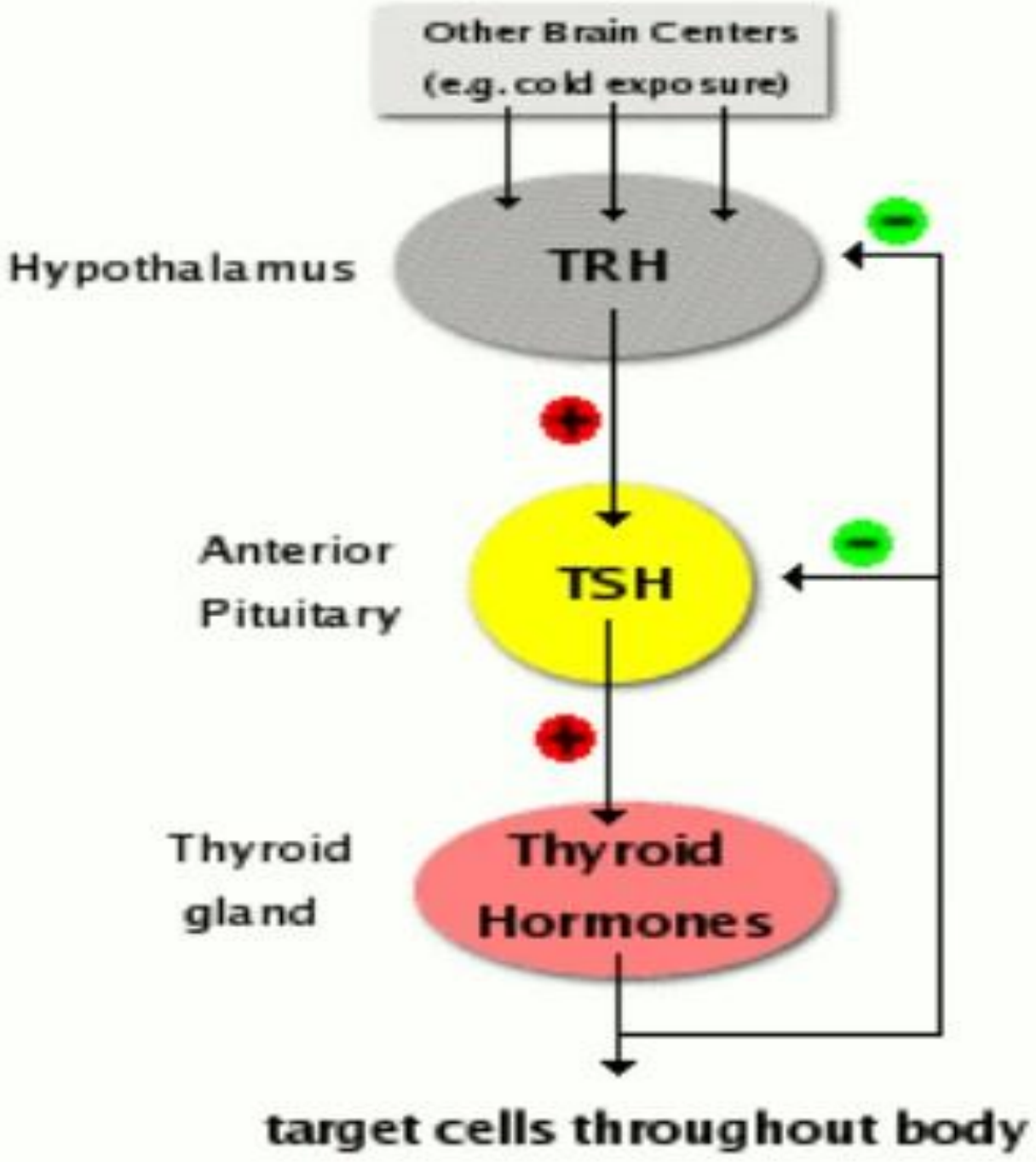
- Increase rate at which other substances enter or leave cell.
- Can stimulate a target cell to synthesize enzymes, proteins, or other substances.
- Can prompt a target cell to activate or suppress cellular enzymes.



FEEDBACK CONTROL SYSTEM OF HORMONE SECRETION

Suppose the rate of metabolic rate of dog decreases

Hypothalamus responds to this slow rate by releasing more Thyrotrophin releasing hormone **TRH** which causes pituitary gland to release more **Thyrotrophin** or Thyroid stimulating hormone **TSH**. This hormone cause Thyroid to secrete Thyroxin which increases metabolic rate and vice versa.



FIXED-MEMBRANE RECEPTOR MECHANISM

- With fixed MRM an endocrine cell secretes a water soluble hormone that circulates through blood.
- At the cells of target organs, hormone act as ***"first or extracellular messenger"***, binding to a specific receptor site for that hormone on plasma membrane.
- The hormone receptor complex activates the enzyme ***ADENYLASE CYCLASE*** in the membrane, the activated enzyme converts the ATP into a nucleotide known as ***CYCLIC AMP***, which becomes ***"the second or intracellular messenger",*** cyclic APM diffuses through the cytoplasm and activates an enzyme known as ***PROTEIN KINASE***, which causes the cell to respond, after inducing the target cell the enzyme ***PHOSPHODIESTRASE*** inactivates cyclic AMP,
- In the mean time the membrane receptors loses the first messenger and becomes available for new reaction

Some Hormones of Invertebrates

- Almost all invertebrate taxa produce hormones
- Hormones may be synthesized by **endocrine cells** as in Cnidarians,Nematodes and Annelids
- By **endocrine glands** as in Molluscs, Arthropods and Echinoderms.
- Invertebrates hormones are often **neuropeptides** or steroids.

Various Endocrinal system in the vertebrates:

Axis:

When no. of glands are regulated under a sequential signal is called an axis.

Hypothalamus pituitary Target organ axis:

- Similar in all vertebrates.
- Most primitive in Agnatha.
- To advanced in jawed fishes.
- Clearly defined in Amphibians & Reptiles.

Target Organs:

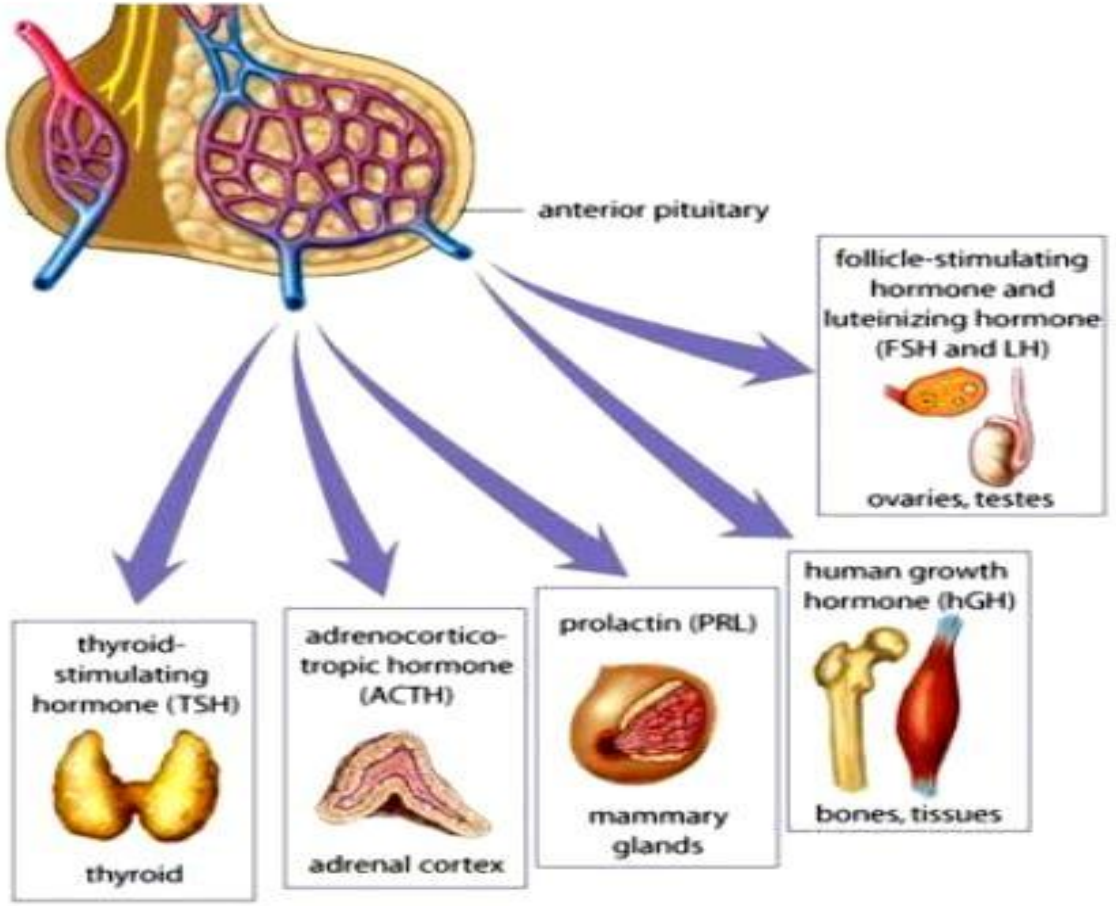
- ✓ Thyroid glands.
- ✓ Adrenal glands.
- ✓ Gonadal glands.

Thyroid Axis

Pituitary secretes thyrotrophic that stimulates thyroid gland to secrete thyroid hormone, thyroxin & tridothyronine

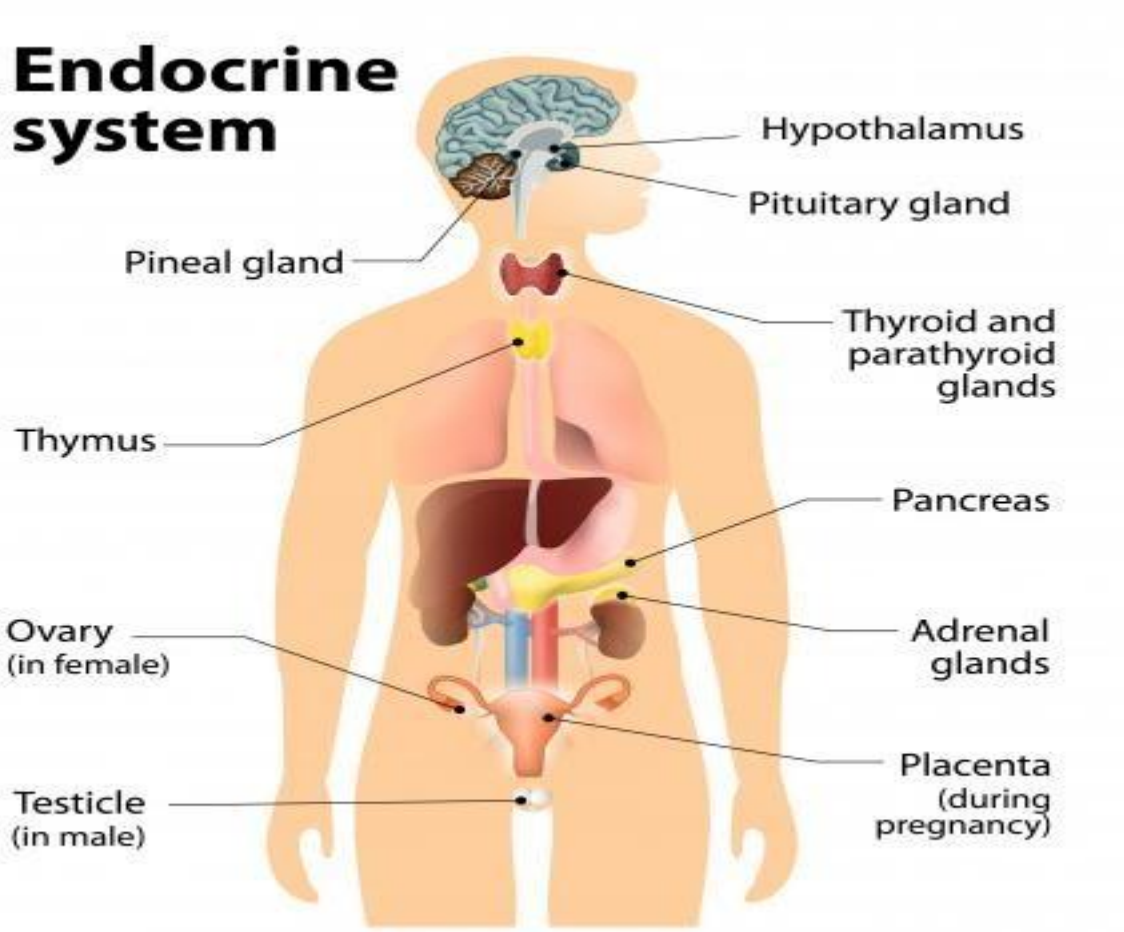
Function:

Control & regulate growth & development.



Adrenal Axis:

- Axis is not common in mammals & non-mammals.
- In non-mammal adrenal cortex & medulla have different names
- Interregnal cells chromaffin cells respectively.
- In fishes they are embedded in kidneys.
- In amphibians they spread diffusely on the surface.



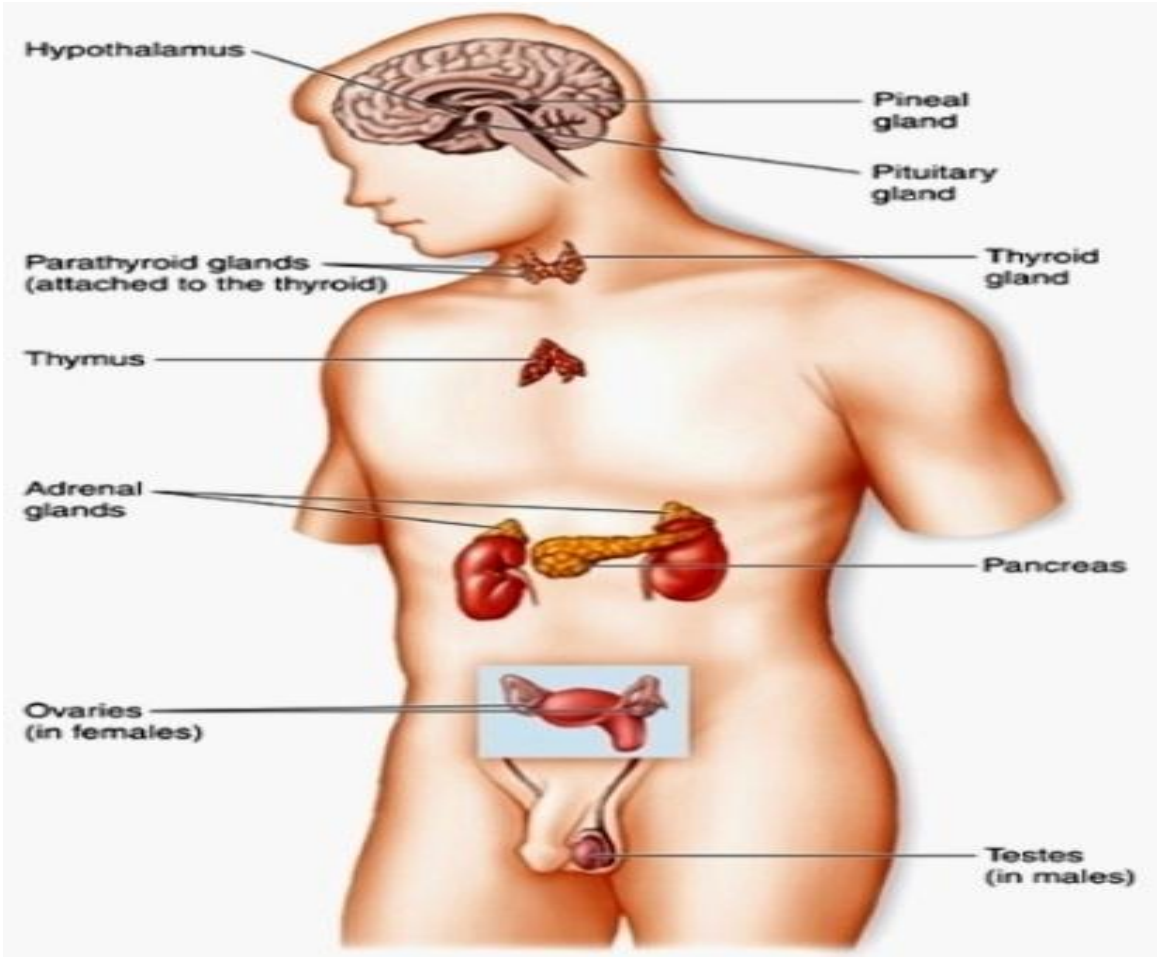
Gonadal Axis:

Gonads secrete steroid hormones

- Androgen.
- Estrogen.
- Progesterone.
- By gonadotropin secreted by pituitary.

Function:

- **Ovulation** & **sperm release**.



Other Vertebrate Glands:

Pancreas

Secretion

- Insulin
- Glucagon
- Somatostatin

Parathyroid glands:

Calcium regulating hormone

Secretion:

- Calcitonin hormone

Other hormones:

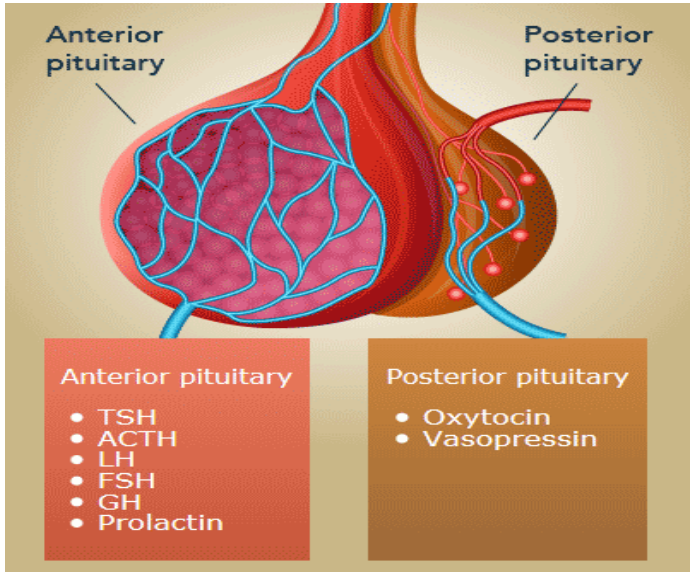
- Gastrointestinal hormone
- Cholecystokinin
- Pineal complex melatonin
- Prostaglandins & Liver

Endocrine system of birds

- Include ovary, testes, adrenal, pituitary, thyroid, pancreas, thymus, ultimobranchial and bursa of fabricuis
- Have same functions as in mammals
- Pituitary gland secrete prolactin that stimulates the production of pigeon’s milk in pigeons
- It develops brood patch

Pituitary gland in mammals (Hypophysis)

- Located below the hypothalamus
- Two lobes
- Anterior Lobe (adenohypophysis)
- Posterior Lobe(neurohypophysis)

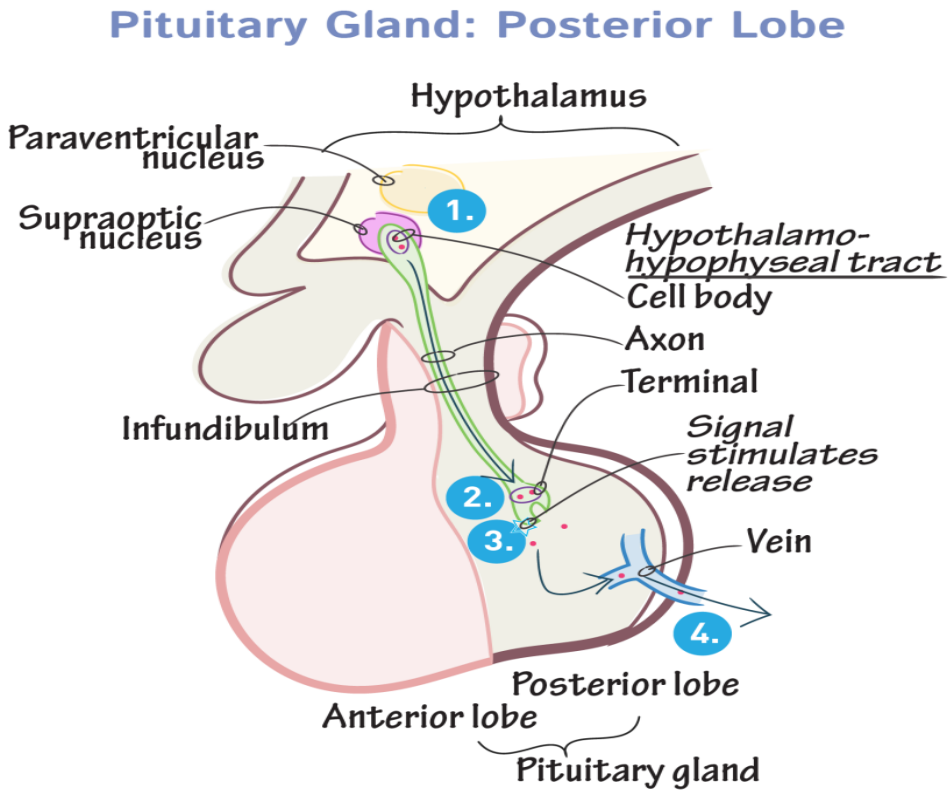


Oxytocin

- Role in mammalian reproduction
- Effect on smooth muscles
- Stimulates contraction of uterus
- Promote ejection of milk from mammary glands

Adenohypophysis

- Secrete two tropic hormones somatotropin and prolactin
- four other hormones ;
- Thyrotropin
- adrenocorticotropic
- luteinizing hormone
- follicle stimulating hormone



Functions

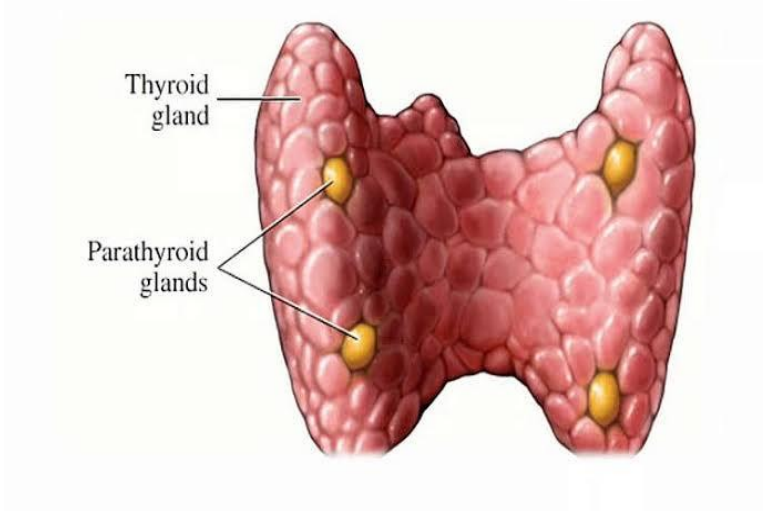
- **Somatotropin: induce cell division and causes growth of whole body**
- **Prolactin: enhance mammary gland development**
- **Thyrotropin: stimulate thyroid gland synthesis**
- **Adrenocorticotropic :controls stress and insulin production**
- **Leutinizing hormone : secrete estrogen and progrsteron**
- **Follicle stimulating hormone: cause maturation of eggs**

Thyroid hormones

- Two types of thyroid hormones:
  1. Thyroxine
  2. Triiodothyronine
- Both of them influence overall growth, development and metabolic rates.
- Calcitonin
- Helps control extracellular levels of calcium ions.

Parathyroid Gland

- Secrets parathyroid hormone (Parathormone), which elevates levels of blood calcium
- Raises blood levels of calcium by promoting kidney retention of calcium, encouraging its absorption across the walls of the digestive tract, and affecting bone deposition.

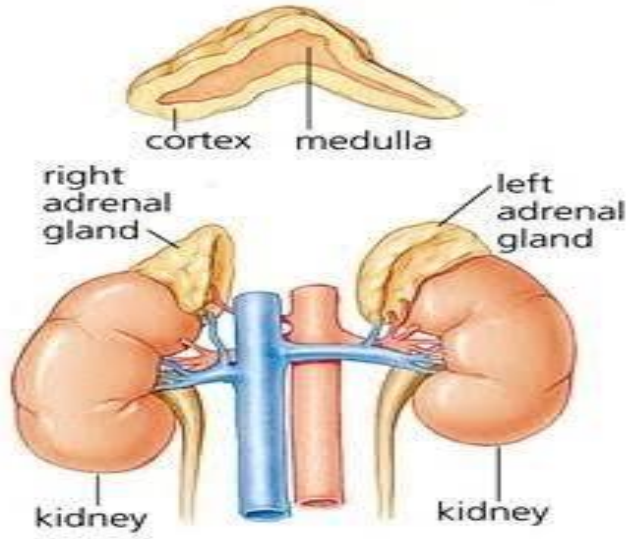


Parathyroid gland

Adrenal Gland

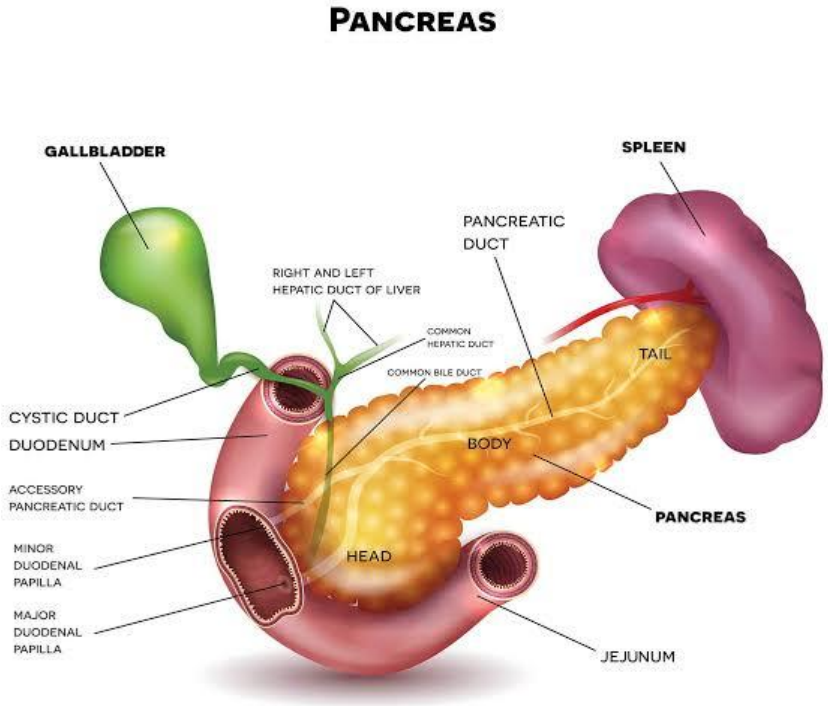
- In mammals, two adrenal glands rest on top of the kidneys. Each gland consists of two separate glandular tissue. Inner portion is medulla and outer is cortex.
- Function:

• One of the important functions of the adrenal gland is coordinating the whole organism's response to stress.



The Pancreas

A composite gland consisting of exocrine which consists of **Acini** That secrete digestive enzymes into ducts and endocrine portions known as the
Islets of Langerhans consists of masses of endocrine cells embedded within the exocrine pancreas.



Islets of Langerhans

- Secretes insulin and glucagon.
- Insulin removes glucose from the blood.
- Glucagon returns glucose to the blood.
- Alpha cells produces glucagon.
- Beta cells insulin.

Gonads

The Gonad is the organ that makes gametes.
In males, gonad is known as **testes**
which secrete androgen and testosterone.
In female, gonad is known as **ovaries**
which secrete estrogen and progesterone.
The product gametes are haploid germ
cells.
For example, spermatozoan and egg
cells are
gametes.

Male Gonadal Function

Testosterone

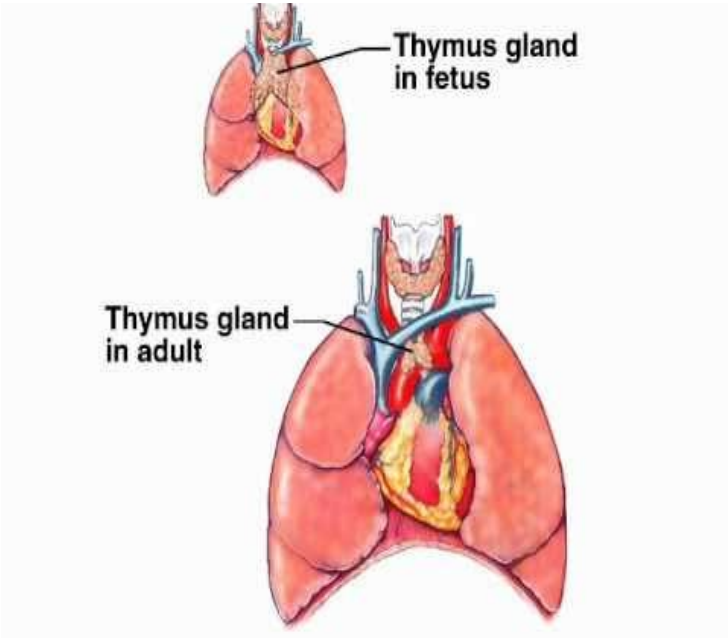
Acts with LH and FSH to stimulate spermatogenesis	Necessary for growth and maintenance of the male sex organs And sexual behavior	In humans, stimulates the growth of facial and pubic hair and enlargement of larynx which deepens voice

Female Gonadal Function

Estrogen:	Progesterone
• Helps to regulate the menstrual cycle and estrus cycles. • Development of the mammary glands and other female sexual characteristics.	• Regulate the menstrual cycle and estrous cycle • Development of the mammary glands • Aid in placenta formation during pregnancy.

Thymus Gland

- Anatomy
  - Upper mediastinum
    - Large in infants (70g)
    - Atrophied in adults (3g)
    - 2 lobed organ
- Hormones – Thymosin
- Target – T lymphocytes
- Hormone Functions
  - Promote production and maturation of T lymphocytes



Thymus Gland