

Overview of the Neuroendocrine system

Lecture notes for students

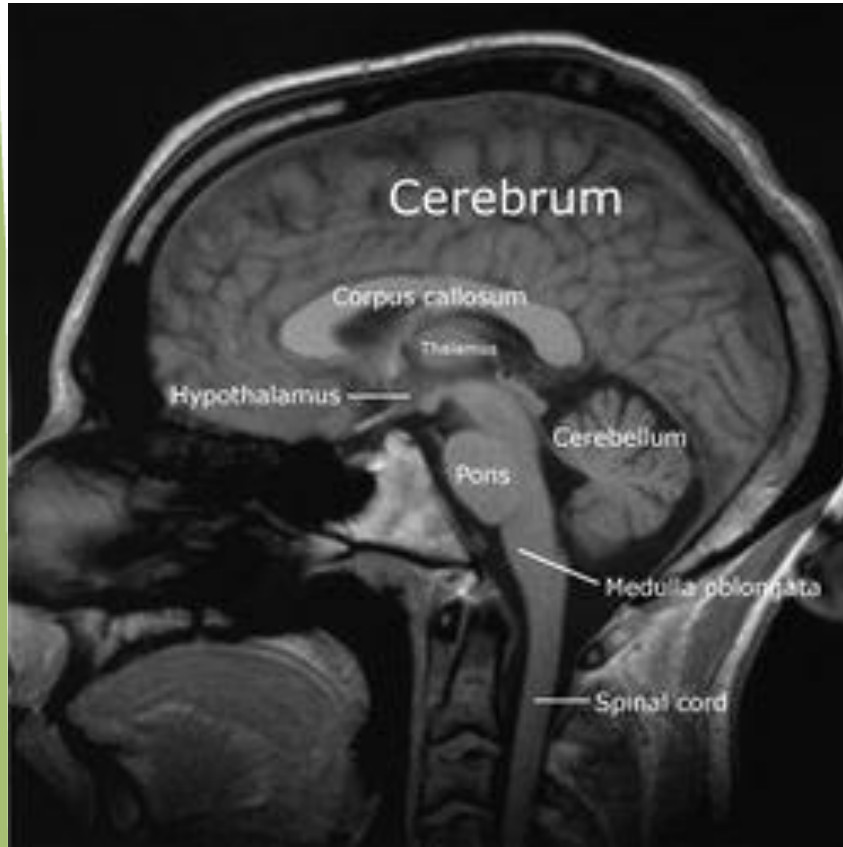
By

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Phd.



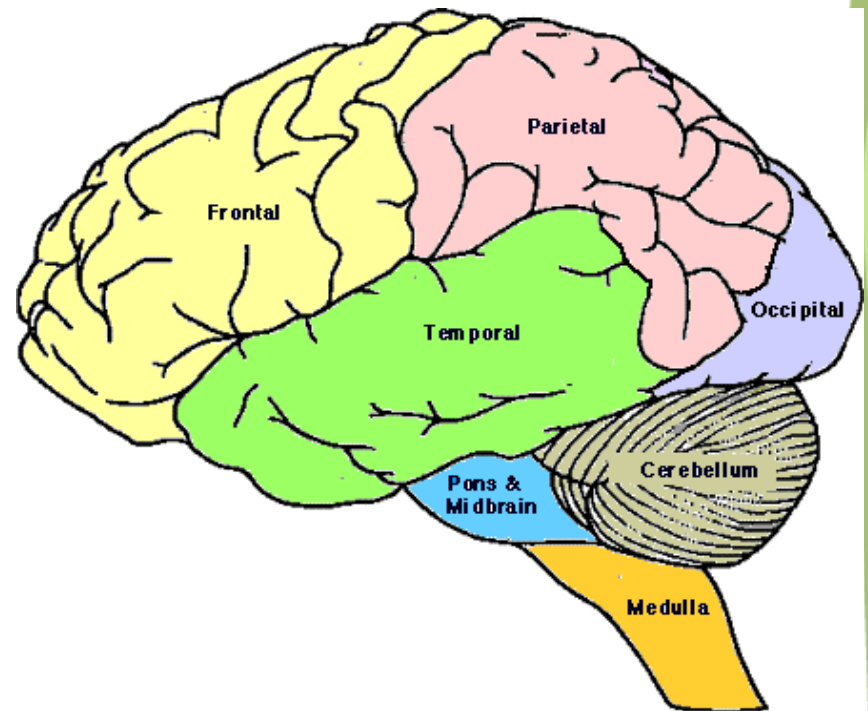
The Nervous System



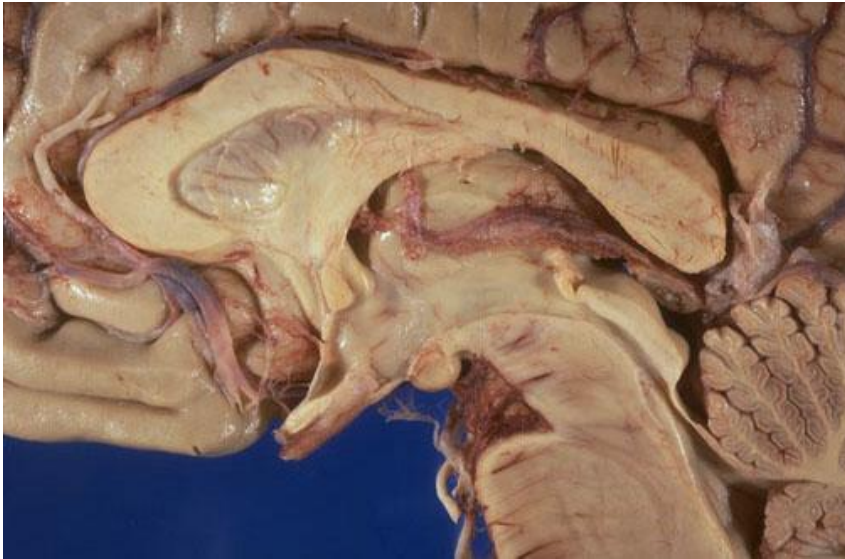
- **Central and peripheral units**
- brain and spinal cord
- nerves outside of the CNS

The Brain

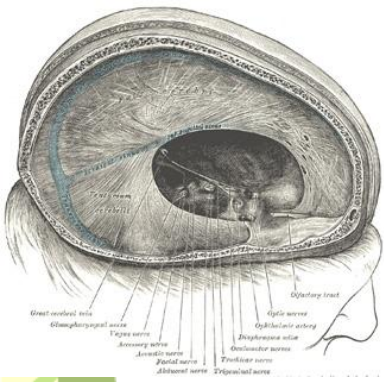
- **3 Pound Universe**
- about 3 lbs (~1400 gm)
- All sensation and consciousness originates



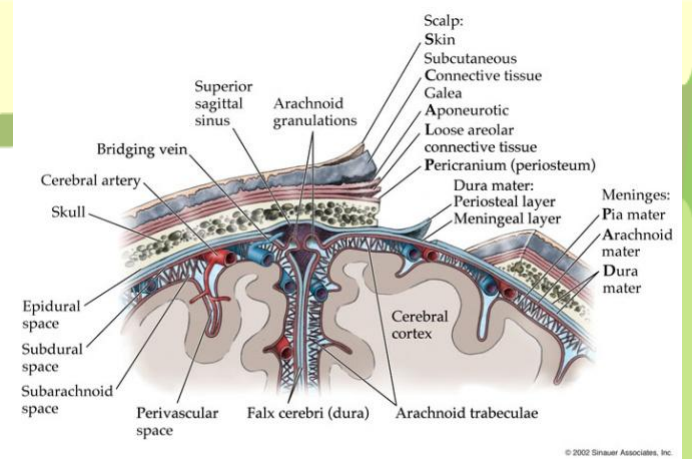
Cerebrospinal Fluid



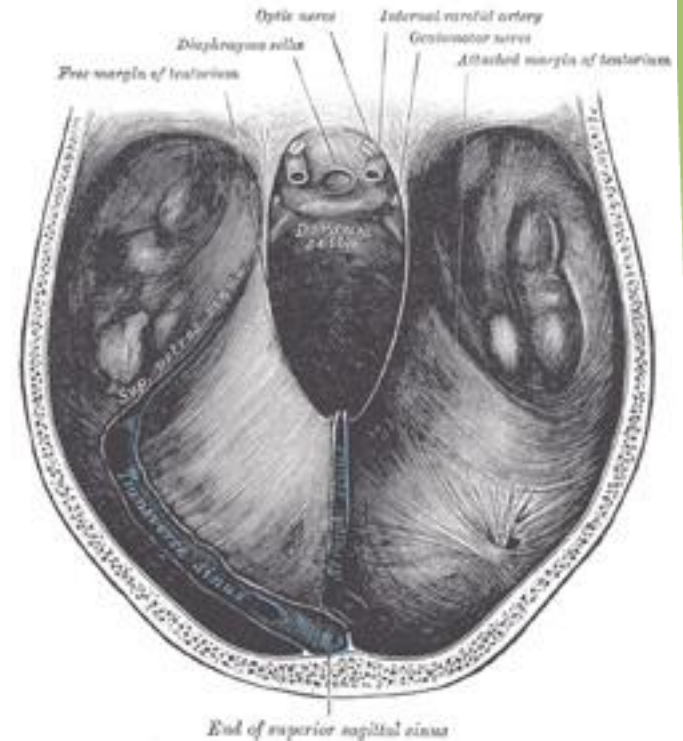
- Immersed in CSF
- Total volume is 150mls
- A hollow tube with bulges:
- 4 interconnected fluid-filled reservoirs (ventricles)



Coverings



- Covered by Tough Meninges and Protected by Bone
 - Dura : outermost- firmly attached to skull
 - arachnoid: middle
 - pia mater: bottom, firmly attached to brain, contains many BVs
- Inflammation of brain meninges = meningitis



Organization

- The Brain Has a Hierarchical Organization
- Upper centers control lower centers
- Cortex tends to dominate the spinal cord
- But many basic life support functions (i.e., respiration, blood pressure) are under control of "lower" centers

Organization

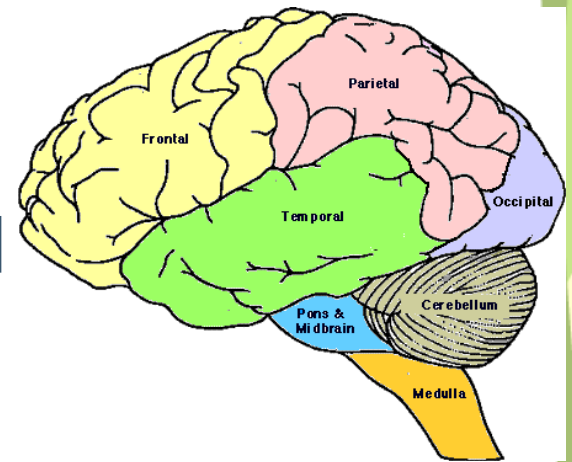
- **The Central Nervous System also has other patterns of organization**
 - Sensory/motor:
 - White matter/gray matter:

White matter/gray matter

- White matter consists of the myelinated axons of nerves, usually going up and down
- Gray matter contains the cell bodies (containing the nucleus) , dendrites with synapses and blood vessels
- In both the spinal cord and brain cell bodies are clustered into ganglia and nuclei

Central Nervous System- Brain

- Forebrain- Cerebral hemispheres and thalami
- Midbrain
- Hindbrain- Pons, Cerebellum and Medulla
- Lobes named as for the skull bones which cover them: frontal, parietal, occipital, temporal

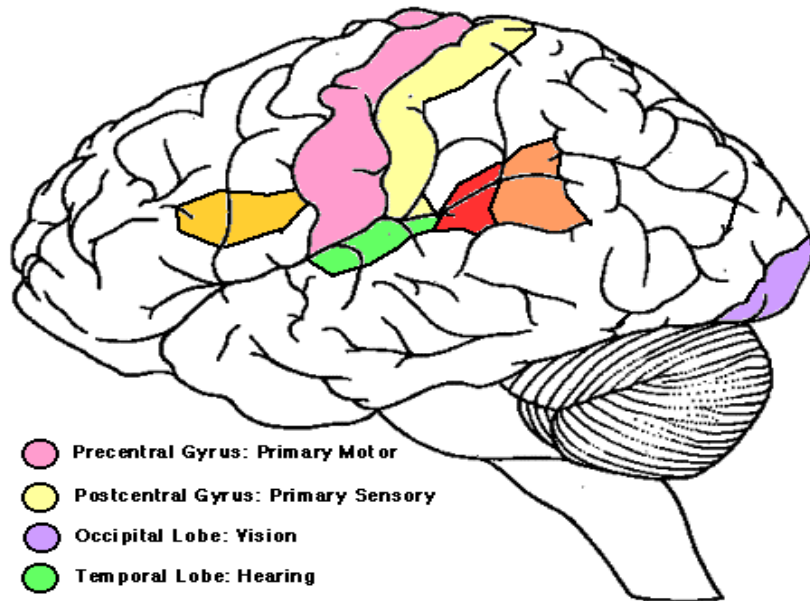


The Cerebrum



- **Serves Higher Mental Functions**
- largest and most complex part of the brain
 - Controls most of the lower centers
 - Many folds increase surface area
- involved in consciousness, thinking, learning, emotions

The Cerebrum - Functional localization



● Precentral Gyrus: Primary Motor

● Postcentral Gyrus: Primary Sensory

● Occipital Lobe: Vision

● Temporal Lobe: Hearing

Speech Areas:

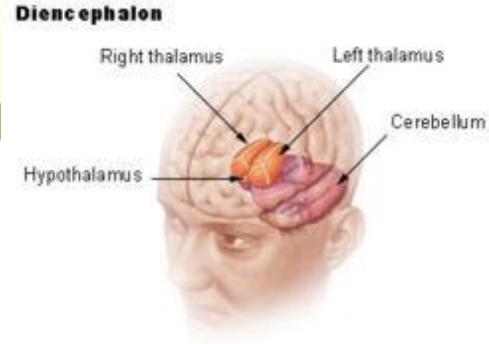
● Broca's

● Wernicke's

● Angular Gyrus

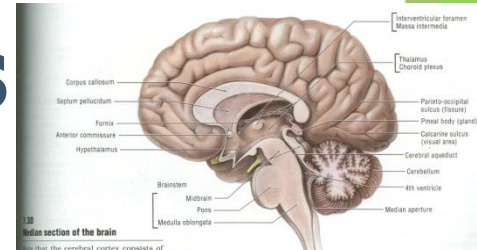
- Primary Sensory Areas
 - Postcentral gyrus: skin sensations, taste
 - Occipital lobe: vision II
 - Temporal lobe: hearing VIII auditory
 - Frontal lobe: smell I: olfactory
- Motor Areas
 - Precentral gyrus: primary motor area
 - Frontal lobe: premotor area
 - Broca's area: frontal lobe, speech motor

The Diencephalon



- **Made up of the Thalamus, Hypothalamus & Pineal**
- Region just below the cortex is the diencephalon = thalamus + hypothalamus + epithalamus
 - Thalamus is a sensory relay center ("bedroom")
 - Hypothalamus (under the thalamus)-is the Major Center for Control of the Internal Environment
 - Epithalamus/ Pineal (above the thalamus) : secretes hormone melatonin- involved in sleep and attention

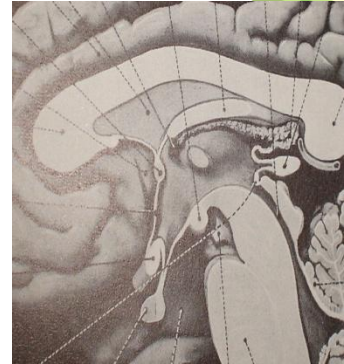
The Hypothalamus

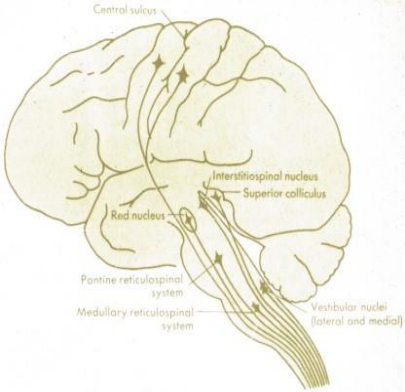


- Some of the homeostatic functions controlled by the hypothalamus
 - Body temperature: controls blood supply to skin, sweating, shivering
 - Blood pressure: controls heart rate & stroke volume, dilation of arterioles- connections to medulla
 - Blood glucose: mostly hormonal control
 - Blood pH: controls respiratory rate, kidney functions
 - Blood osmotic pressure: controls secretion of ADH, thirst mechanisms

The Hypothalamus-Other functions:

- Sleep cycle: suprachiasmatic and preoptic nuclei
- Control of reproductive functions
 - Sex drive
 - Menstrual cycle: involves anterior pituitary
 - Uterine contraction at parturition: involves posterior pituitary
 - Milk release: involves posterior pituitary
- Light reflex: constriction of pupil by bright light
- Food drive: controls hunger- affects supply of nutrients
- Controls pituitary gland: hormonal control of many body fns





Midbrain

- Most of the midbrain is covered by the other lobes and cannot be seen
- Medulla, pons, midbrain = brain stem
- **Has Centers for Optic and Auditory Reflexes**
 - Dorsal side is the tectum (roof)
 - Middle- tegmentum
 - Ventral- crus cerebri
 - Cerebral aqueduct, connecting 3rd and 4th ventricles

The Pons

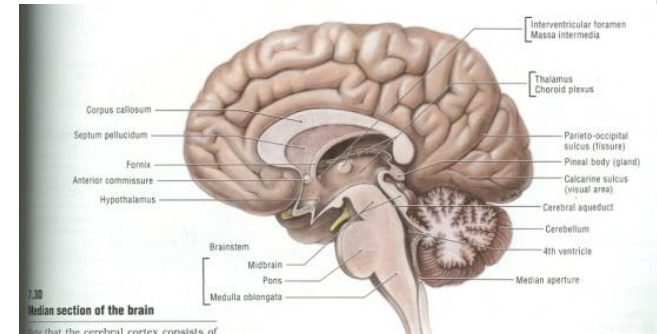


- **Connects the Cerebellum to the Brain Stem**
- prominent ventral bulge, just above the medulla
- Pons means bridge- connected to R and L cerebellum by fiber tracts in peduncles
 - Involved in control of breathing and in control of pain sensation
 - Reticular formation of pons is involved in sleep (both rapid-eye-movement and slow wave types)
 - Most of the 4th ventricle is between the pons and cerebellum

The Cerebellum



- **Coordinates Body Movements**
- The cerebellum is a large bulge on posterior side of brain- name means "little brain"
 - Required for:
 - posture
 - balance
 - smooth, coordinated movements (especially simultaneous movements of different body parts)
 - lesions cause clumsy movement, ataxia (unsteady gait), overshooting of movements, poor balance



The Medulla Oblongata



- **Has Centers for Basic Life Support**
- The medulla oblongata is the section of brain stem just above the spinal cord (sometimes called the myelencephalon)



The Medulla Oblongata



- Pyramids: bulges of ventral surface- major site for crossing of both sensory and motor nerves
 - Centers for regulation of blood pressure and breathing are found here
 - Swallowing and vomiting centers
- Olives: nuclei which send sensory information to the cerebellum
- Reticular formation (continues to midbrain)- involved in consciousness, attention, sleep

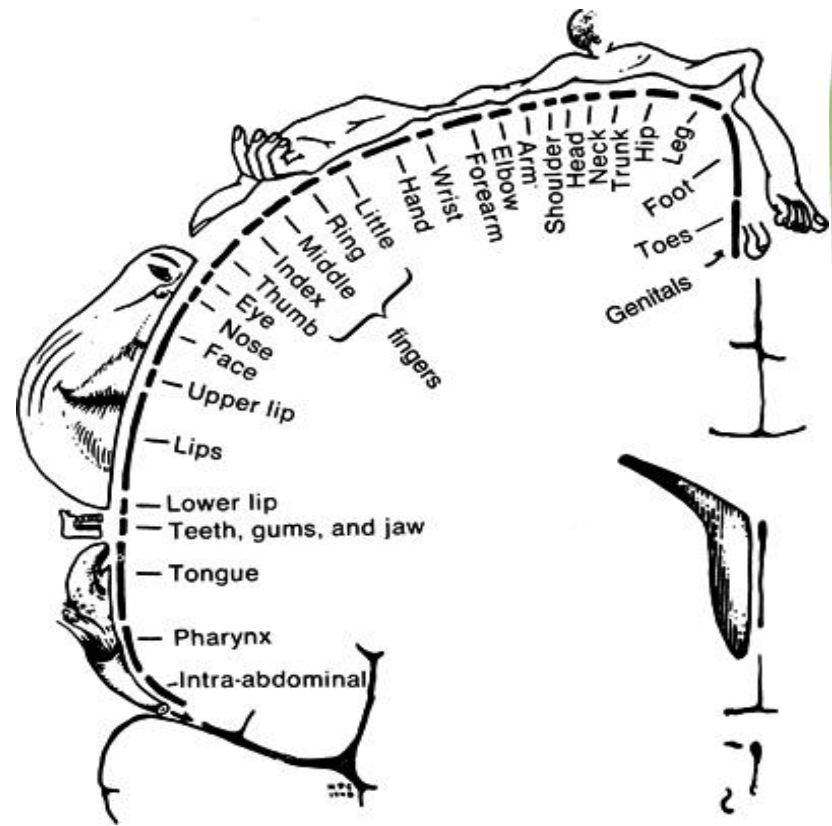
Sensory: Somatic (skin & muscle)

Senses:

- Site-Postcentral gyrus (parietal lobe).
- This area senses touch, pressure, pain, hot, cold, & muscle position.
- The arrangement is upside-down (head below, feet above) and is switched from left to right (sensations from the right side of the body are received on the left side of the cortex).

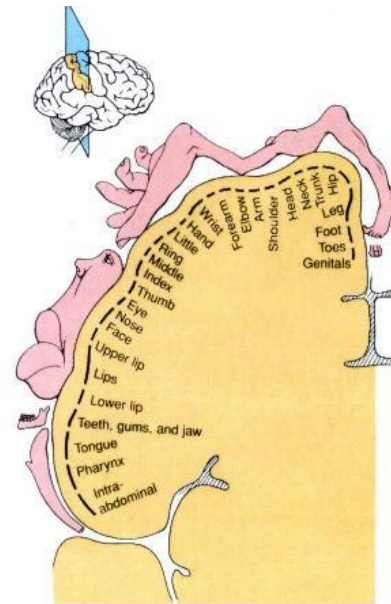
Sensory homunculus

- Some areas (face, hands) have many more sensory and motor nerves than others.
- A drawing of the body parts represented in the postcentral gyrus, scaled to show area, is called a homunculus .

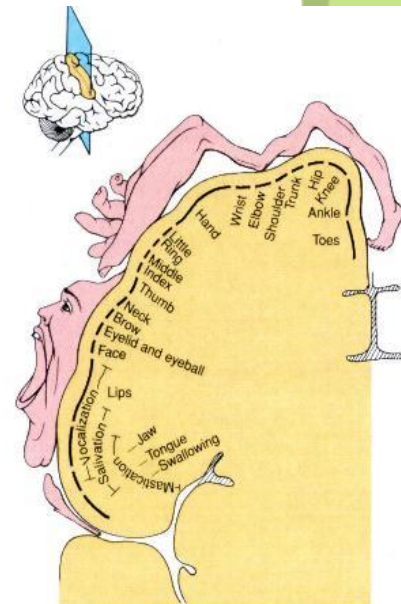


Motor homunculus

- Like the sensory cortex, the arrangement is in the form of an upside-down homunculus.
- The fibers are crossed-stimulation of the right cortex will cause contraction of a muscle on the left side of the body.

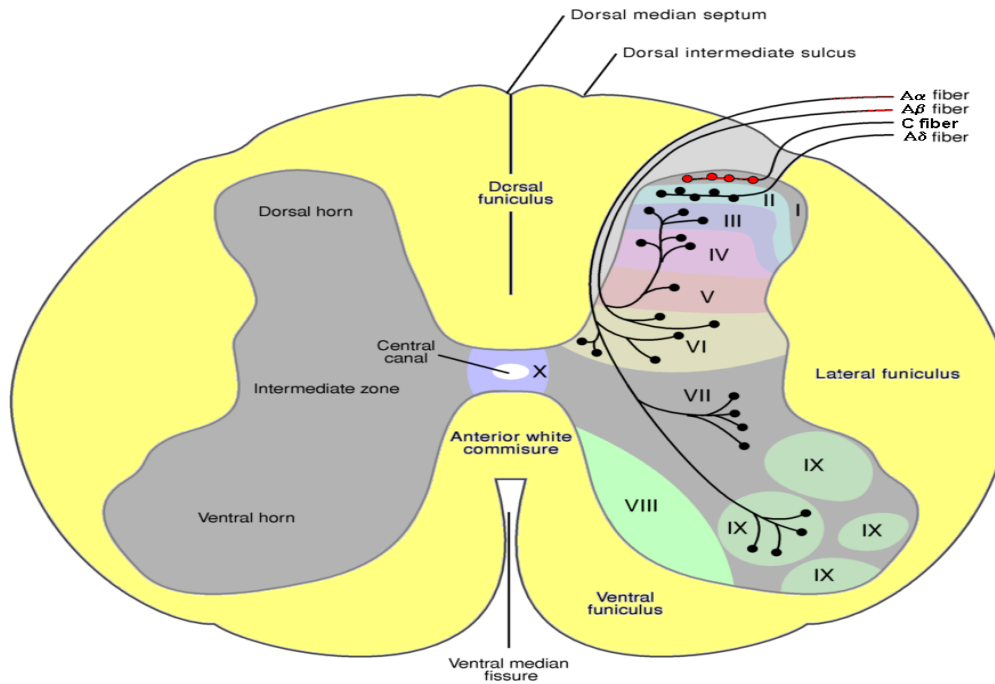


(a) Somatosensory cortex in right cerebral hemisphere



(b) Motor cortex in right cerebral hemisphere

Spinal cord



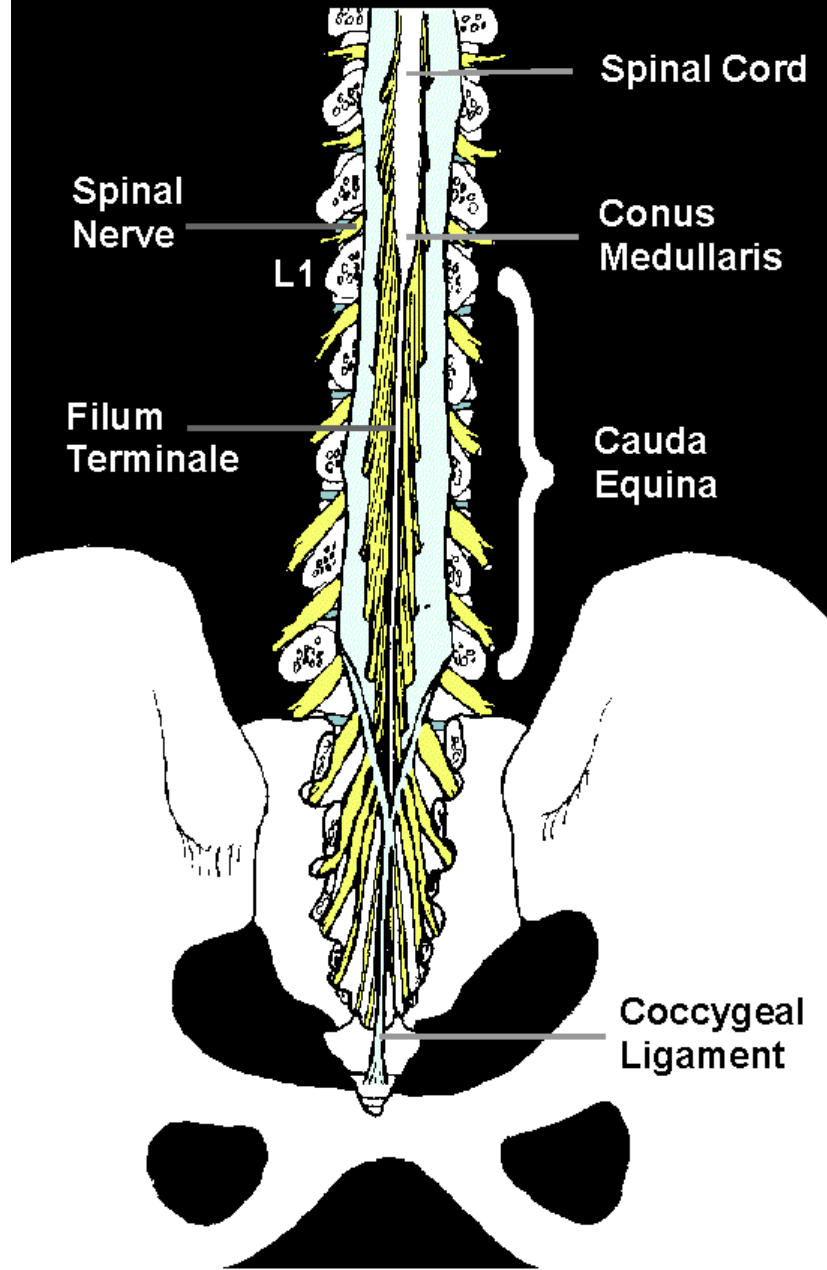
- Unlike the brain, the grey is inside.

Spinal Cord Anterior View

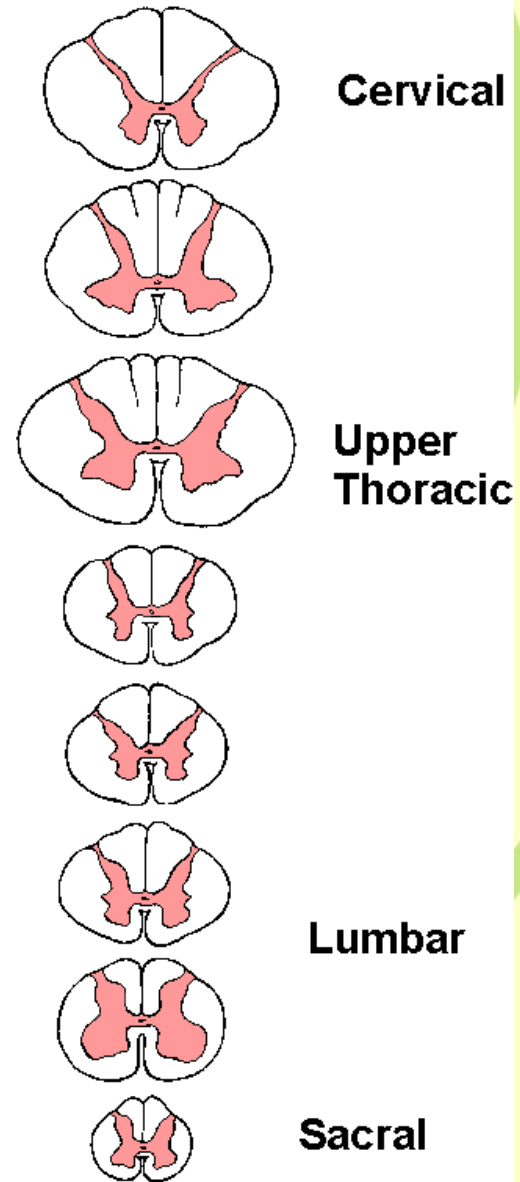


Sobotta

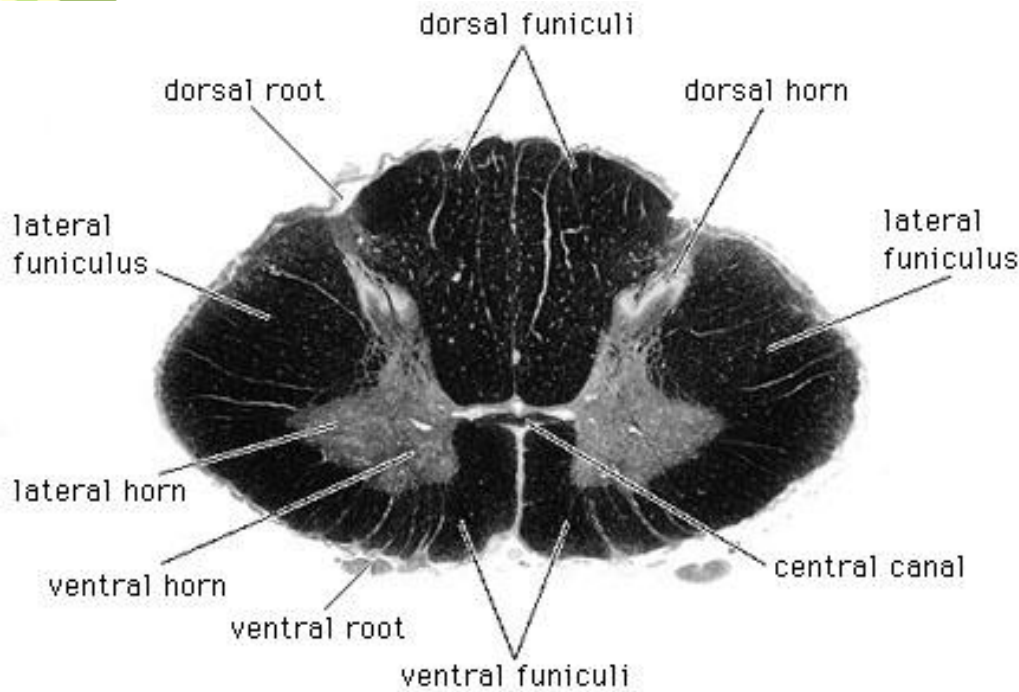
Termination of Spinal Cord Posterior View



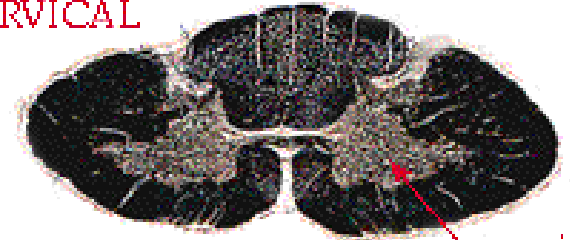
Segmental Cross Section of Spinal Cord



Lower Cervical section

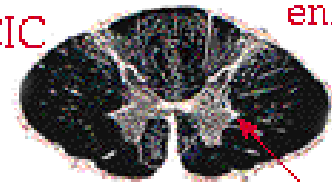


CERVICAL



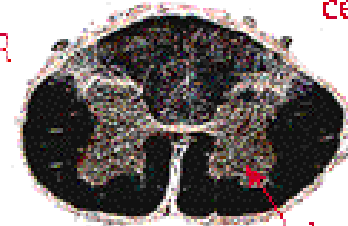
cervical enlargement

THORACIC



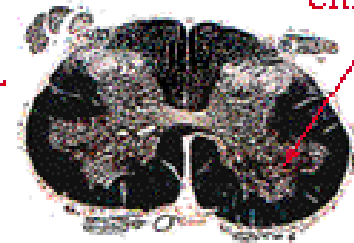
intermed. cell column

LUMBAR

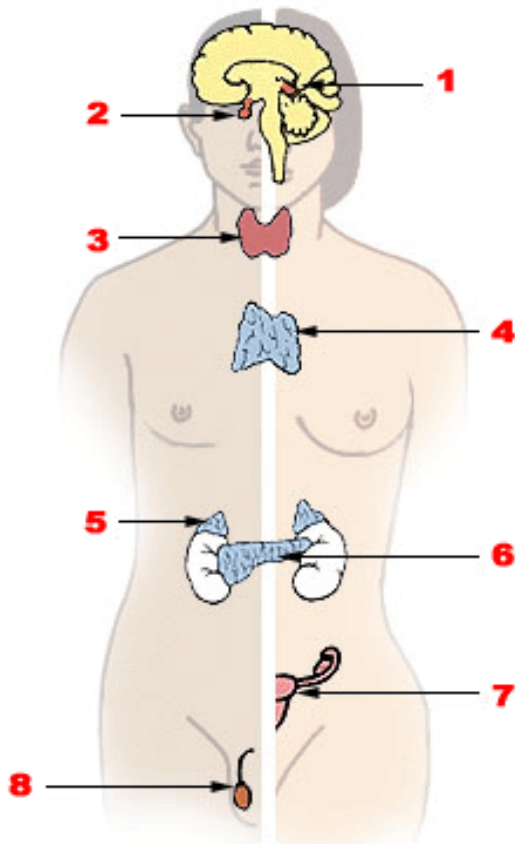


lumbosacral enlargement

SACRAL



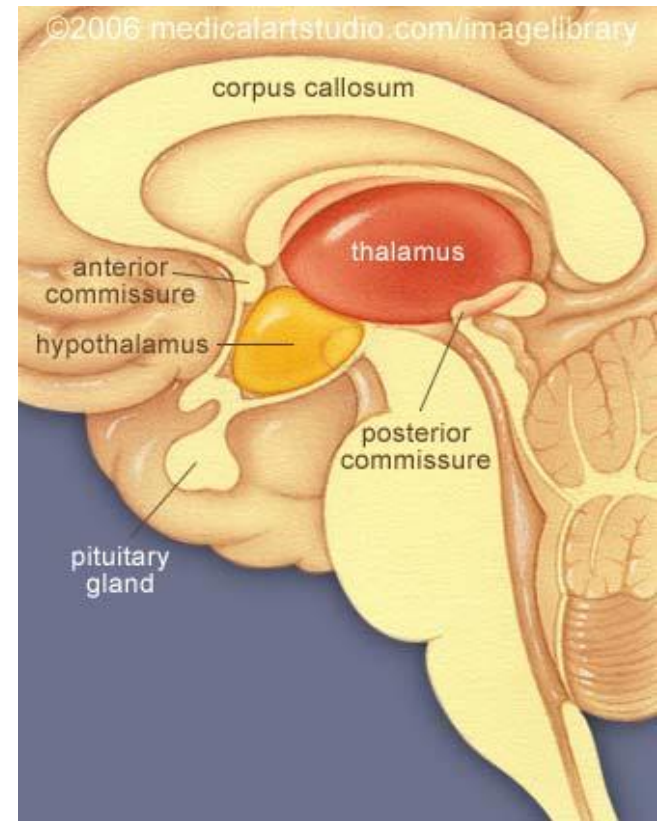
Endocrine System



- Pineal gland & Hypothalamus
- Pituitary gland
- Thyroid & Parathyroids
- Thymus
- Suprarenal
- Pancreas & Enteroendocrine
- Ovary
- Testis

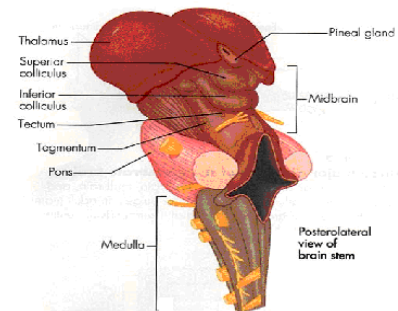
PINEAL GLAND/BODY/ epiphysis cerebri

- Is a neuroendocrine structure.
- About 5-8mm in length and 3-5mm in diameter about 120mg.
- Found in posterior extremity of 3rd ventricle.

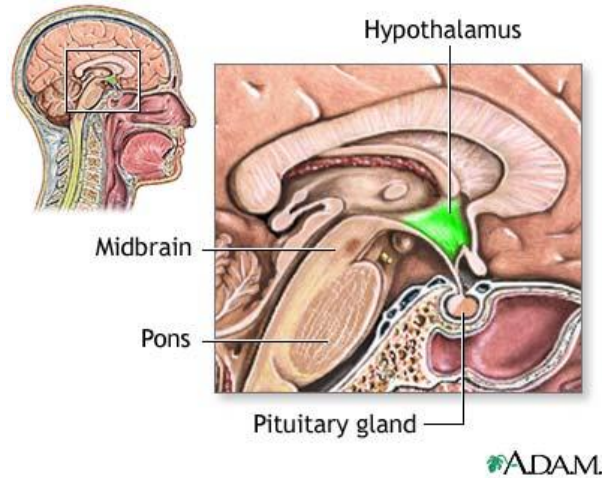


PINEAL GLAND/BODY-Function

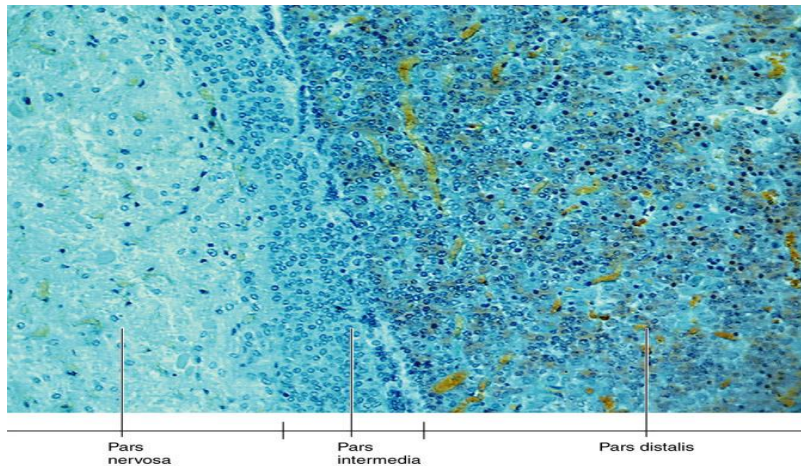
- Regulation of the circadian (24 hour rhythm) and seasonal biorhythms.
- Responds to light transmitted to cerebral cortex and relayed...
- Produces melatonin and other peptides.
- More produced during dark hours.
- The molecules influence rhythmic secretion of gonads and other organs



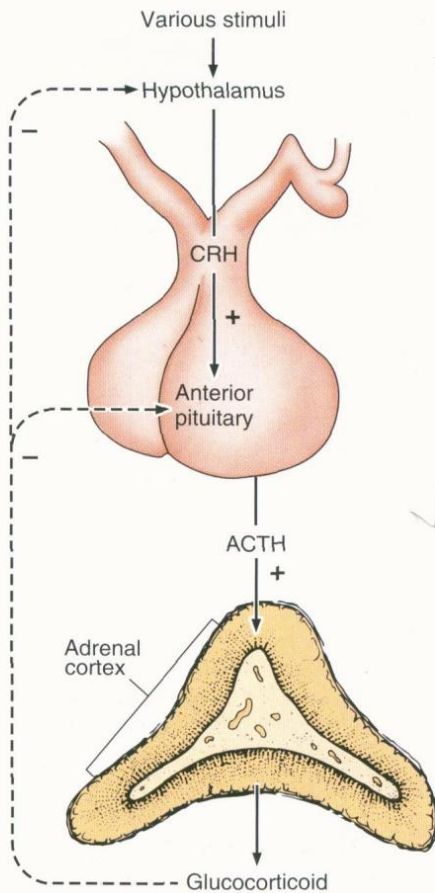
PITUITARY GLAND/ hypophysis cerebri



- 0.5g, 10*13*6 mm. Located in the cranium, attached to the hypothalamus.
- 2 parts: adenophypophysis, neurohypophysis.



PITUITARY GLAND/ hypophysis cerebri



- Neuro...pars nervosa & infundibulum (neural stalk).
- Adenohypophysis....pars distalis (anterior lobe), pars tuberalis(around neural stalk) and pars intermedia.

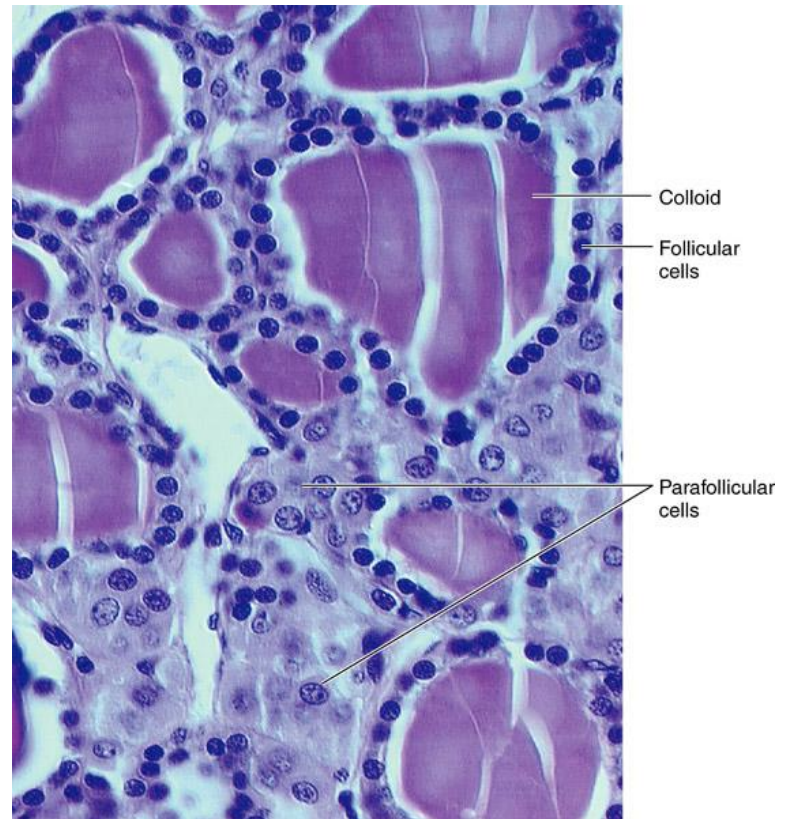
THYROID



- **Function**....synthesis of T4, T3 and Calcitonin.
- **Location**.....cervical region, anterior to larynx.
- 2 lobes united by the isthmus.
- loose connective tissue capsule which sends septa into parenchyma.
- Septi reach all parts of gland and thin out to form irregular tissue mainly reticular fibres.

Effects of T3 and T4

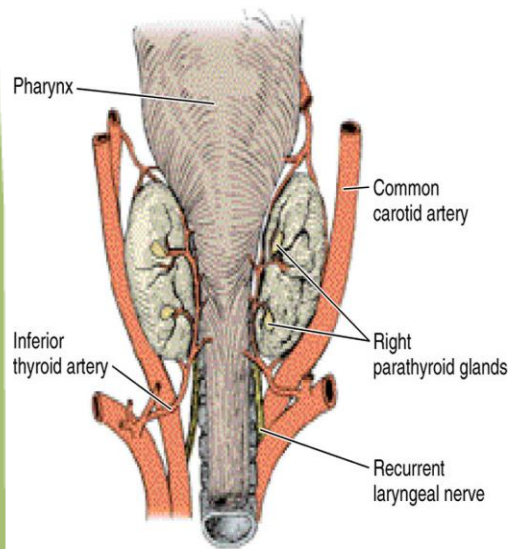
- Stimulate metabolism.
- **DISORDERS**
- Goiter
- Hypothyroidism
 - Iodine deficiency
 - Enzyme defects, gland absence or removal
 - Drugs blocking synthesis
- Hyperthyroidism



Parafollicular cell (C-cell)

- Part of follicular epithelium or in clusters between follicles.
- Larger than follicular cells, less stained.
- Little amount of rER, long mitochondria, and large golgi. Contain granules with hormone.
- Synthesize calcitonin....lowers blood calcium levels by inhibiting osteoclast activity.

Parathyroids

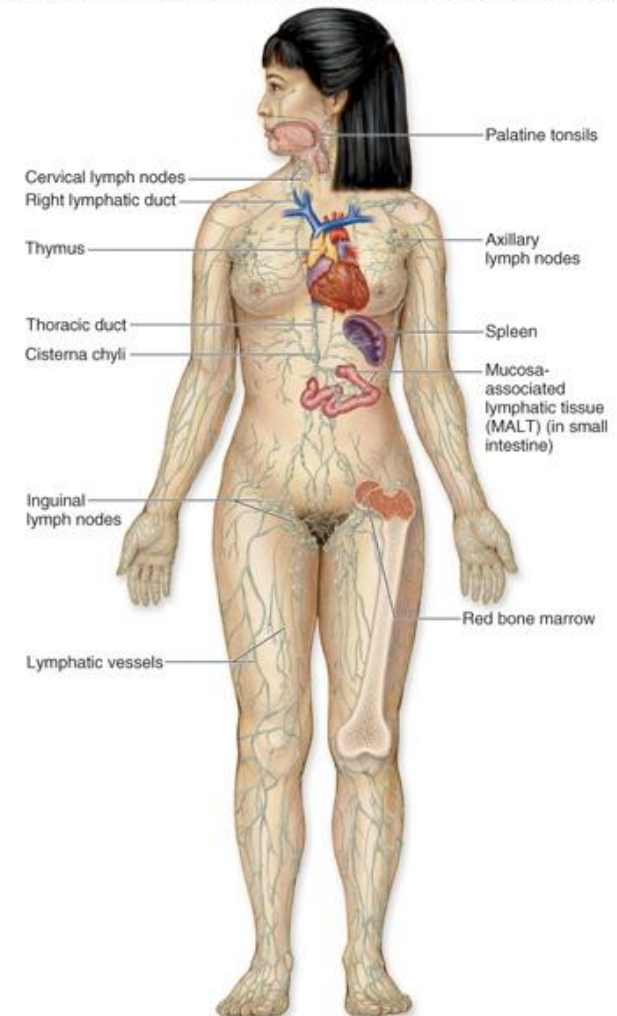


- 4 small glands.....3*6 mm.
- Location: behind each pole of thyroid gland.
- Each is within a capsule which sends septa into gland that merge with reticular fibres that support clusters of cells.

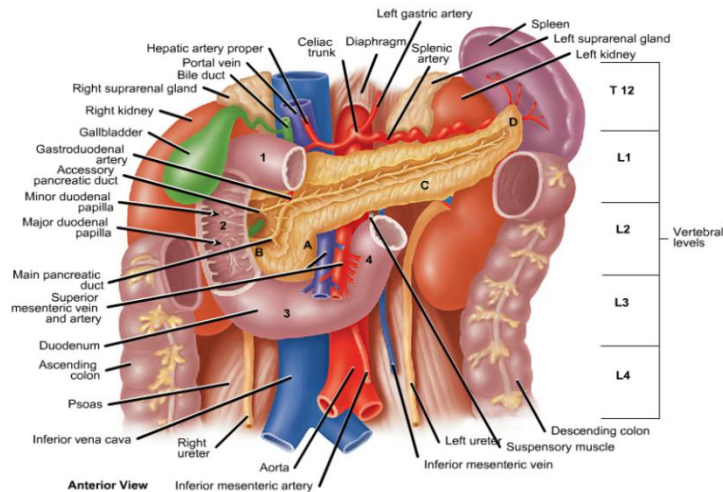
Thymus

- Lymphoid organ
- Development of immunocompetent T cells, development of immune self-tolerance
- **Thymulin, thymopoietin, thymosin** to regulate T cell maturation, proliferation and function

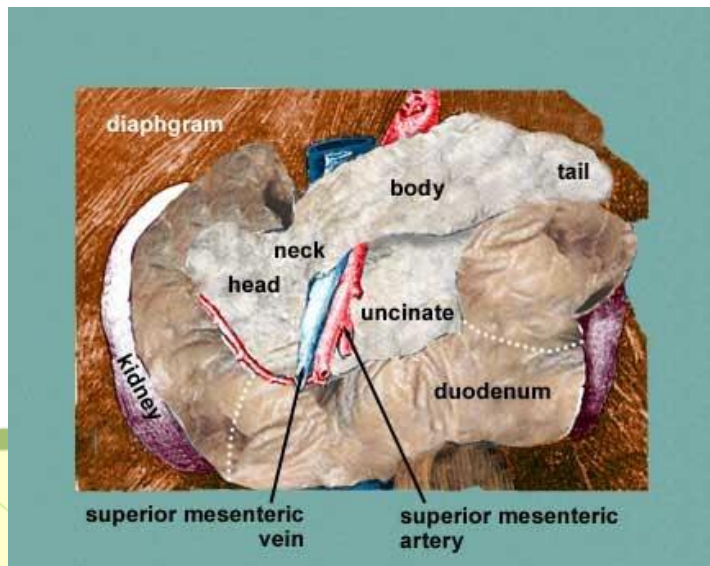
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PANCREAS

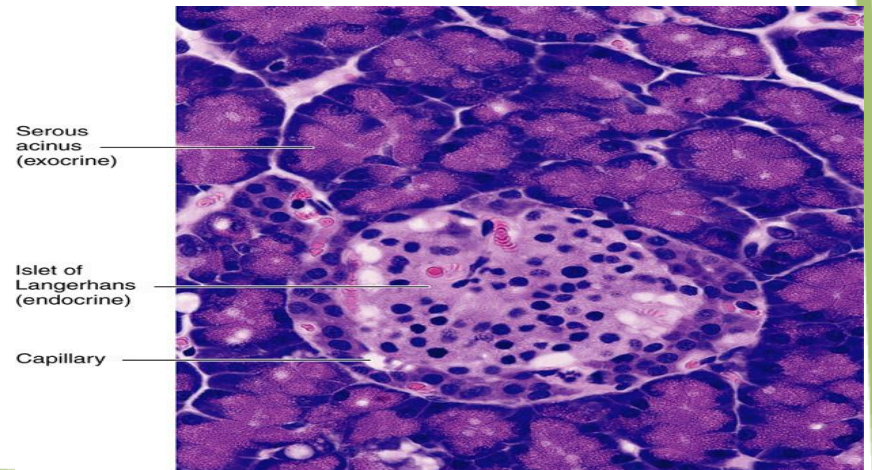
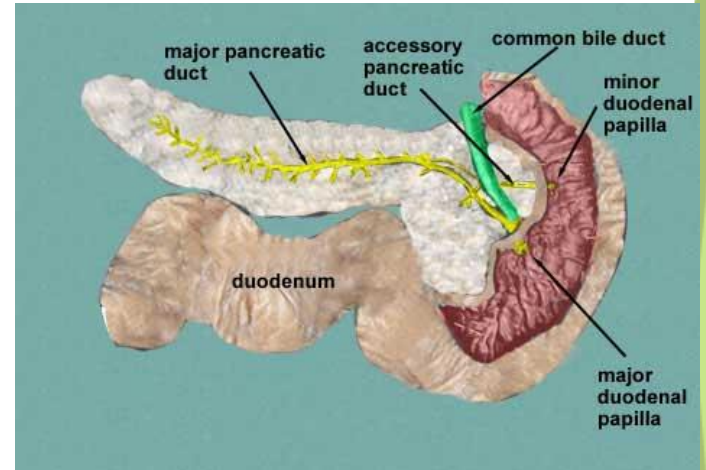


- looks like a fish. Has a head, neck, body and tail.
- Structure- soft grayish-pinkish organ which histologically looks like salivary gland except that it has islets of langerhans



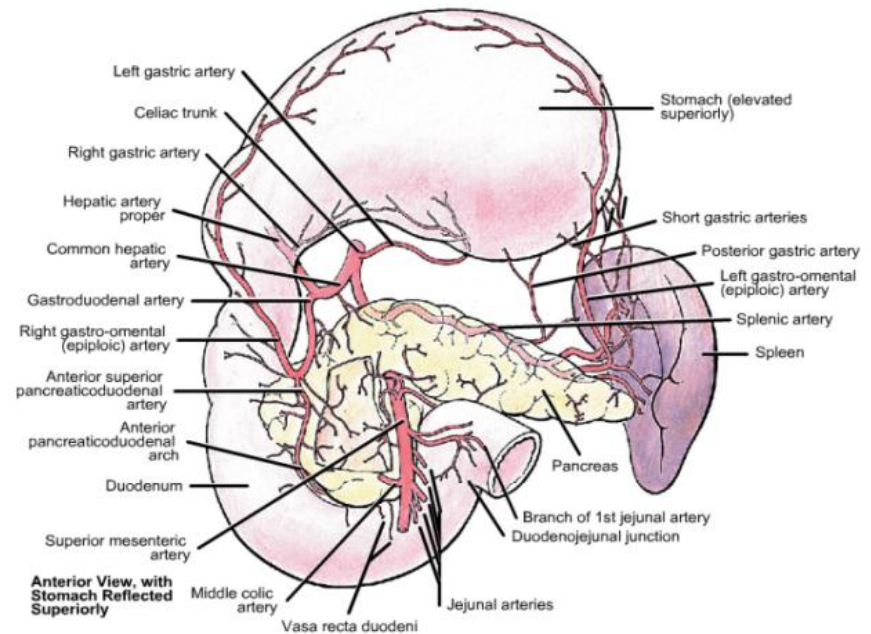
PANCREAS

- 20cm long, 80g
- Mixed endocrine and exocrine gland
- Lies across upper abdomen



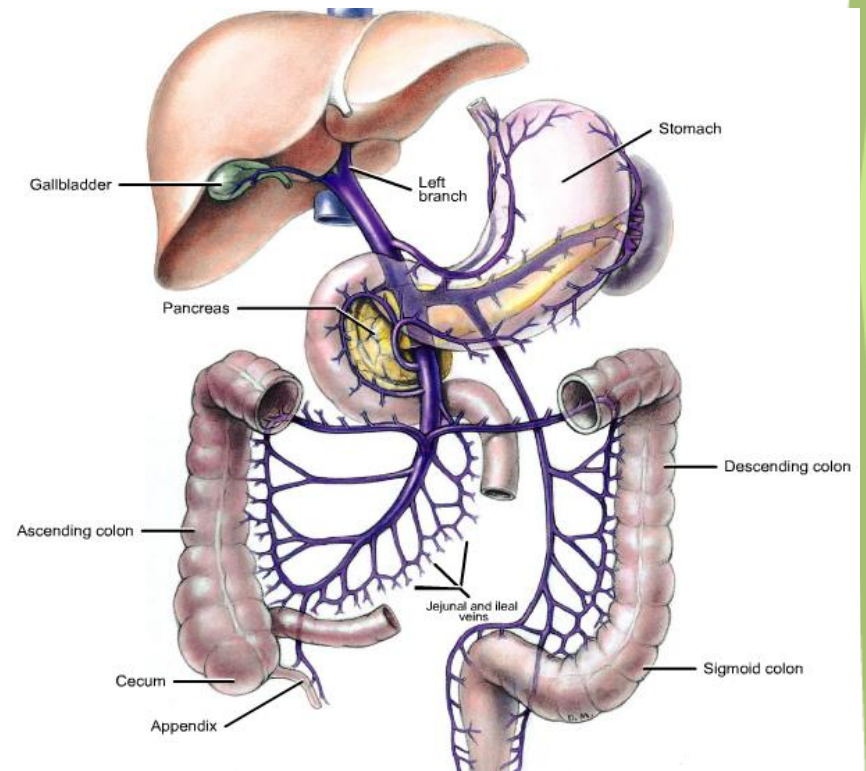
PANCREAS

- Functions
 - Endocrine...hormone production
 - Exocrine.... Enzyme production
- Exocrine pancreas 99% by volume
- Islets of Langerhans – 1% (2 million islets)

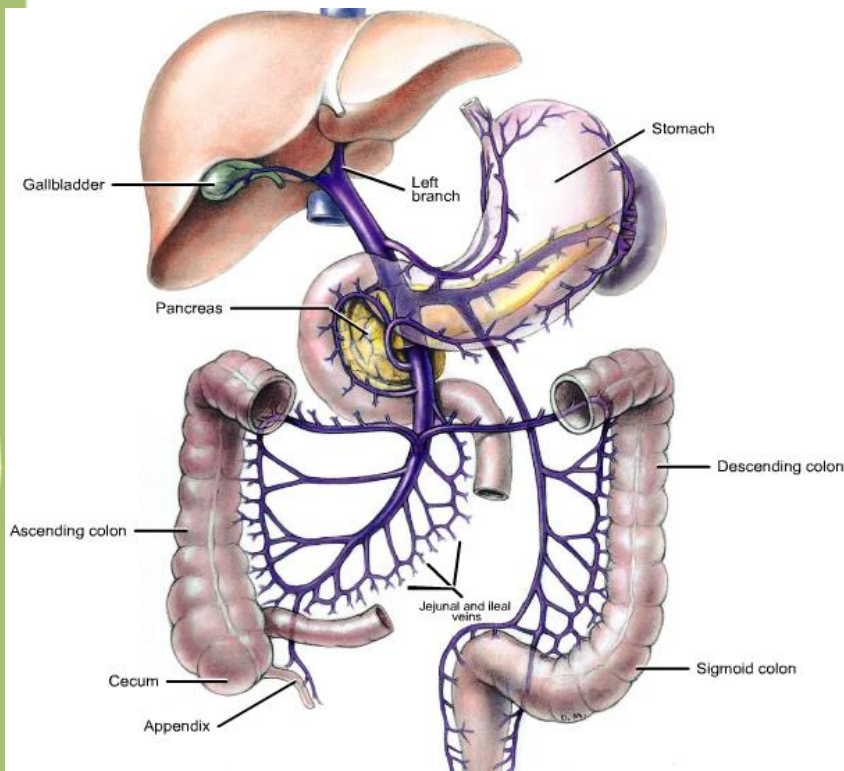


Entero-endocrine cells

- GI lining; cells with small membrane-bound secretory granules
- More than 17, classified according to site, shape, density of granules
- Gastrin, ghrelin, CCK, GIP, secretin, motilin, PP, somatostatin, histamine, bombesin, VIP etc.



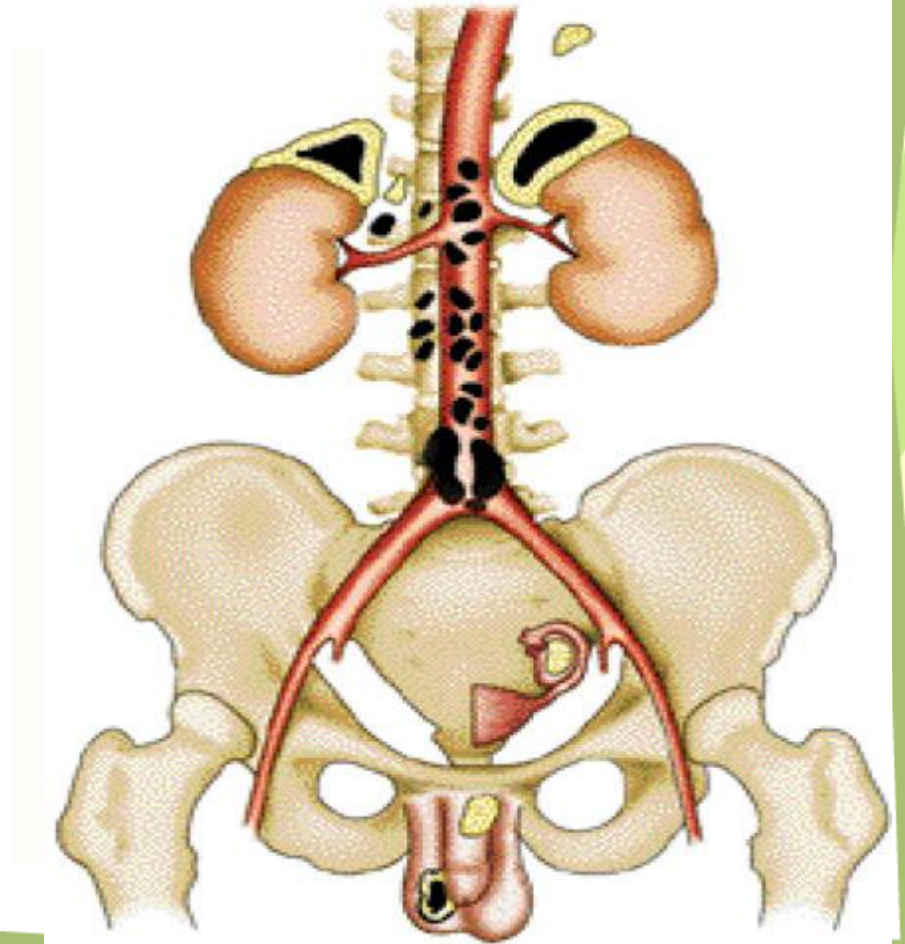
Entero-endocrine cells



- Actions range; gastric secretion, appetite/hunger regulation, pancreatic secretion, motility of GI, etc.
- Secretions: hormones, paracrine, neurotransmitters, putative hormones

Suprarenal gland

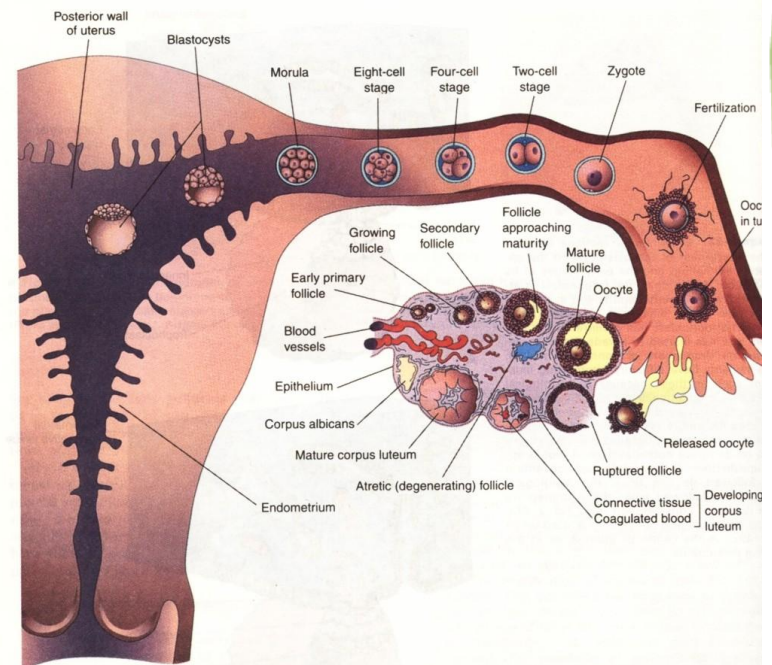
- 4-6cm long, 1-2cm side, 4-6mm thick; 8g
- Cut surface: capsule, cortex, medulla
- Distinct functions, origins, morphologies for zones



Endocrine ovary

- Theca interna cells surround the ovum, have LH receptors and hence synthesize androgens which serve as precursors for estrogens

44 ■ THE BEGINNING OF HUMAN DEVELOPMENT



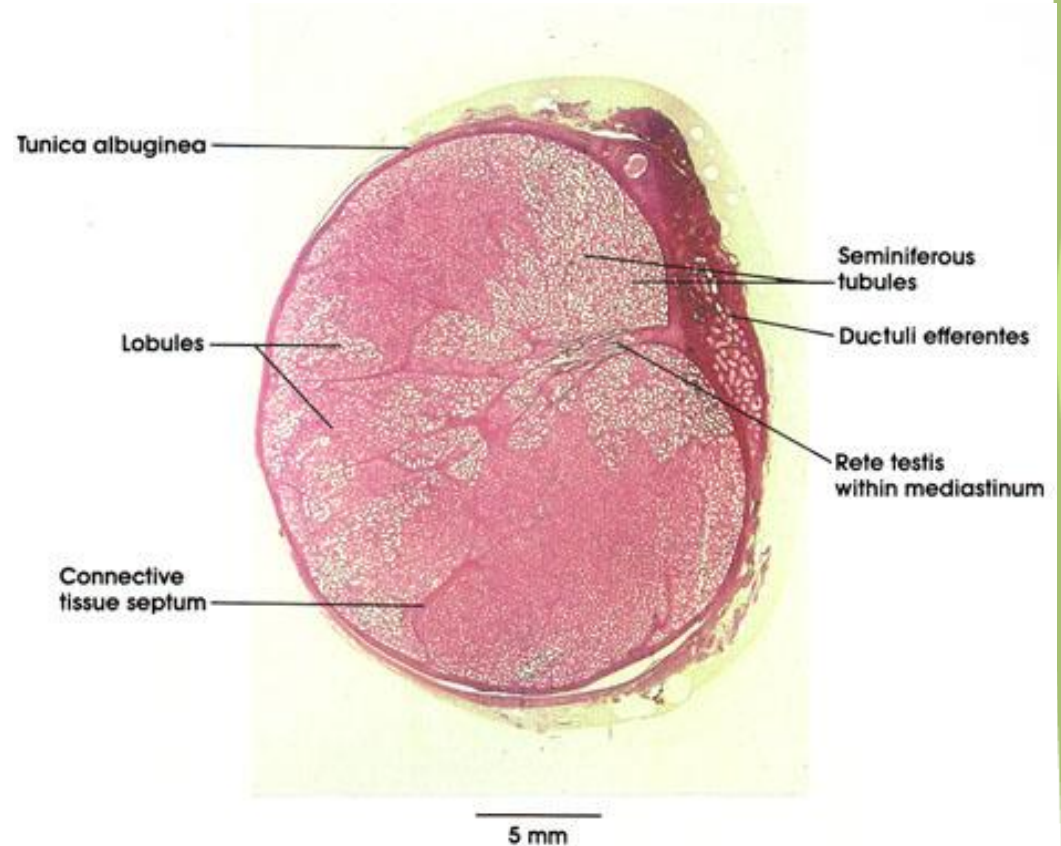
■ Figure 2-24. Diagrammatic summary of the ovarian cycle, fertilization, and human development during the first week. Stage 1 of development begins with fertilization in the uterine tube and ends when the zygote forms. Stage 2 (days 2 to 3) comprises early stages of cleavage (from 2 to about 16 cells, the morula). Stage 3 (days 4 to 5) consists of the free unattached blastocyst. Stage 4 (days 5 to 6) is represented by the blastocyst attaching to the posterior wall of the uterus, the usual site of implantation. The blastocysts have been sectioned to show their structure.

Endocrine kidney

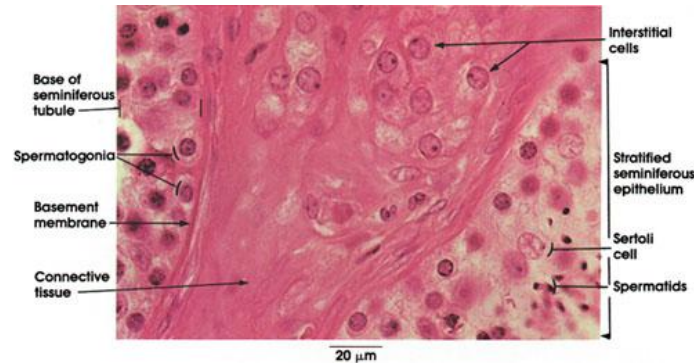
- Synthesis and secretion of erythropoetin for rbc formation in response to reduced oxygen concentration
- Synthesis and secretion of renin- controls blood volume and pressure/ changes angiotensinogen to angiotensin
- Hydroxylation of 25- OH vitamin D3 to active 1,25 OH_2 vit D3
- NB: JGA

Endocrine testis

- The testis is a mixed endocrine and compound, tubular, cytogenic exocrine gland.



Interstitial cells of Leydig



- eosinophilic, with much smooth ER, lipid droplets, and crystals of Reinke,
- lie outside the tubules' BLs, constituting a diffuse, steroid-secreting endocrine gland.
- Produce *testosterone*

Interstitial **cells of Leydig**

- secrete testosterone required for:
 - spermatogenesis;
 - development and maintenance of reproductive ducts and accessory glands;
 - secondary sexual characteristics;
 - male mating behaviour;
 - general anabolic effects on metabolism.