



University of Kragujevac
Faculty of Medical Sciences
Integrated Academic Studies of Medicine
Department of Histology and Embryology

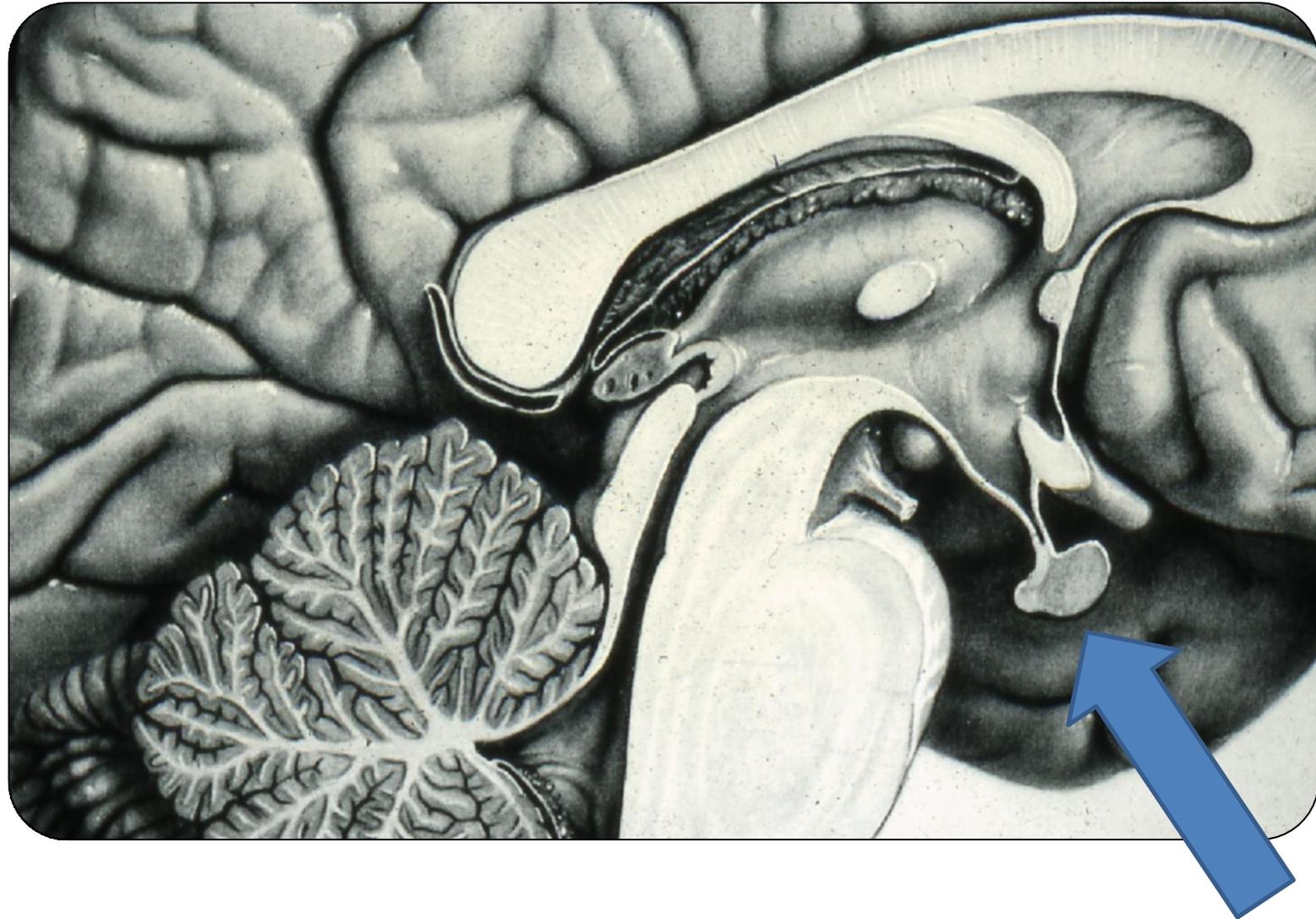
Endocrine system

Skin

ENDOCRINE SYSTEM

- ❖ The endocrine system produces various secretions called **hormones** that serve as effectors to **regulate the activities** of various cells, tissues, and organs in the body. Its functions are essential in maintaining homeostasis and coordinating body growth and development.
- ❖ Endocrine glands possess **no excretory ducts** and their secretions are carried to specific destinations via the extracellular matrix of connective tissue into the **vascular system**. In general, endocrine glands are aggregates of epithelioid cells (epithelial cells that lack free surface) that are embedded within connective tissue.
- ❖ **H o r m o n e** is a secretory product of endocrine cells and organs that passes into the circulatory system (bloodstream) for transport to target cells.

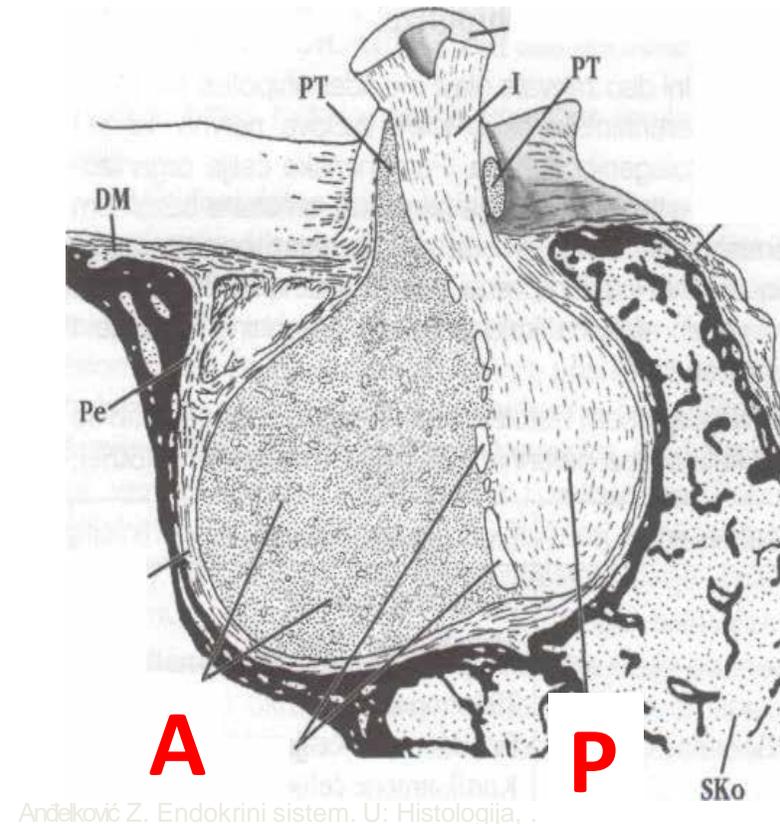
Pituitary gland



The **pituitary gland** and the **hypothalamus**, the portion of the brain to which the pituitary gland is attached, are morphologically and functionally linked in the **endocrine and neuroendocrine control of other endocrine glands**

The pituitary gland has two functional components:

- ❖ **Anterior lobe** (adenohypophysis), the glandular epithelial tissue
- ❖ **Posterior lobe** (neurohypophysis), the neural secretory tissue

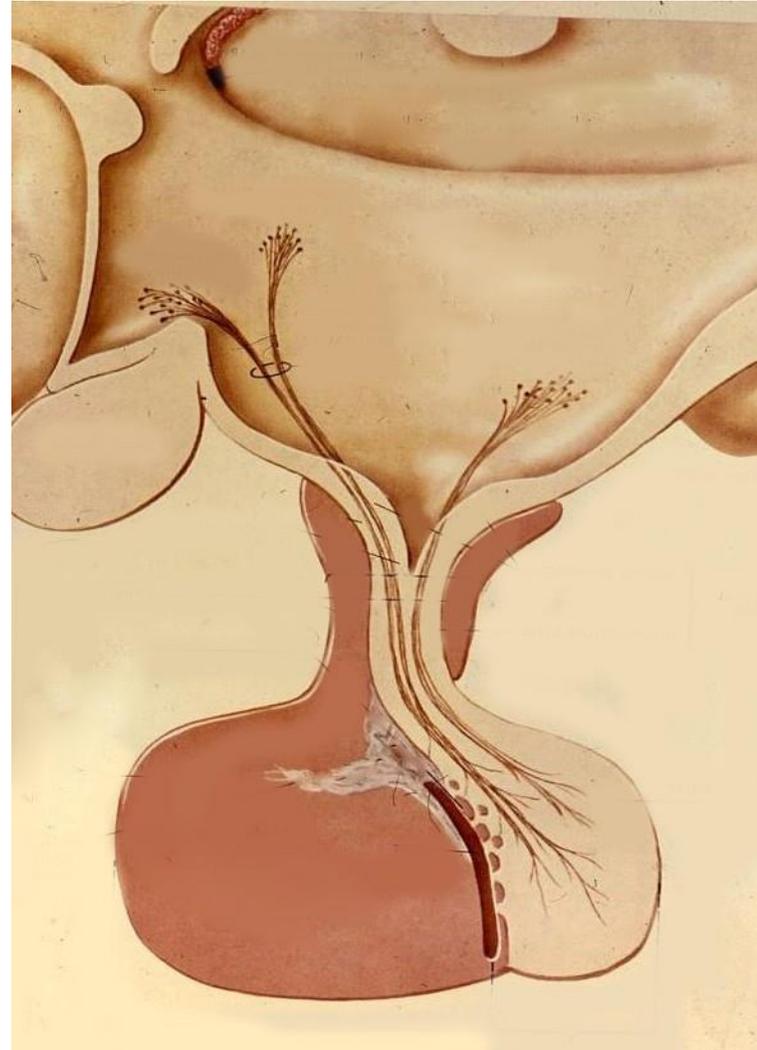


Anterior lobe

- ❖ About 75% of the hypophysis belongs frontal lobe.
- ❖ The basic division of cells is according to affinity for histological staining:
 - ❖ chromophilic (50%)
 - ❖ chromophobic (50%)

Chromophilic cells include:

- ❖ acidophils (about 40% - the cytoplasm is colored red)
- ❖ basophils (about 10% - the cytoplasm is colored purple)



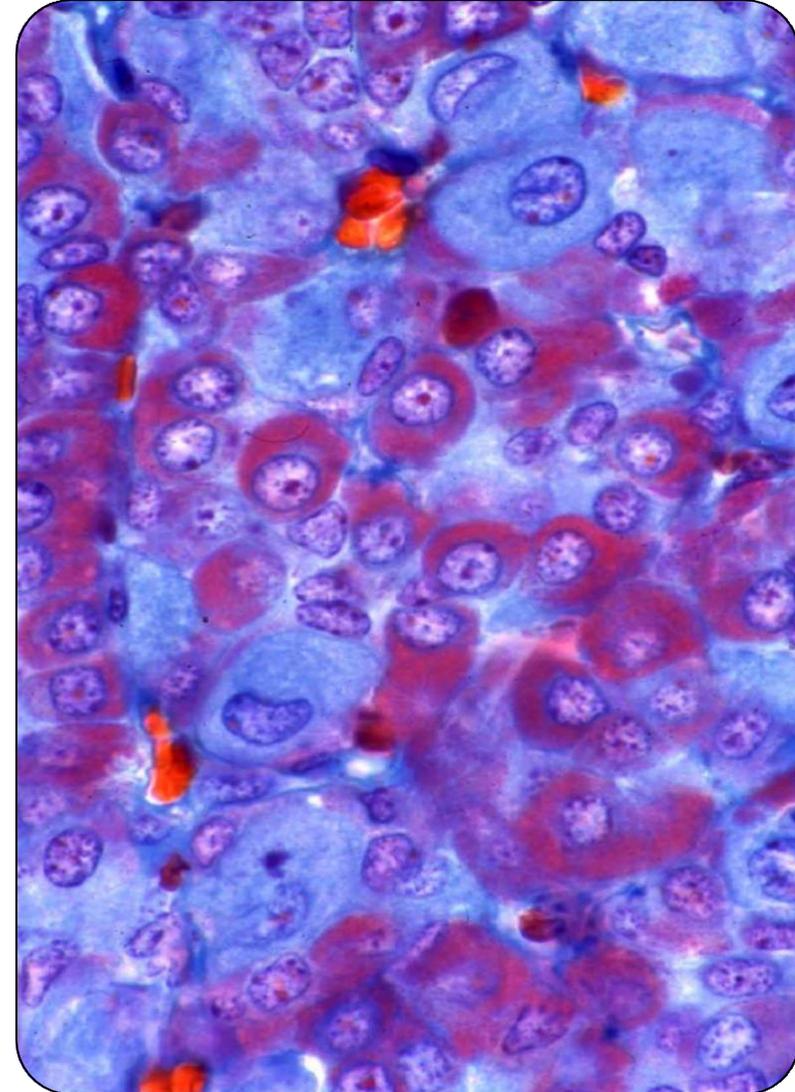
Acidophils -10%

Somatotropes - STH (secretes somatotrophic hormone)

- ❖ The most numerous among the secretory cells.
- ❖ Medium size, oval shape.
- ❖ Dark granules evenly distributed throughout the cytoplasm.

Lactotropes- LTH (secrete lactotropic hormone - prolactin)

- ❖ Oval shape, round nucleus.
- ❖ More in women.
- ❖ Active during pregnancy and breastfeeding - the number of secretory granules increases.
- ❖ With the cessation of breastfeeding, lysosomal enzymes break down the granules - autophagy.



Basophils – 40%

Thyrotropes -TSH (secretes thyrostimulating hormone)

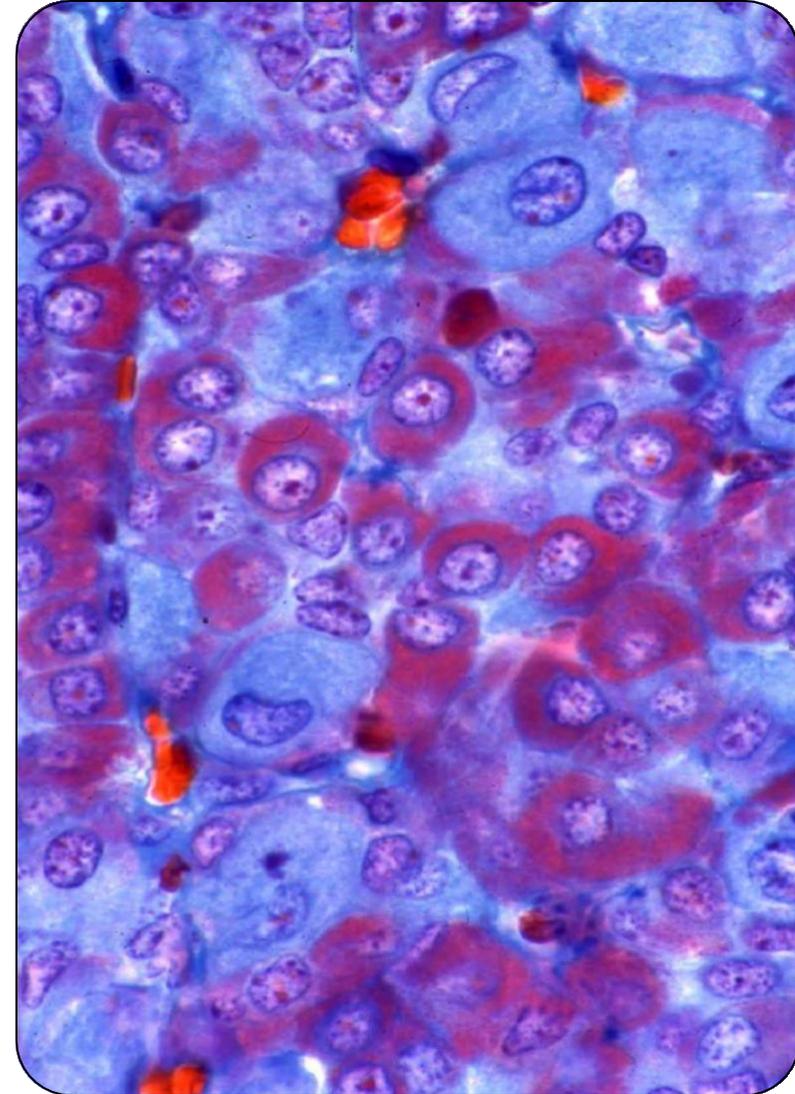
- ❖ Represented in smaller numbers than the others. Star-shaped, elliptical core, small granules.

Gonadotropes - FSH/LH (secrete follicle-stimulating and luteinizing hormone)

- ❖ The largest cells of the adenohypophysis. Oval shape, round nucleus. Both hormones are in the same granules.

Corticotropes - ACTH (secreting adrenocorticotrophic hormone)

- ❖ Polygonal or elongated, with an oval eccentric core. Peripheral - smaller number of granules. Weak affinity to base colors.



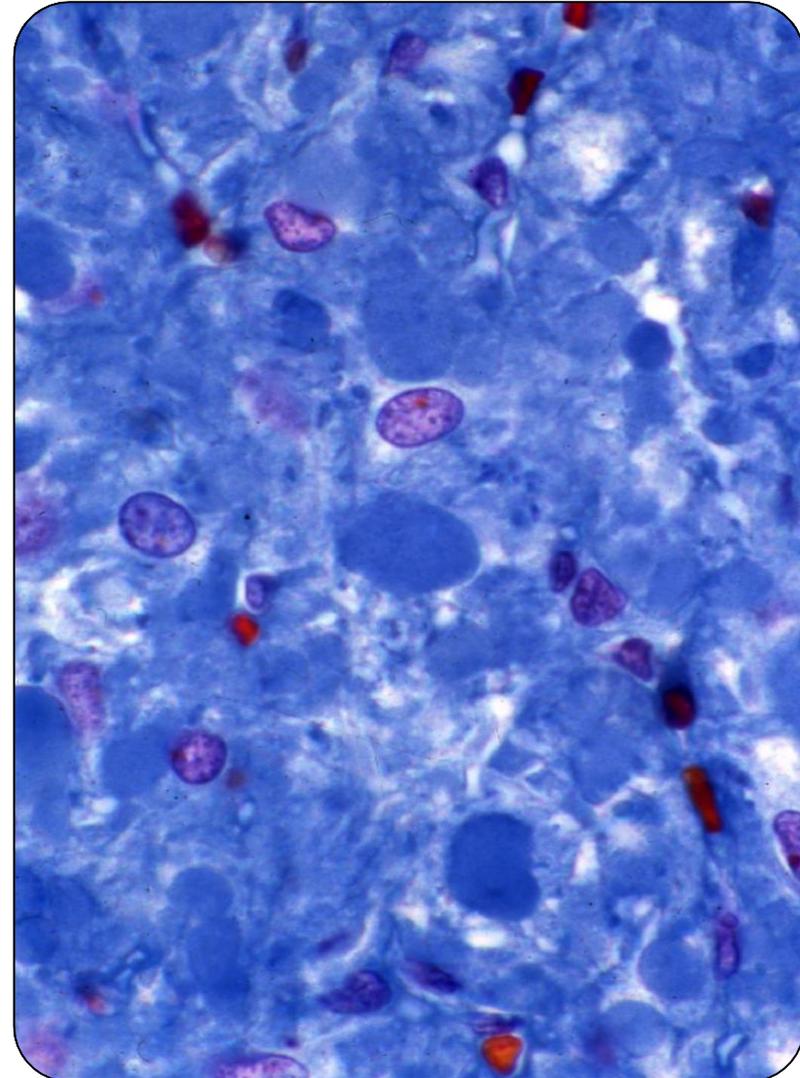
Chromophobes – 50%

Folliculo-stellate cells

- ❖ Star-shaped with extensions between endocrine cells.
- ❖ They have a nutritional and supportive role.

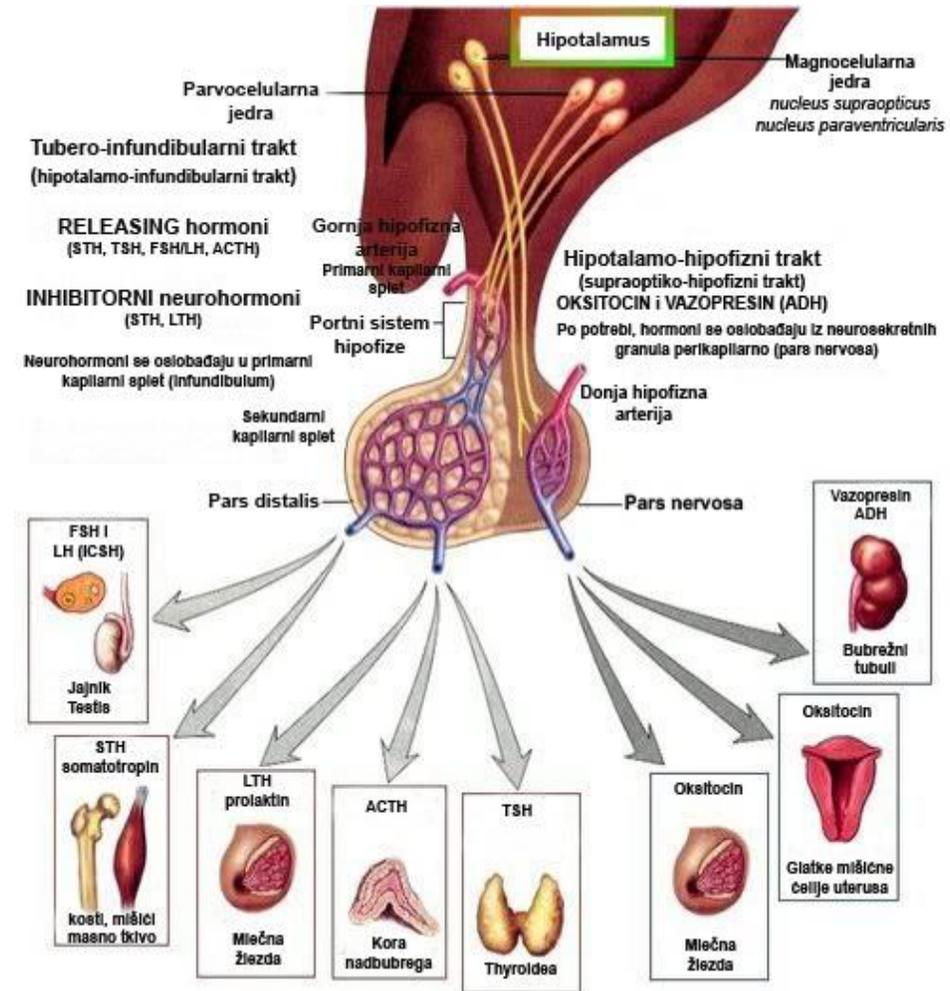
Stem (precursor) cells

- ❖ Small oval-shaped cells.
- ❖ Round nucleus and weakly expressed organelles.
- ❖ The other cells of the adenohypophysis arise from them.

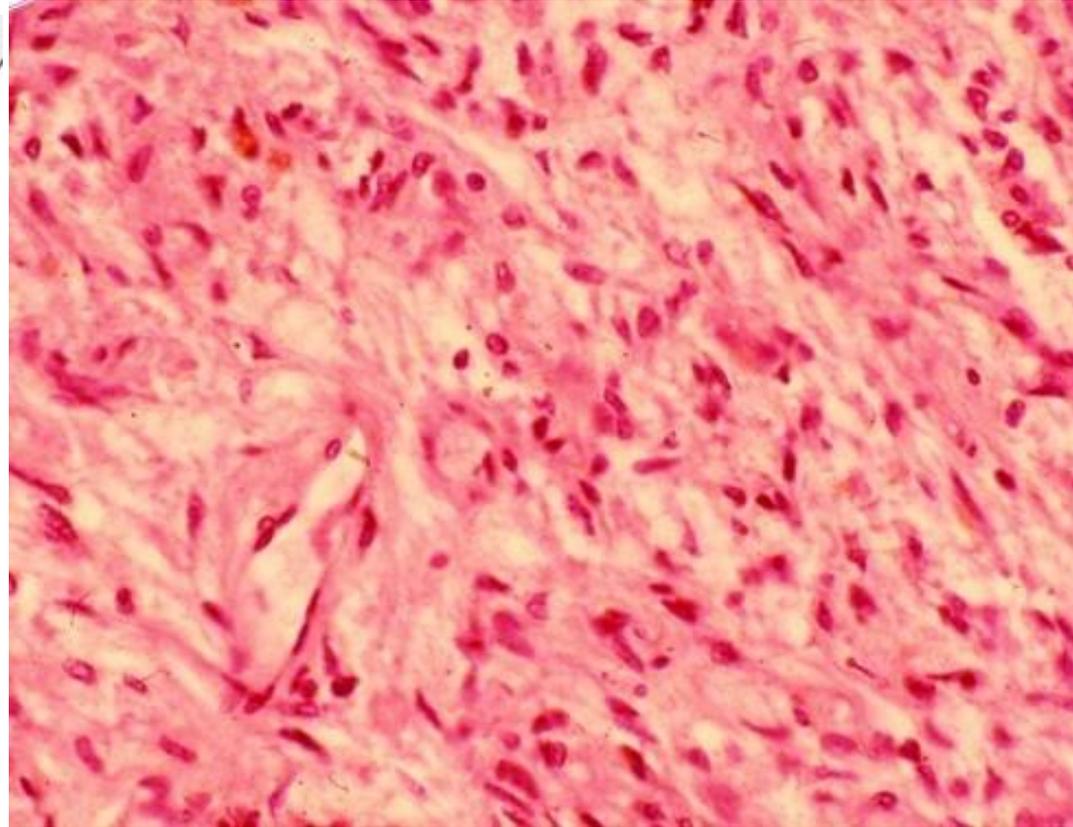
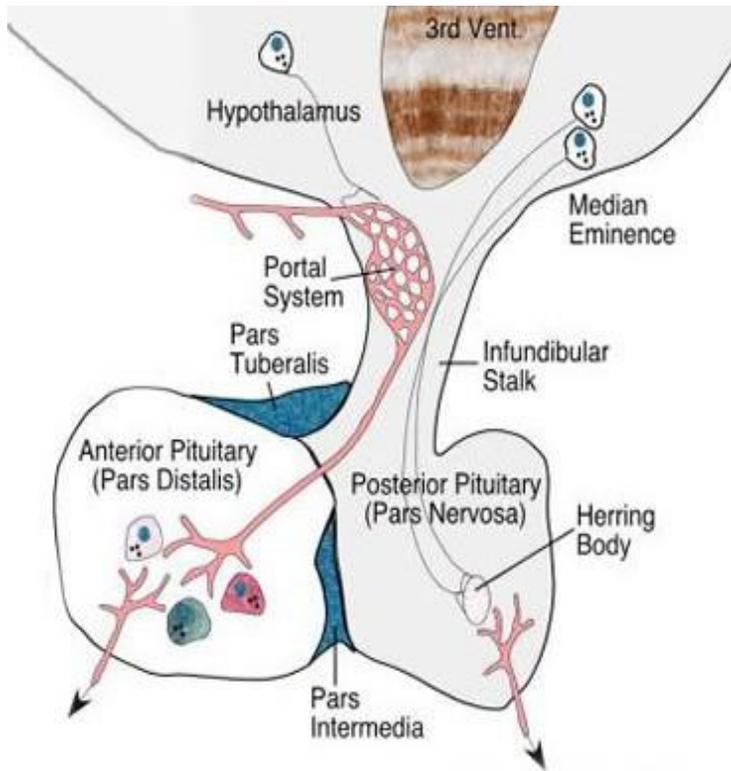


Pituitary secretion control

- ❖ The secretion of all cells of the anterior lobe is under the control of **regulatory hormones** (neurohormones) of the **hypothalamus**.
- ❖ They are released at the ends of the tuberoinfundibular tract.
- ❖ They are transported through the bloodstream to the endocrine cells.
- ❖ Neurohormones with a **stimulating** effect (releasing factors) stimulate the secretion of STH, TSH, FSH/LH/ICSH and ACTH cells.
- ❖ **Inhibitory** neurohormones act on STH and LTH cells.

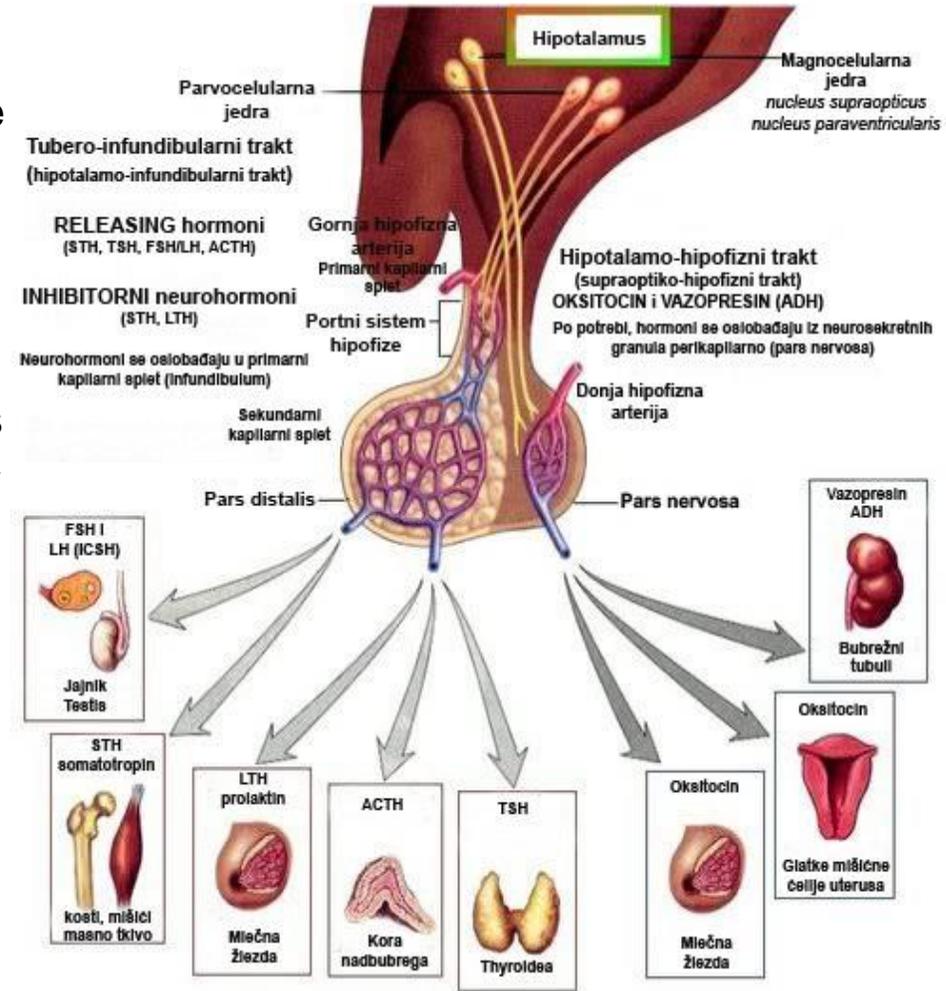


Posterior lobe



The posterior lobe of the pituitary gland is an extension of the central nervous system (CNS) that **stores and releases secretory products from the hypothalamus.**

- ❖ Contains the **nonmyelinated axons** and their nerve endings of approximately 100,000 neurosecretory neurons whose cell bodies lie in the **supraoptic nuclei and paraventricular nuclei** of the hypothalamus. The axons form the hypothalamo-hypophyseal tract.
- ❖ They do not terminate on other neurons or target cells but end in close proximity to the fenestrated capillary network.



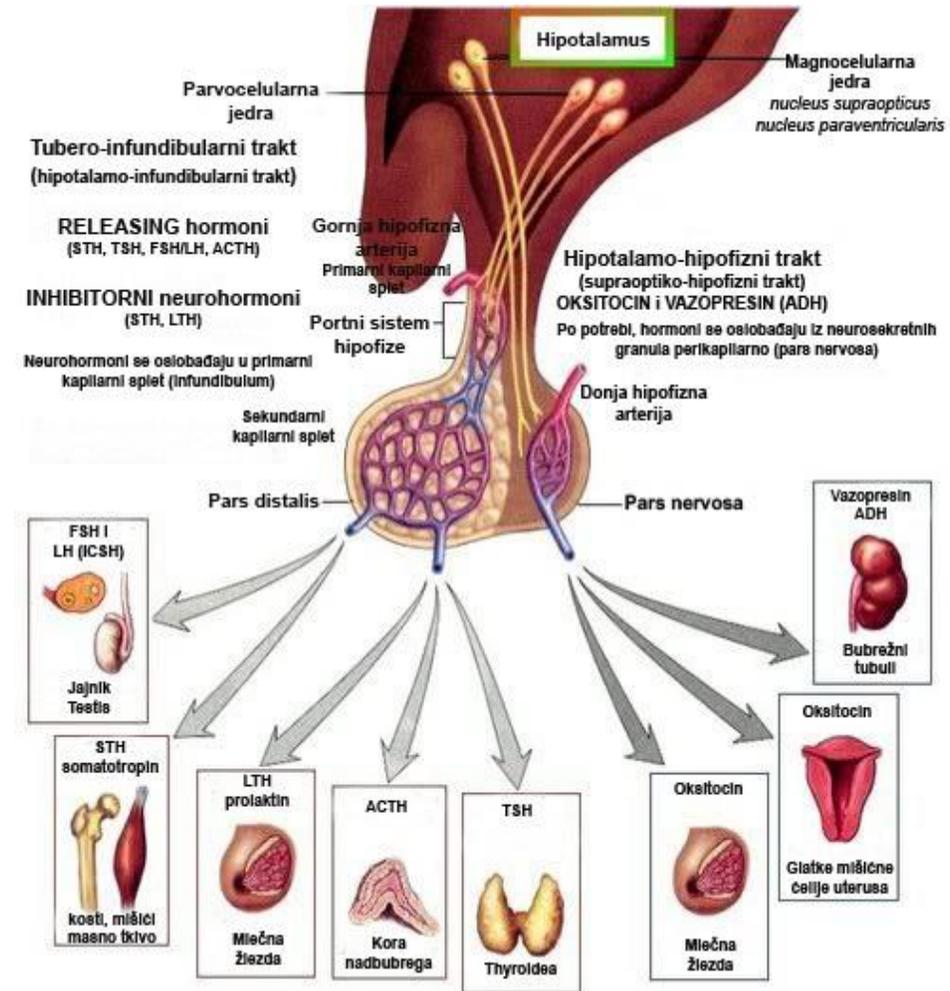
The posterior lobe of the pituitary gland is not an endocrine gland. Rather, it is a storage site for neurosecretions of the neurons of the supraoptic and paraventricular nuclei.

Неуросекреторна влакна задњег режња хипофизе

- ❖ The membrane-bound neurosecretory vesicles that aggregate to form Herring bodies contain either **oxytocin** or **antidiuretic hormone** (also called vasopressin).
- ❖ Each hormone is a small peptide of nine amino acids. Each vesicle also contains neurophysin.

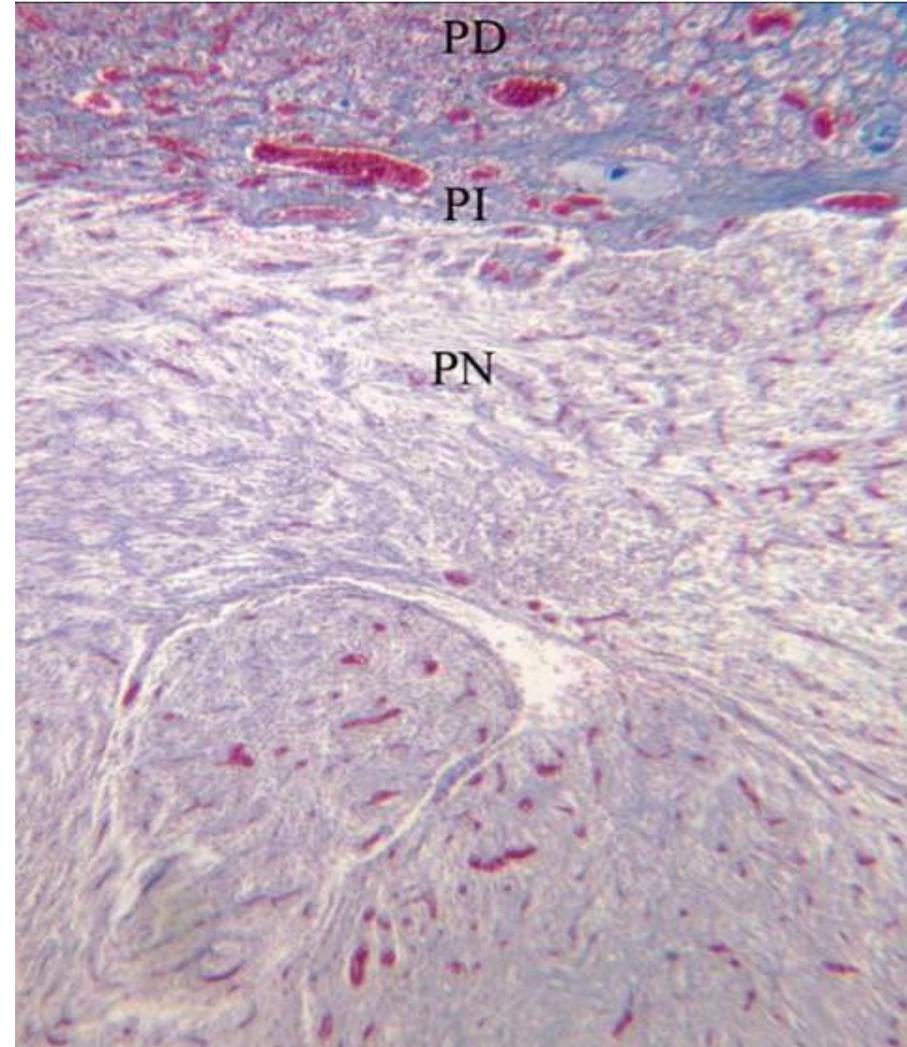
Oxytocin is a potent promoter of smooth muscle contraction.

ADH is the main hormone involved in regulation of water homeostasis and osmolarity of body fluids .



Pituicytes

- In addition to the numerous axons and terminals of the hypothalamic neurosecretory neurons, the posterior lobe of the pituitary gland contains fibroblasts, mast cells, and specialized glial cells called **pituicytes** associated with the fenestrated capillaries.
- These cells are irregular in shape, with many branches, and resemble astroglial cells.



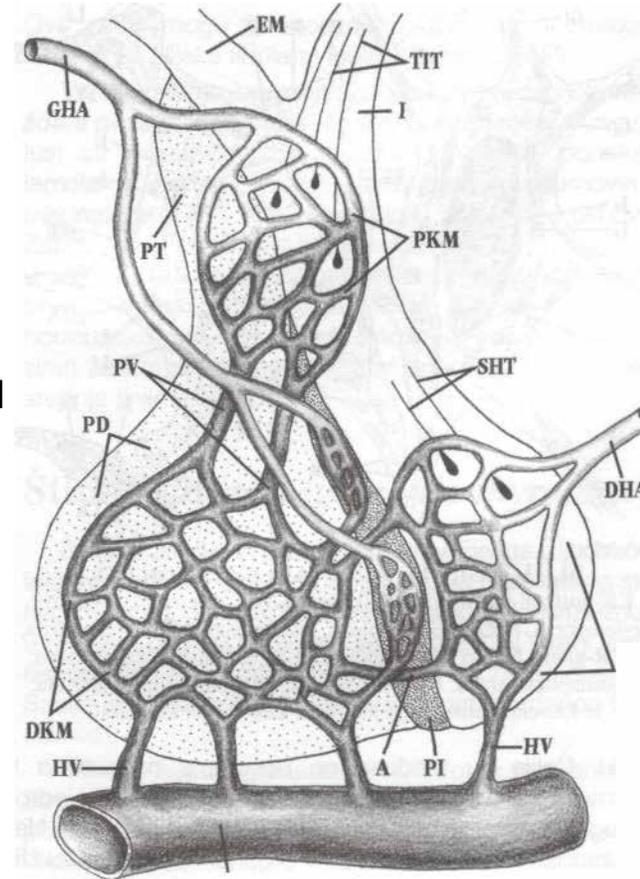
Pituitary vascularization

Superior and inferior hypophyseal arteries - branches of the internal carotid artery.

Superior hypophyseal artery – gives two branches to pars distalis (1) and pars intermedia (2).

From the first branch - several branches at the pars tubularis level form the first capillary network into which hypothalamic hormones are introduced from the ends of the hypothalamo-infundibular tract.

They go down the front side of the infundibulum to the pars distalis where they capillarize giving another capillary network in which hormones diffuse from the blood to the gland cells of the pars distalis, and the hormones of the adenohypophysis in the opposite direction - into the bloodstream.



Pituitary function is under control of two groups of hypothalamic nuclei which secrete neurohormones:

- ❖ Magnocellular nuclei:

- ❖ supraoptic nucleus

- ❖ paraventricular nucleus

Their axons form hypothalamo-pituitary tract at the ends of which they are secreted oxytocin and vasopressin (ADH).

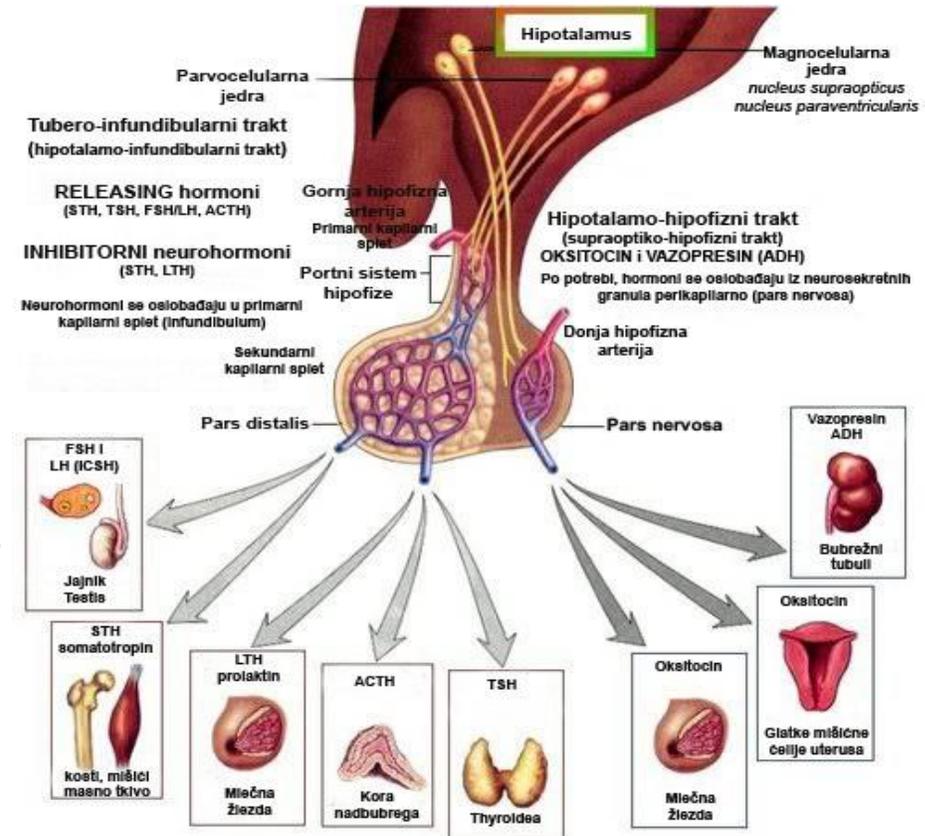
- ❖ Parvocellular nuclei

Their axons form the hypothalamo-infundibular tract.

Neurons synthesize regulatory hormones (neurohormones).

Neurohormones with a stimulating effect - realizing factors stimulate the secretion of STH, TSH, FSH/LH/ICSH and ACTH cells.

Inhibitory neurohormones act on STH and LTH cells.



Pineal gland

The pineal gland (pineal body, epiphysis cerebri) is an endocrine or neuroendocrine gland that **regulates daily body rhythm.**

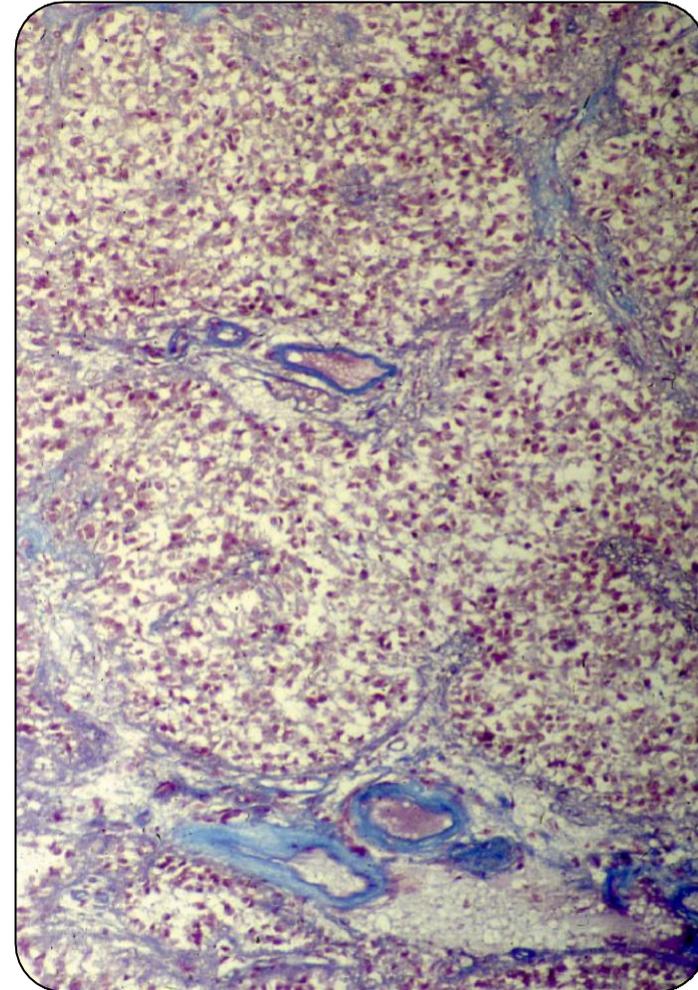
Consists of stroma and parenchyme. The capsule and septa form the stroma. Parenchyma is made up of two types of cells:

- ❖ pinealocytes (95%)
- ❖ interstitial (glial) cells (5%)

Pinealocytes are the main cells arranged in bands.

They have extensions - shorter ones end between neighboring pinealocytes, longer ones towards - capillaries.

They have well-developed organelles, lipofuscin granules and specific protein structures - **synaptic ribbons** to which synaptic vesicles are attached.



- ❖ The pineal gland is a photosensitive organ and an **important timekeeper and regulator of the day/night cycle (circadian rhythm)**. It obtains information about light and dark cycles from the retina via the retino-hypothalamic tract, which connects in the suprachiasmatic nucleus with sympathetic neural tracts traveling into the pineal gland.
- ❖ Pineal activity, increases during darkness and decreases during light. In humans, these circadian changes of melatonin secretion play an important role in regulating body rhythms.



Thyroid gland

Consists of

❖ **Parenchyma**

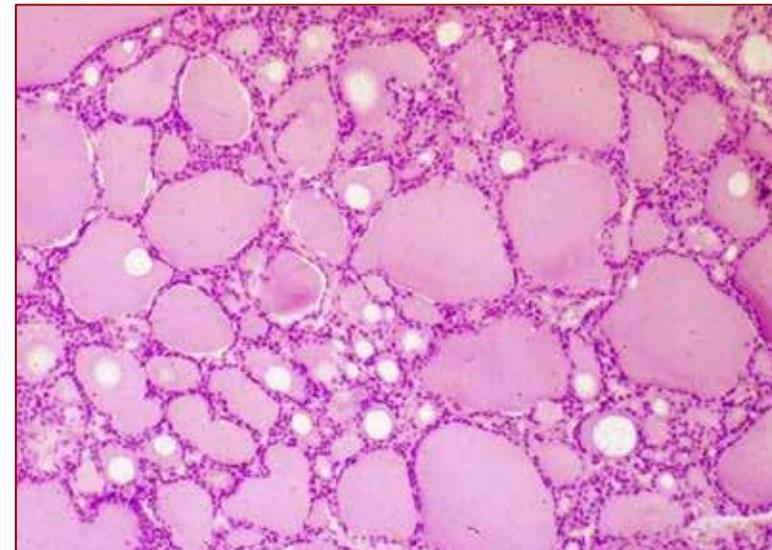
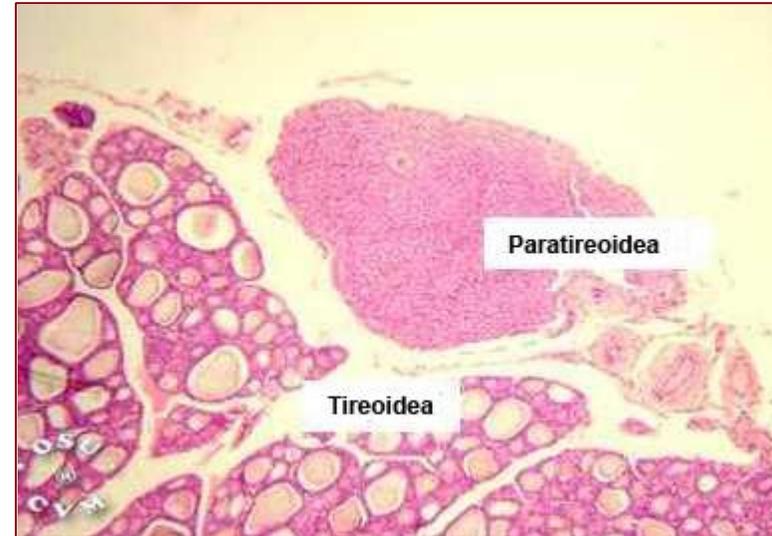
Thyroid follicles are the structural and functional unit of the thyroid gland. The follicles contain a gel-like mass called colloid

❖ **Stroma**

Thin fibrous capsule

Trabeculae dividing the parenchyma

Blood and lymphatic vessels, nerve fibers



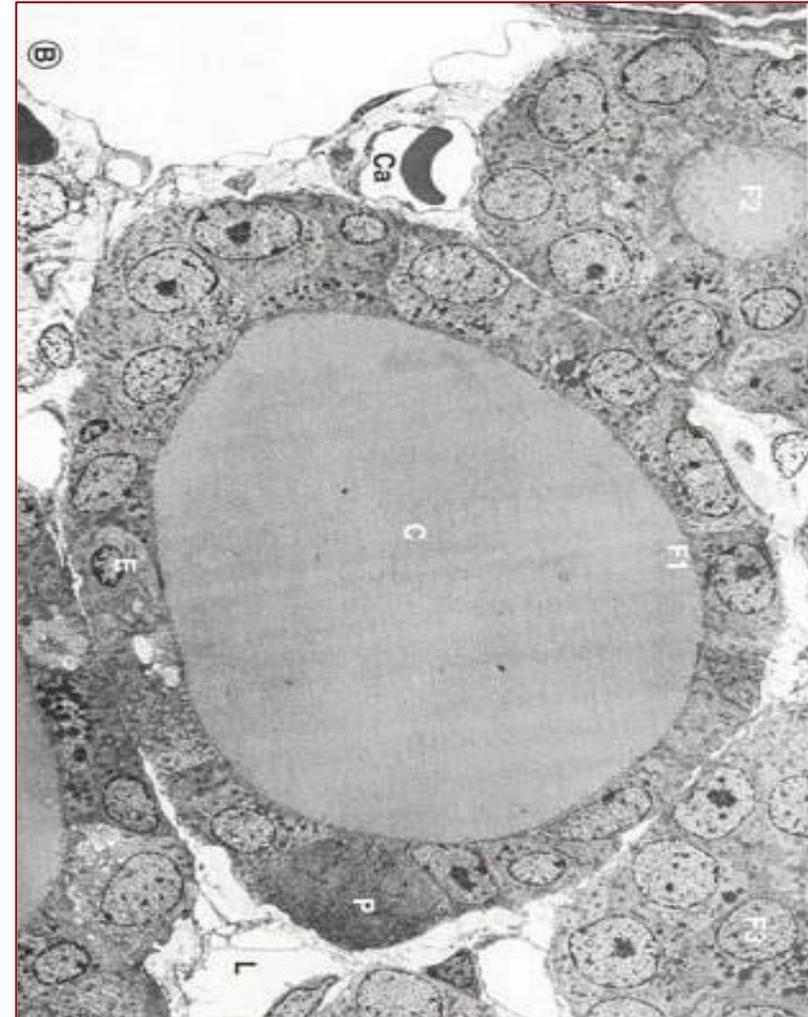
Follicular epithelium

Follicular epithelium contains two types of cells: **follicular and parafollicular cells**.

Follicular cells (principal cells) are responsible for production of the thyroid hormones T4 and T3. These cells vary in shape and size according to the functional state of the gland e.g. degree of stimulation by the TSH hormone (**resting - cuboidal; active - cylindrical shape**) They synthesize thyroglobulin.

Apical pole - microvilli and thyroperoxidase enzyme, secretory vesicles (thyroglobulin) and colloidal droplets (endocytotic vacuoles)

Basal pole – receptors for TSH and iodide transporter.



Follicular cells

The synthesis of the two major thyroid hormones, thyroxine (T4) and triiodothyronine (T3), takes place in the thyroid follicle in a series of discrete steps

1. Synthesis of thyroglobulin

The precursor of thyroglobulin is synthesized in the rER

2. Resorption , diffusion , and oxidation of iodide.

Follicular epithelial cells actively transport iodide from the blood into their cytoplasm

3. Iodination of thyroglobulin residue

Addition of one iodine atom to a single tyrosine residue forms moniodotyrosine (MIT). Addition of a second iodine atom to the MIT residue forms a diiodotyrosine (DIT)

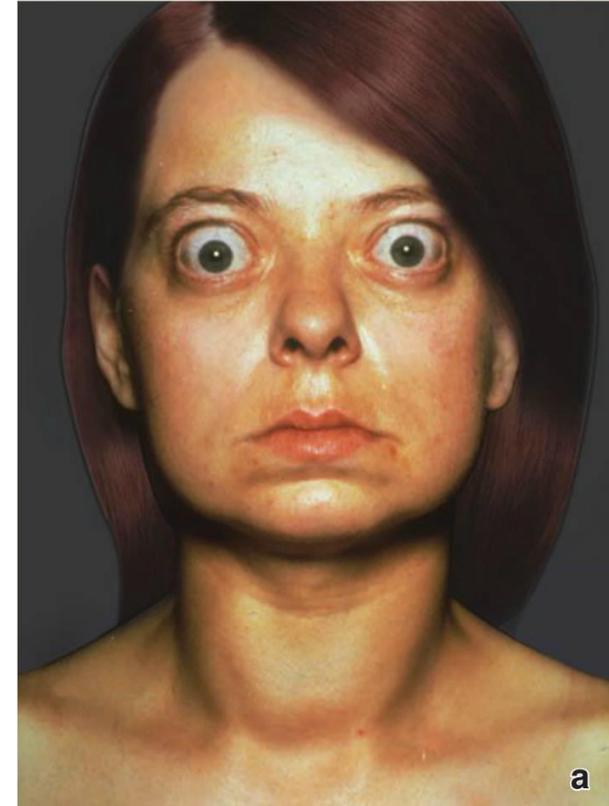
4. Formation of T4 and T3

Thyroid hormones are formed by oxidative coupling reactions of two iodinated tyrosine residues in close proximity.

5. Resorption of colloid

In response to TSH, follicular cells take up thyroglobulin from the colloid by a process of receptor-mediated endocytosis.

6. Release of T4 and T3



Parafollicular cells



- They belong to **DNES**. Originating from the neural crest.
- Position: **intrafollicular** (between thyrocytes), **parafollicular** (between thyrocytes and b.l.) and **interfollicular** (between follicles).
- Not in contact with the colloid, secretes calcitonin directly into the blood.
- Bright cytoplasm, synthetic organelles, basal-secretory granules (calcitonin)

Parathyroid glands, 4 of them

Consists of

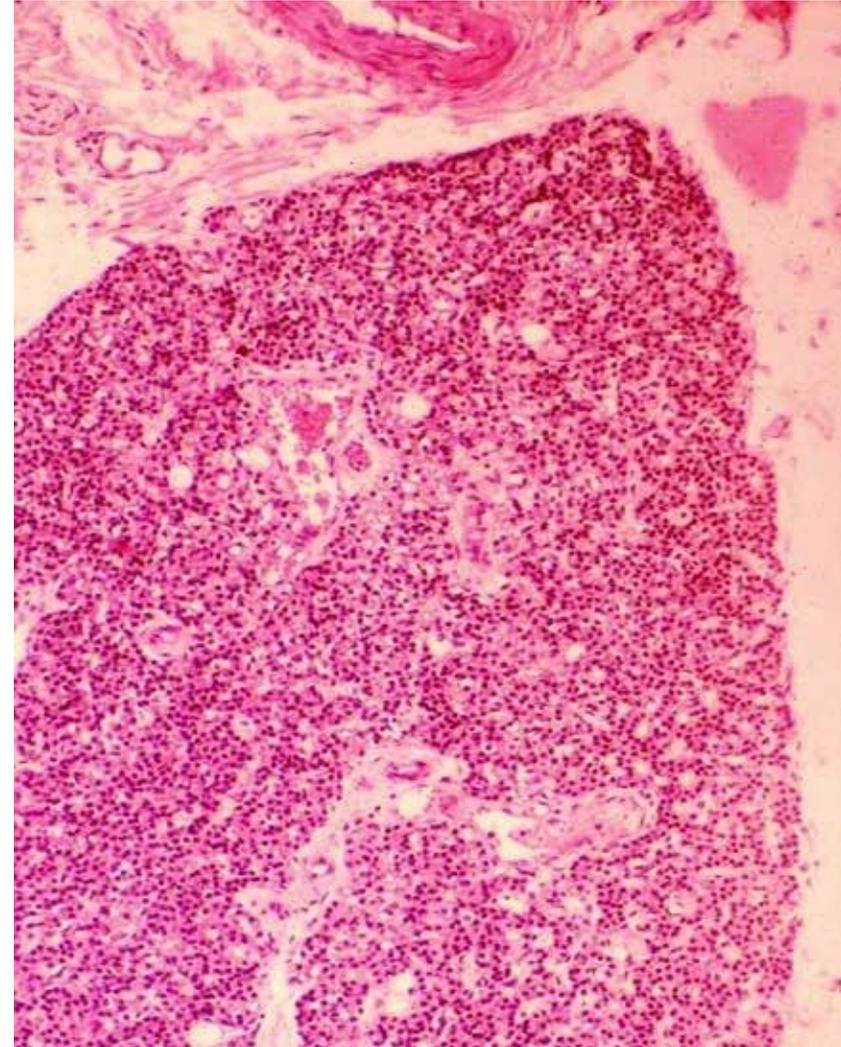
❖ **Parenchyma**

- **Principal cells** (produce parathormone – PTH)
- **Oxyphil cells** (polygonal, larger in size, no secretory activity, appear in children from the age of 6)

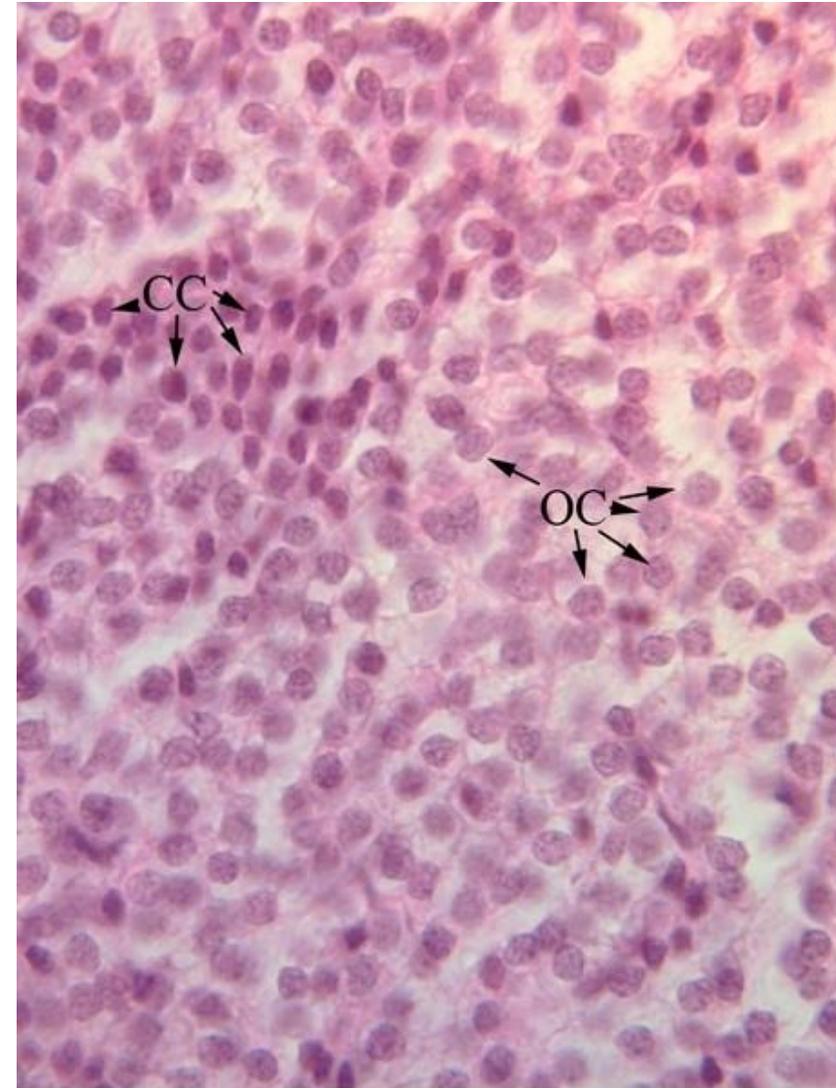
❖ **Stroma**

- Capsule
- Trabeculae
- Intralobular network of reticular fibers

Parathyroid hormone regulates calcium and phosphate levels in the blood.



- ❖ **Principal (chief) cells**, the more numerous of the parathyroid, are responsible for regulating the synthesis, storage, and secretion of large amounts of PTH. They are small, polygonal cells, with a diameter of 7 to 10. Have a centrally located nucleus.
 - In the cytoplasm – organelles of the synthetic pathway and secretory granules with PTH and chromagranin A.
- ❖ **Oxyphilic cells** are found singly or in clusters; the cells are considerably larger than the principal cells, and have a distinctly acidophilic cytoplasm. Mitochondria, often with bizarre shapes and sizes, almost fill the cytoplasm and are responsible for the strong acidophilia of these cells. No secretory vesicles and little if any rER are present.



CC - chief cells

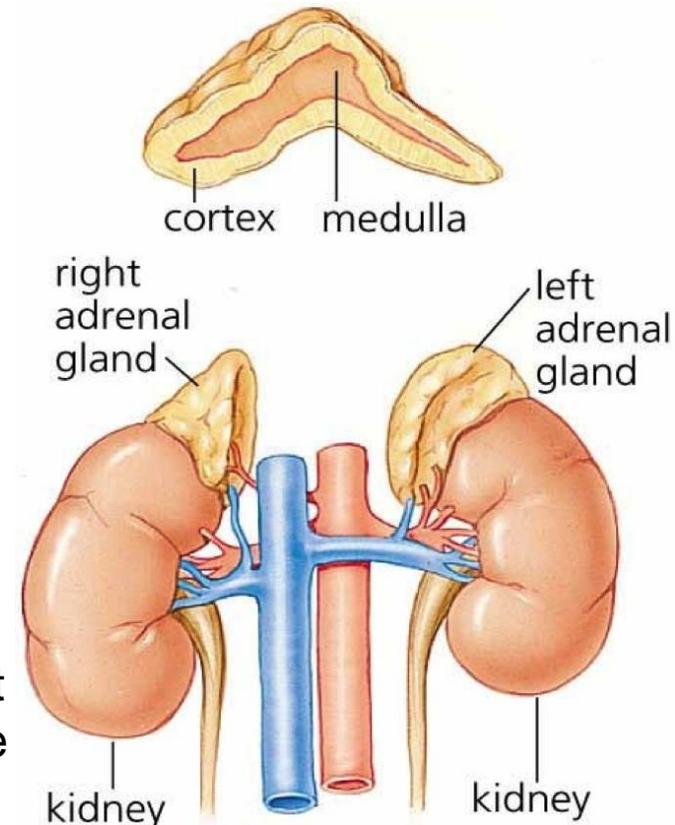
OC - oxyphil cells

Adrenal glands

Embedded in the perirenal fat at the superior poles of the kidneys.

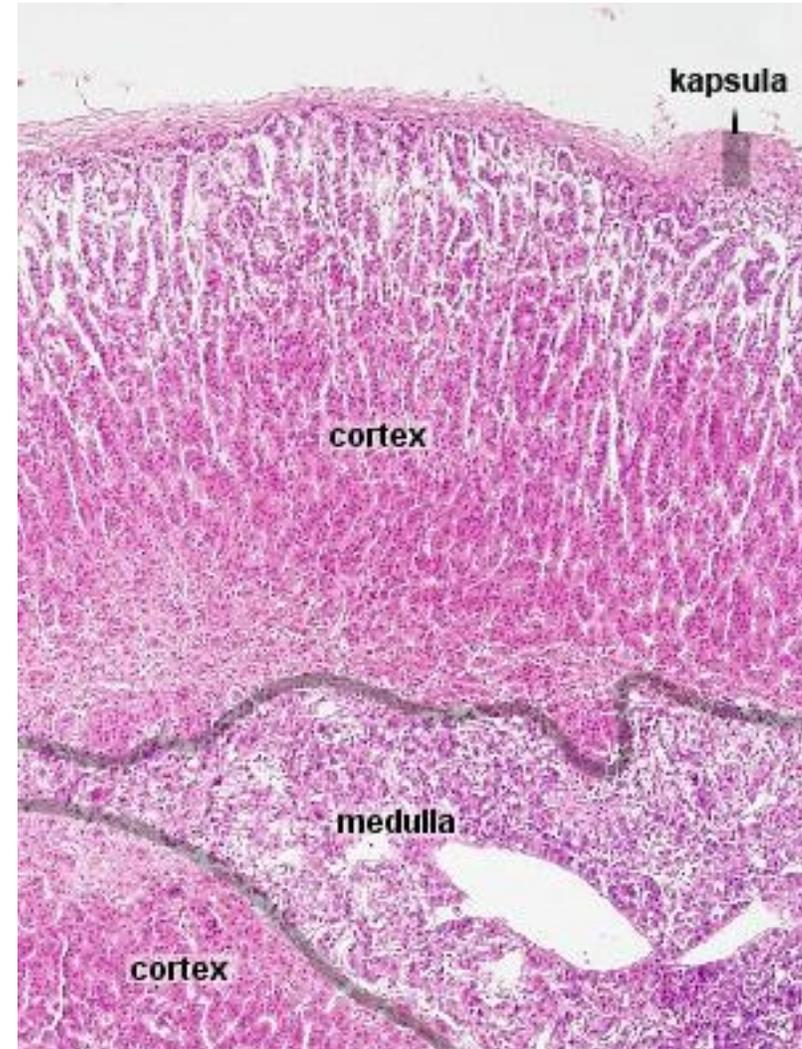
The adrenal glands are covered with a thick **connective tissue capsule** from which **trabeculae** extend into the parenchyma, carrying blood vessels and nerves. The secretory parenchymal tissue is organized into two distinct regions

- ❖ **Cortex** is the steroid-secreting portion. It lies beneath the capsule and constitutes nearly 90% of the gland by weight.
- ❖ **Medulla** is the catecholamine-secreting portion. It lies deep to the cortex and forms the center of the gland.

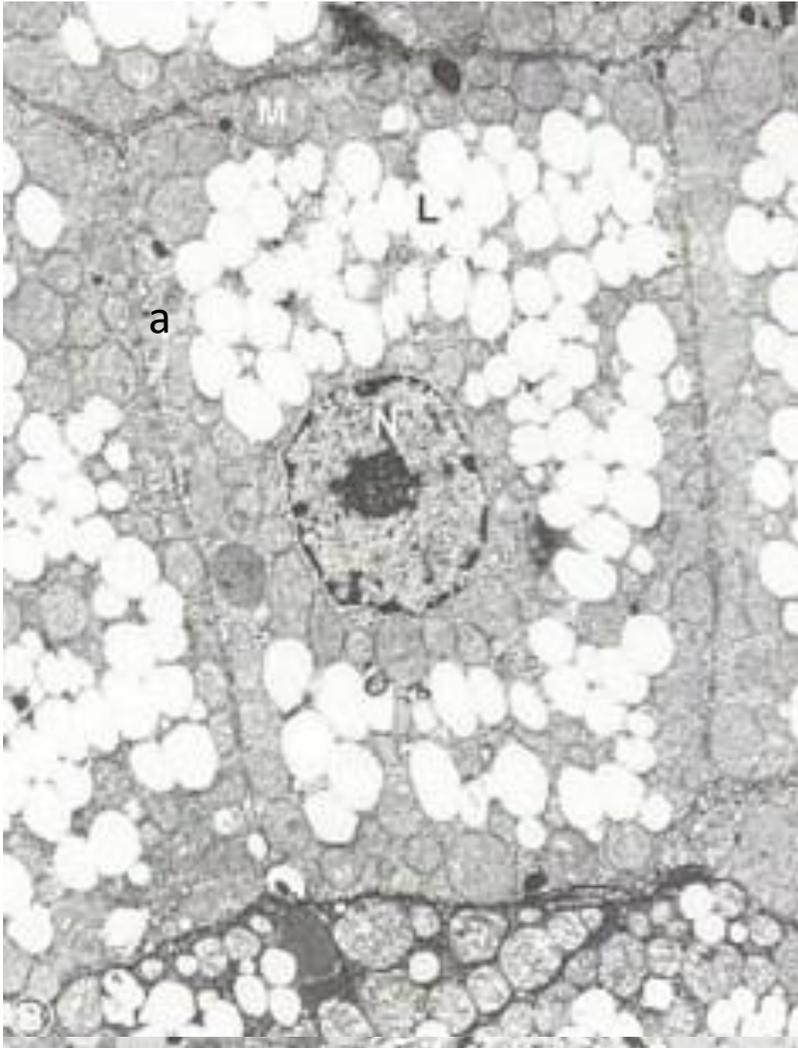


The adrenal cortex is divided into three zones on the basis of the arrangement of its cells:

- ❖ **Zona glomerulosa**, the narrow outer zone up to 15% of the cortical volume, secretes the primary **mineralocorticoid** called **aldosterone**.
- ❖ **Zona fasciculata**, the thick middle zone nearly 80% of the cortical volume, secretes **glucocorticoids** (cortisol) that regulate glucose and fatty acid metabolism.
- ❖ **Zona reticularis**, the inner zone that constitutes only 5% to 7% of the cortical volume secretes adrenal androgens.



TO EASILY REMEMBER SALT, SUGAR, SEX



Zona glomerulosa

- Cylindrical cells grouped in arcs.
- Acidophilic cytoplasm, nucleus small and dark, pronounced nucleoli.
- The function is controlled by the renin-angiotensin-aldosterone system.

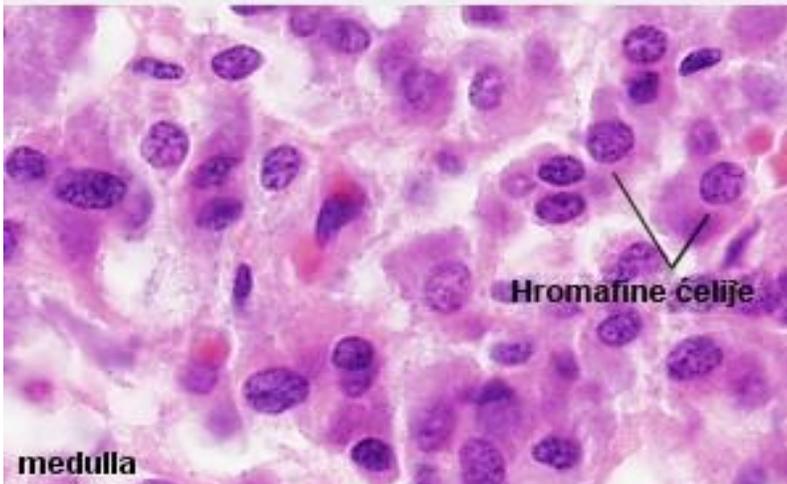
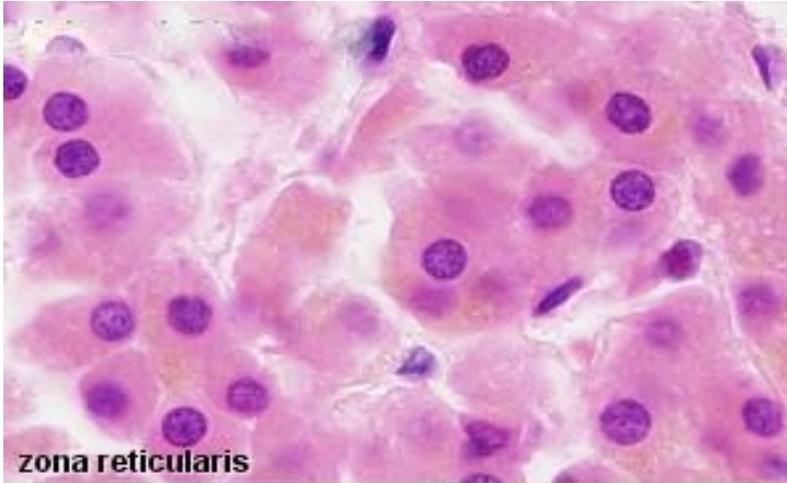
Zona fasciculata

- They are made up of large, bright cells filled with lipid droplets.
- Cells are arranged in long straight cords, one or two cells thick, that are separated by sinusoidal capillaries.
- Their function is controlled by ACTH.

Zona reticularis

- Polygonal cells arranged in a network pattern.
- They contain brownish lipofuscin ("aging pigment").
- Secretory activity takes place under the influence of ACTH.

Medulla



The medulla consists of

- ❖ **chromaffin cells** (synthesize adrenaline and noradrenaline) and
- ❖ **ganglion cells**.

Chromaffin cells are also called medullary cells. They have no dendrites or axons, but make synapses with presynaptic fibers SY - postsynaptic neurons. Large oval cells, possess a basal lamina (separates them from the pericapillary spaces). Have euchromatic nucleus, expressed nucleoli, sER, ribosomes, mitochondria.

In their cytoplasm, granules of both types of catecholamines, epinephrine and norepinephrine.

Ganglion cells

Axons extend peripherally to the parenchyma of the adrenal cortex to modulate its secretory activity.

Adrenal gland function

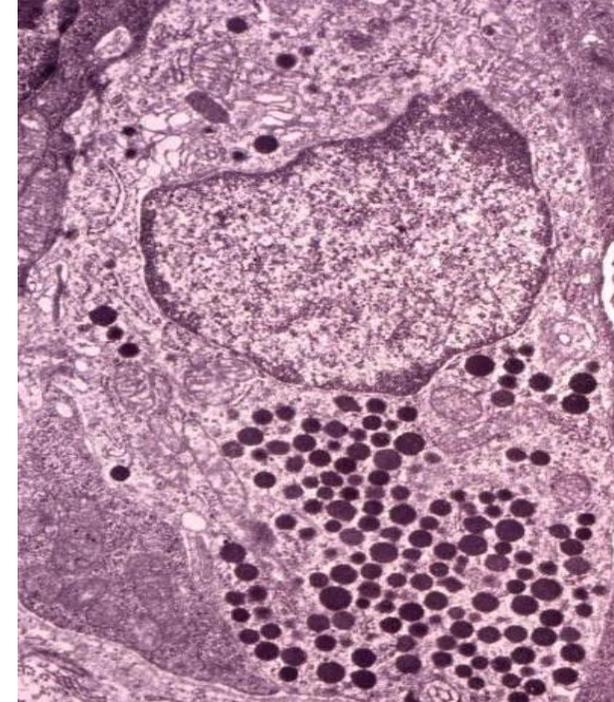
Endocrine gland	Hormone	Function	Secretion control is made by
Adrenal Cortex	Glucocorticoids	Raises glucose levels in the blood, stimulates glucose production by cells, reduce the inflammatory response	Raised blood glucose levels
	Mineralocorticoids	Acts on the distal convoluted tubules of the renal nephrons; regulates uptake of sodium and acid/base balance	Low blood glucose levels
	Sex hormones	(Very small quantities)	_____
Adrenal Medula	Adrenaline and Noradrenaline	Fear, fight, fright syndrome	Sympathetic nervous system

DNES

The **neuroendocrine system** is made up of special cells called **neuroendocrine cells**. They are spread throughout the body. Neuroendocrine cells **are like nerve cells**, but they **also make hormones** like cells of the endocrine system.

They receive signals from the nervous system and respond by making and releasing hormones. These hormones control many body functions.

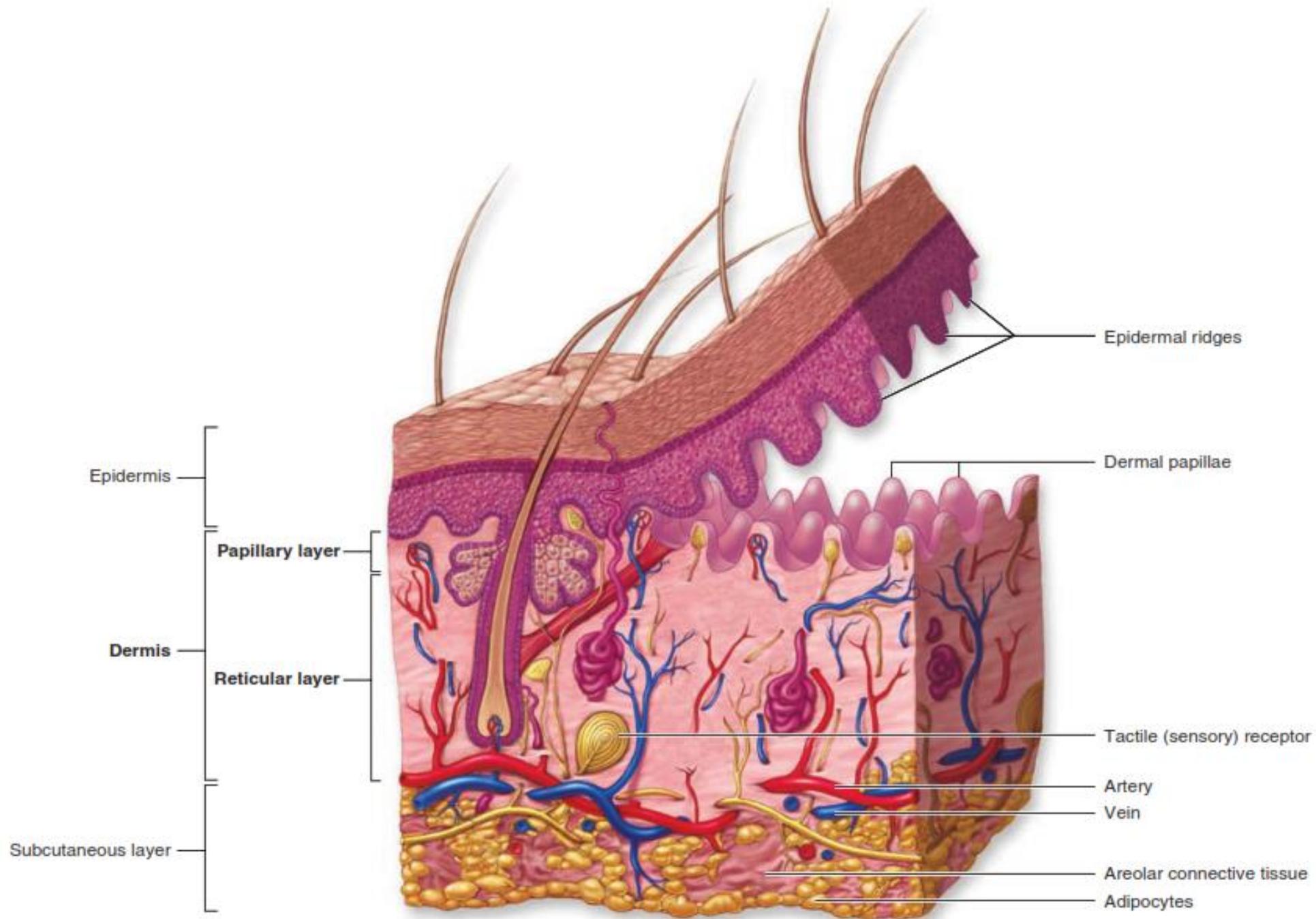
Neuroendocrine cells are found in almost every organ of the body. They are mainly found scattered in the gastrointestinal (GI) tract (including the small intestine, rectum, stomach, colon, esophagus and appendix), the gallbladder, the pancreas and the thyroid (C cells). Neuroendocrine cells are also commonly found in the lungs or airways into the lungs (bronchi), as well as the respiratory tract of the head and neck. They contain round granules of electron-dense content with a bright halo.

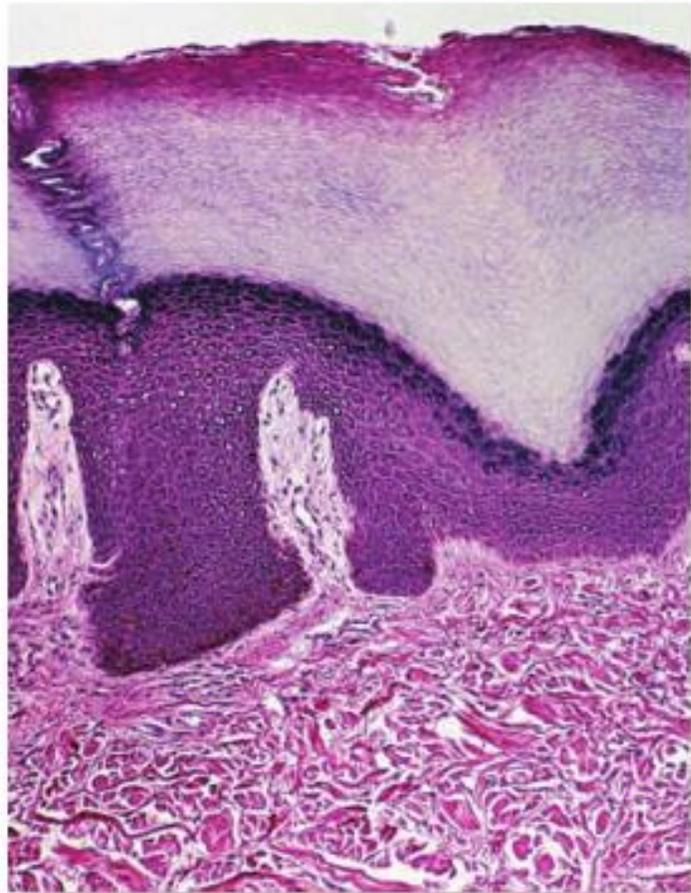


SKIN

The skin

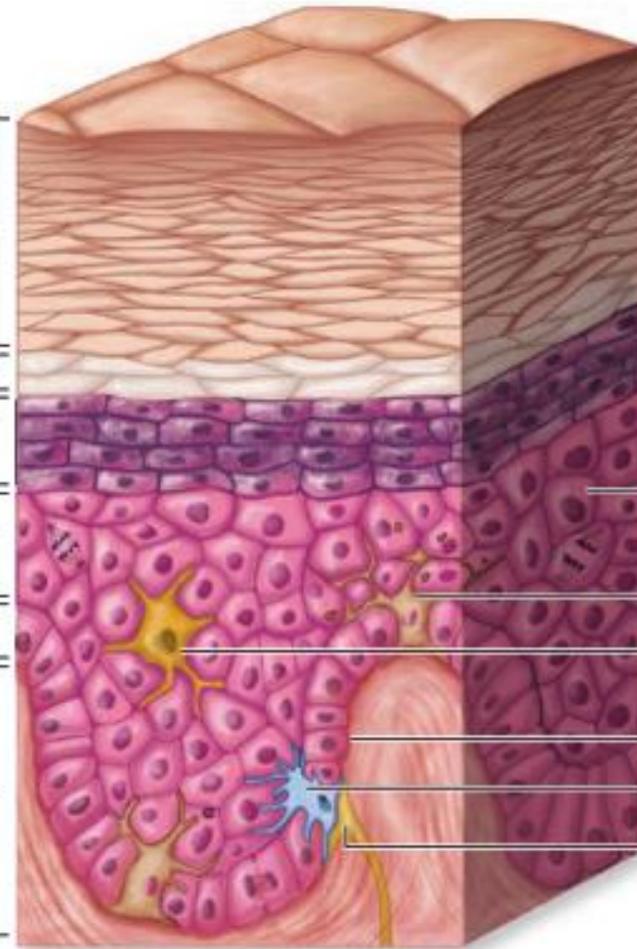
- The skin is the largest single organ of the body, typically accounting for 15%-20% of total body weight and, in adults, presenting 1.5-2m² of surface to the external environment. Also known as the integument (L. integumentum, covering) or cutaneous layer, the skin is composed of the epidermis, an epithelial layer of ectodermal origin, and the dermis, a layer of mesodermal connective tissue.
- At the irregular junction between the dermis and epidermis, projections called dermal papillae interdigitate with invaginating epidermal ridges to strengthen adhesion of the two layers. Epidermal derivatives include hairs, nails, and sebaceous and sweat glands. Beneath the dermis lies the subcutaneous tissue or hypodermis (Gr. hypo, under + derma, skin), a loose connective tissue layer usually containing pads of adipocytes. The subcutaneous tissue binds the skin loosely to the underlying tissues and corresponds to the superficial fascia of gross anatomy.





a

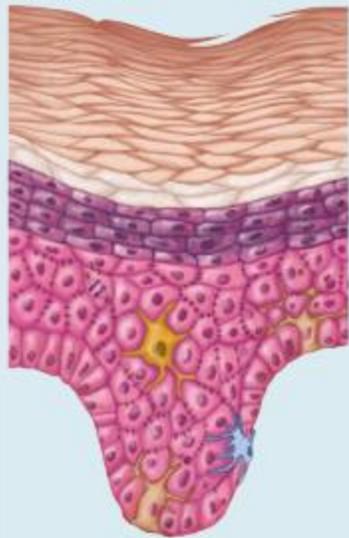
- Stratum corneum
- Stratum lucidum
- Stratum granulosum
- Stratum spinosum
- Stratum basale
- Dermis



b

- Dead keratinocytes
- Living keratinocyte
- Melanocyte
- Langerhans cell
- Basement membrane
- Tactile cell
- Sensory nerve ending

Epidermis



Stratum corneum

Stratum lucidum

Stratum granulosum

Stratum spinosum

Stratum basale

Stratum corneum

Stratum lucidum

Stratum granulosum

Stratum spinosum

Stratum basale

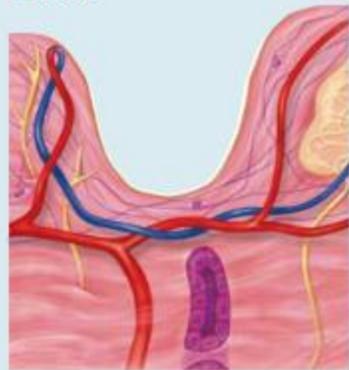
Most superficial layer; 20-30 layers of dead, flattened, anucleate, keratin-filled keratinocytes; protects against friction and water loss

2-3 layers of anucleate, dead cells; seen only in thick skin
3-5 layers of keratinocytes with distinct kerato-hyaline granules

Several layers of keratinocytes all joined by desmosomes; Langerhans cells present

Deepest, single layer of cuboidal to low columnar cells in contact with basement membrane; mitosis occurs here; melanocytes and Merkel cells also

Dermis



Papillary layer

Reticular layer

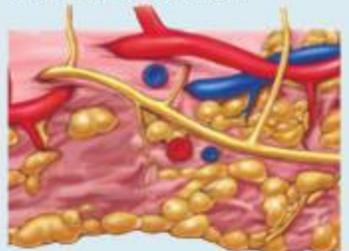
Papillary layer

Reticular layer

More superficial layer of dermis; composed of areolar connective tissue; forms dermal papillae; contains subpapillary vascular plexus

Deeper layer of dermis; dense irregular connective tissue surrounding hair follicles, sebaceous glands and sweat glands, nerves, and deep plexus of blood vessels extending into subcutaneous layer

Subcutaneous layer

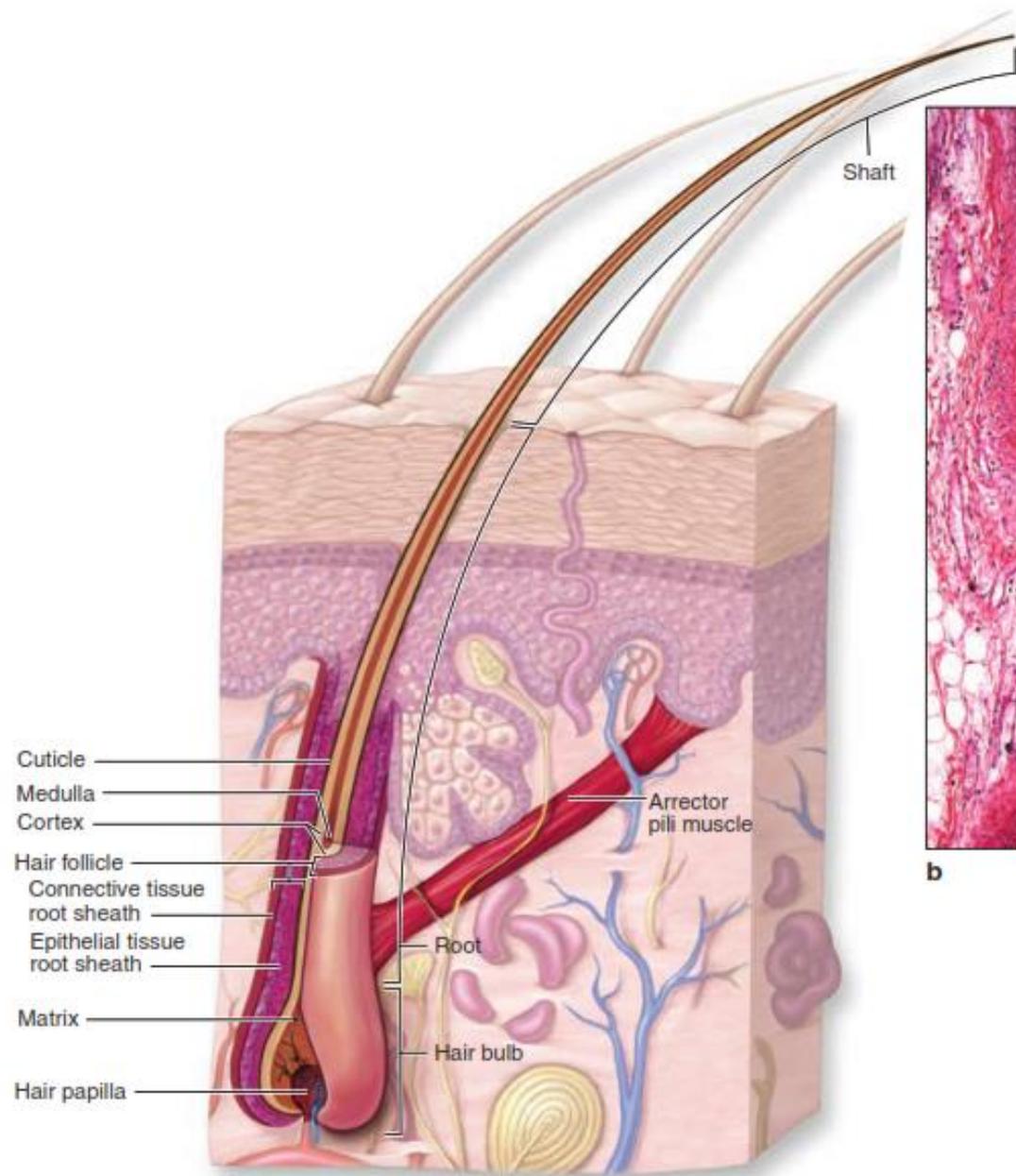


No specific layers

Not considered part of the integument; deep to dermis; composed of areolar and adipose connective tissue

Hair

- Hairs are elongated keratinized structures that form within epidermal invaginations, the hair follicles
- The color, size, shape, and texture of hairs vary according to age, genetic background, and region of the body. All skin has at least minimal hair except the glabrous skin of the palms, soles, lips, glans penis, clitoris, and labia minora.
- The face has about 600 hairs/cm² and the remainder of the body has about 60/cm².



- Cuticle
- Medulla
- Cortex
- Hair follicle
- Connective tissue root sheath
- Epithelial tissue root sheath
- Matrix
- Hair papilla

Arrector pili muscle

Root

Hair bulb

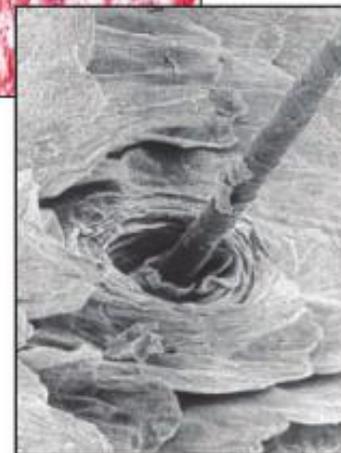
Shaft



- Connective tissue root sheath
- Epithelial tissue root sheath
- Medulla
- Cortex
- Matrix

Hair follicle

b

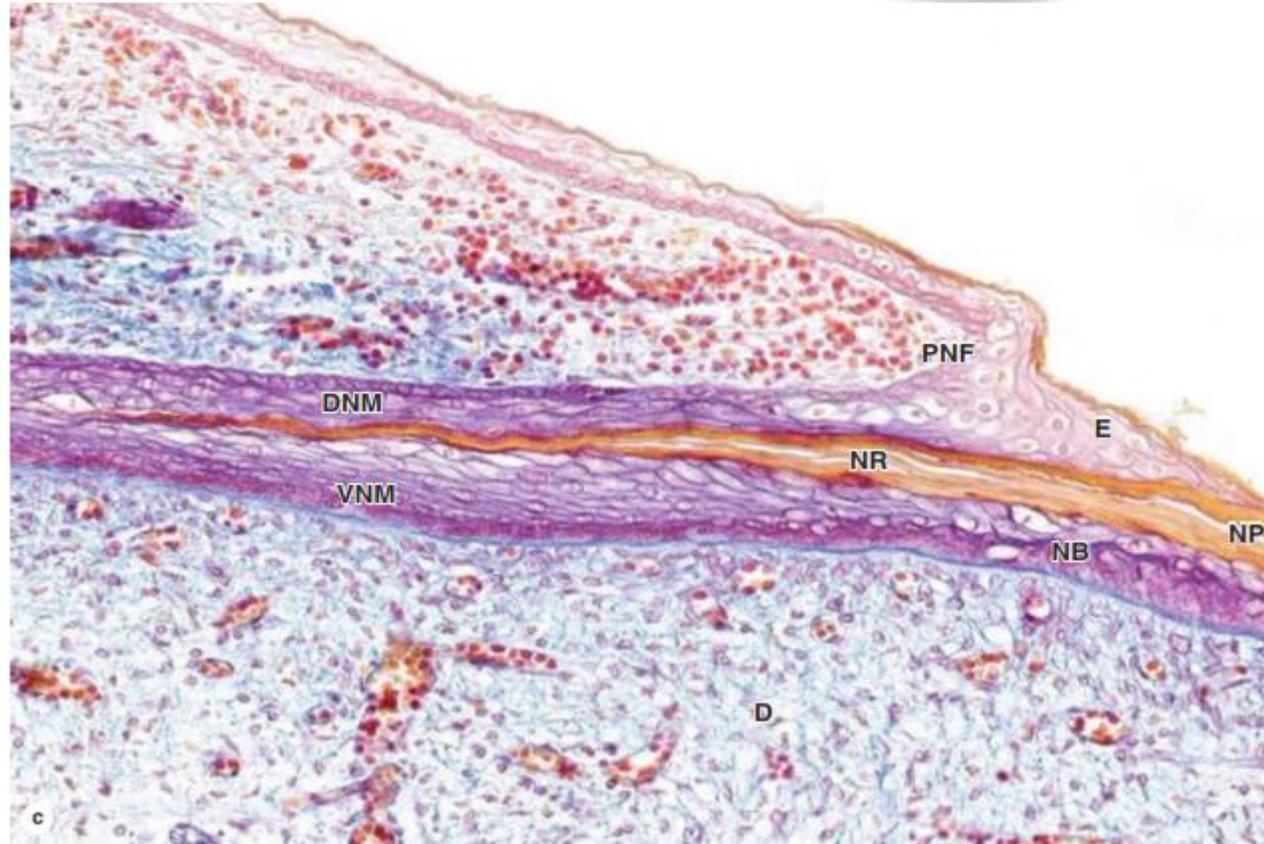
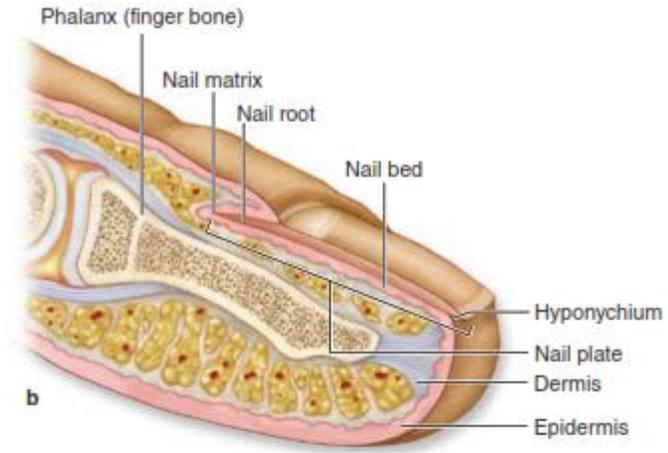
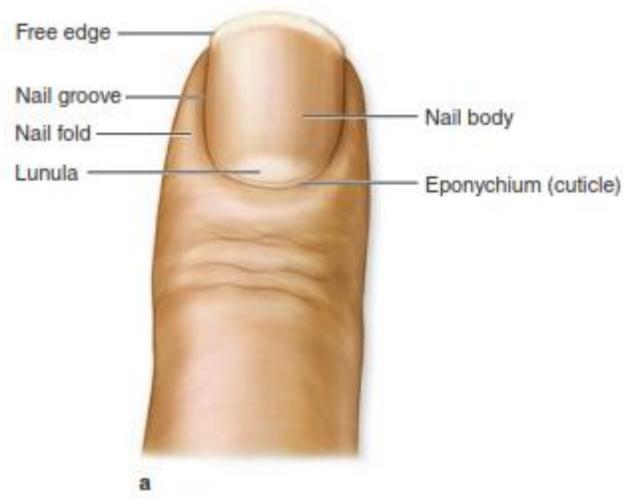


c

a

Nails

- A process of keratinization also produces the nails, which are hard plates of keratin on the dorsal surface of each distal phalanx
- The proximal part of the nail is the nail root and is covered by a fold of skin, from which the epidermal stratum corneum extends as the cuticle, or eponychium.
- The nail plate is bound to a bed of epidermis, the nail bed, which contains only the basal and spinous epidermal layers.
- The nail root forms from the nail matrix in which cells divide, move distally, and become keratinized in a process somewhat similar to hair formation but without keratohyaline granules.
- The nail root matures and hardens as the nail plate
- Continuous growth in the matrix pushes the nail plate forward over the nail bed (which makes no contribution to the plate) at a rate of about 3 mm/mo for fingernails and 1 mm/mo for toenails.
- The distal end of the plate becomes free of the nail bed at the epidermal fold called the hyponychium.



Glands of the skin

- Sebaceous Glands
- Sweat Glands:
 - Eccrine sweat glands
 - Apocrine sweat glands

